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eMotion

Estimation of the User's Emotional State by Mouse Motions.

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Statement Under Oath

I hereby state under oath, that I created this work independently and on my own. All thoughts that adopted directly or indirectly from other sources are marked as such. This work was neither submitted to any other examination board yet, nor published.

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Feldkirch, 2005-08-22 Wolfgang Mähr

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Abstract

Emotions play an important role in human interaction with humans and machines. As machines are not able to measure or interact with these emotions in communication with humans, an important part of the communication bandwidth is lost. A machine that recognises and interacts with our emotions is more fun to work with and results in less mistakes.

Different methods for emotion measurement have been developed, subjective and objective measures alike. The methods which are highly developed (self-assessment and measurement of physiological changes) need user co-operation and impede the workflow and can therefore not be used continuously. The newer, less experienced methods (measurement of facial expression and voice changes) have the problem of not "feeling" the user and are therefore not so reliable. This study tries to show a new way of emotion measurement via the user's mouse motions combining the advantages of the other methods by being directly connected but not intrusive.

To prove this new concept, a set of software tools for measurement was written and an experiment for validation was planned, implemented and executed. The results of these experiments (N=39) show that it is possible to use the computer mouse as a sensor for emotional states. Mouse movement speed values (acceleration, average speed and uniformity) were statistically significantly different for high and low levels of arousal. When comparing the movement characteristics differences per person after watching films with higher and lower level of arousal, the movement speed (MS) was lower ($M(dMS)_{low} = 0.03$, $M(dMS)_{high} = 0.00$, $p < 0.01$) and the movement precision (CN) higher ($M(CN)_{low} = 1.07$, $M(CN)_{high} = 1.11$, $p = 0.03$).

Keywords: Affective computing, User emotion, Emotion measurement, Mouse motion, Mouse movements, Emotion, Arousal, Human-computer interaction

Zusammenfassung

Emotionen spielen eine wichtige Rolle in der menschlichen Kommunikation mit Mensch und Maschine. Ein grosser Teil der Kommunikationsbandbreite geht dadurch verloren, dass Maschinen unsere Emotionen nicht messen und damit auch nicht interagieren können. Arbeit an einer Maschine, die dies könnte, würde mehr Spass machen und weniger Fehler produzieren.

Es gibt verschiedenste objektive und subjektive Methoden zum Messen von Emotionen. Die weiter entwickelten Methoden (Selbsteinschätzung per Fragebogen und Messung von physiologischen Veränderungen) benötigen die Zusammenarbeit des Benutzers, behindern den Arbeitsablauf und können daher nicht dauerhaft eingesetzt werden. Die neueren Methoden (Analyse von Mimik oder Tonfall) sind nicht im direkten Kontakt mit dem Benutzer und sind daher nicht so behindernd aber auch fehleranfälliger. Diese Arbeit versucht eine neue Methode zum Messen dieser Emotionen durch Mausbewegungen im dem Vorteil, dass der Sensor direkt mit dem Benutzer verbunden ist, aber diesen dennoch nicht behindert, einzuführen.

Um dieses neue Konzept zu prüfen, wurde Mess-Software geschrieben und ein Experiment geplant, implementiert und ausgeführt. Die Resultate dieses Experiments (N=39) zeigen, dass es möglich ist, die Maus als Messsensor für Emotionen zu verwenden. Die Geschwindigkeitswerte (Beschleunigung, Durchschnittsgeschwindigkeit und Gleichmäßigkeit) weisen signifikante Unterschiede für starke und schwache Erregung (arousal) auf. So führte das Schauen eines Films mit stärkerer Erregung zum Beispiel einer grösseren Differenz der persönlichen Mausbewegungsgeschwindigkeit ($M(dMS)_{low} = 0.03$, $M(dMS)_{high} < 0.01$, $p = 0.00$), und zu Bewegungen, die weniger präzise waren ($M(CN)_{low} = 1.07$, $M(CN)_{high} = 1.11$, $p = 0.03$).

Schlagworte: Affective computing, Benutzer Emotion, Messung von Emotionen, Mausbewegungen, Emotionen, Gefühle, Erregung, Arousal, Human-computer interaction, Mensch-Maschine-Interaktion

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Chapter 1

Introduction

Our life's and society's dependency on computers is continuously growing. Years after the digital revolution[1] started, computers do strongly influence our western society. Many people use computers for their everyday work and the number of people accessing the Internet is on its way to reach one billion [Internet World Stats, 2005]. Computers become more and more omnipresent, but at the same time less visible. As computers used to be supercomputers or servers in dedicated rooms or personal computers waiting in the office to be worked with, they now are almost everywhere. The mobile phone we use to contact our friends, the chip steering the elevator in the shopping mall, the cash dispenser or the navigation system in our car, they all are computers and they all interact with us humans.

1.1 Background

From this so-called *ubiquitous computing* arises the research question of human-computer interaction (HCI) about *how* we humans interact with machines and how to improve this interaction. As we spend more time interacting with computers, their use should be efficient, intuitive and positive. Efficiency enables us to see these computers as tools and not as an obstacle in completing our tasks, and avoids frustration at use [Scheirer et al., 2001].

[1] The changes in society and technology since the end of the 20th century caused by the rapidly sinking costs and growing possibilities of digital devices like computers and telecommunications. [Wikipedia, 2005]

A tool for efficient working has to be intuitive, so that we can focus our thoughts on how to solve a problem instead of how to use the tool. Humans tend to adapt to new situations, but to rely on what we do, we need trust in things working the way we expect them to. If these basic usage requirements are met, our interaction with computers can be a positive experience. If the interaction with the computer is affective[2], we can assume that the users will not just have a more delightful experience, but will also produce better results by the ongoing emotional interaction [Picard, 1997].

Requirements for emotional interaction are the ability to sense and process the other's emotional state and the possibility to send emotional responses. This is the same for human-human interaction, as it is for human-computer action. The estimation of the correspondent's state can be done by interpreting mimics, posture or cadence. The better the opposite side is known, the better this estimation can be done. The possibilities for computers are similar to the possibilities for humans and methodologies for emotion recognition are already being developed. These techniques rely on sensors measuring blood pressure changes, voice changes, or even recognising emotional facial expressions [Bushko, 2001].

1.2 Positioning of the Work

Special hardware is needed to make affective computing available for standard computers. This fact represents a major challenge to a wider use of interaction enhancement. On one hand, when using biometric sensors for emotional feedback, sensors have to be attached directly to the user, which might impede the user (i.e. by cables), or might even be impossible (for visibility, handling or cost reasons). On the other hand, estimation without direct measurement of biometric values (i.e. self-assessment questionnaires, face recognition, etc.) often is imprecise. I base my work on the hypothesis that emotional affection has influence not just on our thinking and feeling, but also on our minute motor activity [Benyon et al., 2005]. For this reason I will try to search and show significant correlation between movement char-

[2]"Affective computing" is computing that relates to, arises from, or deliberately influences emotion [Picard, 1997].

acteristics and emotional user states. The focus of this work is to prove that it is possible to use a low-price measurement tool like the computer mouse to get the advantages of affective computing without extra costs, infrastructure changes or user annoyance.

1.3 Focus of Work

Before diving into the matter, I will here draw a border to topics that are not treated in this work. First, I will not explain effects of affective computing in detail, except of minor representative examples. Second, I will not discuss the ethical side of affective computing. It is an interesting but out-of-scope discussion about whether it is good when computers interact with our emotions or about what happens with our privacy when computers know the users emotions.[3] I take the example of emotions as a representative for similar psychological phenomenon (like moods or temperament) in the belief that their difference in this specific context is the time dimension and therefore not extraordinary relevant; I believe that the methods of this work can also be applied on moods or temperament, when observations last longer and are more precise. User recognition by mouse movements is another interesting and related topic, which is also out of scope for this work.

1.4 Naming Conventions

To understand this document properly, some definitions and naming conventions are needed. I will use the female form to represent both genders alike. The term ”user” is a shorthand for ”computer user”, whereas the term ”computer” represents any system including a programmable chip. As I focus on the mouse as pointing and input device, the work is obviously mainly applicable on machines using a mouse or other similar input devices. The terms ”emotional state” and ”affective state” label the sum of all the user’s emotional properties, which are temperament, mood and emotion. In

[3] The interested reader might find Picard’s work [Picard, 1997] an interesting starting point.

this sense I will also use "affective computing" as a description of computing, that relates, measures or even influences the user's emotional state, just as defined by Picard [Picard, 1997].

1.5 Structure of the Thesis Paper

This paper is organised as follows: First, I will give an overview of my work for this thesis paper. This is followed by a description of related work and background information about the field of HCI and emotions. Thereafter comes the motivation, why this specific area of work is interesting. This will be followed by my hypotheses, the experiment descriptions and the experimental results. At the end I, will discuss the results and give a future outlook and recommendations. The documentation for the software and the detailed test documents and results can be found in the appendix.

Chapter 2

Overview of the Work

To be able to explain the needed background of this work comprehensively, I will first give a short overview of the work, so that terminology, software and hardware components and concepts can easier be explained and understood. After summarising the work as such, I will give a short overview on the different parts. After this chapter, the background and environment of this project will be explained.

The work for this thesis touches and resides in different sub-fields of HCI. All written software is clearly in the field of software engineering. The hypotheses belong to cognitive psychology and are tested with the help of statistics. The experiment therefore combines three fields: software engineering, psychology and statistics. All these fields require different background knowledge, which will be presented in the appropriate chapters.

The goal of this work is to proof the concept of estimating the user's emotional state by interpreting the mouse movements. For this purpose, a software for recording user mouse movements called Mouse Tracker for OS X (MouseTraX) was created. In the actual state this software only records the mouse data and does not support any further processing of data. The logged mouse position/time pairs were then processed by a couple of scripts to extract possible indicators (i.e. average speed or clicking duration). The concept of my work foresees these variables as indicators for the user's emotional status. To test, if these variables really are indicators, an experiment was made. It was completed by 40 test subjects on campus and consisted of an online questionnaire and the mouse logging software in the background. The data from this experiment was then analysed by statistical methods for significant correlation between the subjects' emotional states and their mouse movements.

2.1 Mouse Tracker

The tracking software was planned to be modular and was developed in Objective-C (ObjC); its documentation can be found in the Appendix C. It was called MouseTraX. A rough overview of the software modules is presented in Figure 2.1. It shows the four parts of MouseTraX, the grey marked parts have been implemented. The core of the system is the MouseTraX-kernel, which gets the tracking data from the operating system. This kernel reacts on all mouse actions and forwards them as logging messages to the appropriate instances. Here, the main functionality was implemented, including the posting into a file and on a network port. This posting on a network port enables a remote client (MouseTraX-client midi) to watch the host computer's mouse properties (i.e. coordinates, events). This client was made in order to make the experiment easier to be supervised from another computer. More functionality is planned in case that this concept is proven to be right. The software is not fully completed yet, but it has sufficient functionality for the the experiment and to prove the concept.

In the long run, two other clients might be interesting. MouseTraX-client mini could be a small widget for reporting the user's current affective state (e.g. an emoticon). MouseTraX-client maxi (Figure 2.2.) could be an analysis tool for recording, visualising and graphical analysis of the mouse movements.

2.2 Experiment

An experiment (schematised in Figure 2.3) was set up to answer the research question of emotion impact on mouse movements (see Chapter 6.1). Each test person was seated at a 12" Apple PowerBook G4 running Mac OS X (OS X) equipped with a two-button-and-scrollwheel mouse where she had

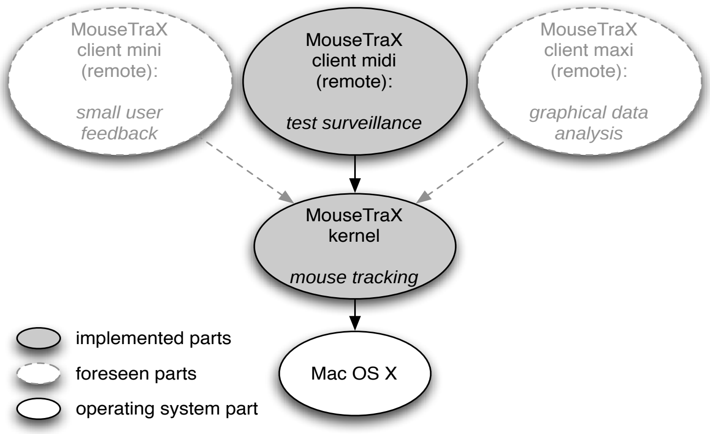


Figure 2.1: MouseTraX Module Overview.

to fill out a questionnaire using the web-browser. This questionnaire was a web application running on the very same machine containing three different videos each triggering one of three different emotional states (neutral, joy or sadness). User mouse movements were logged by MouseTraX, the answers on the general (age, gender, etc.) and self-assessment questions (level of joy, disgust, . . .) and control data (position and events) were logged by the web application. From time to time a 14" iBook running the MouseTraX-client midi was used for test supervision. Test subjects were under direct supervision and were free to ask questions but had the order to focus on the questionnaire. After completion, the test data was analysed statistically to find significant correlation between the subjects' self-assessment and their calculated clicking and movement indicators. For more information on the experiment see Chapter 7.

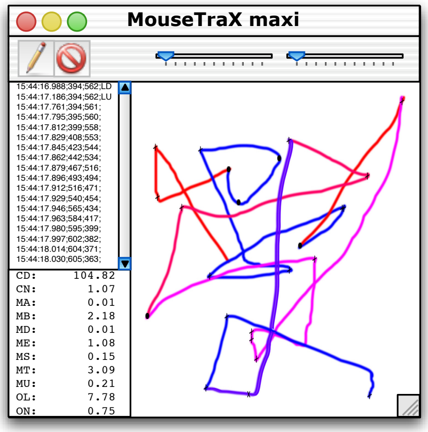


Figure 2.2: MouseTraX-client:maxi GUI Concept:
On the right side we could visualise the the mouse movements, scroll and zoom. On the left side the raw data is displayed and indicators are calculated.

2.3 Summary

This chapter provided an overview of my work for this thesis, introduced a system overview and pointed out the most important parts. The reader should now be able to understand the abbreviations for MouseTraX kernel and client; the experiment layout with three different emotional states and self assessment should be familiar.

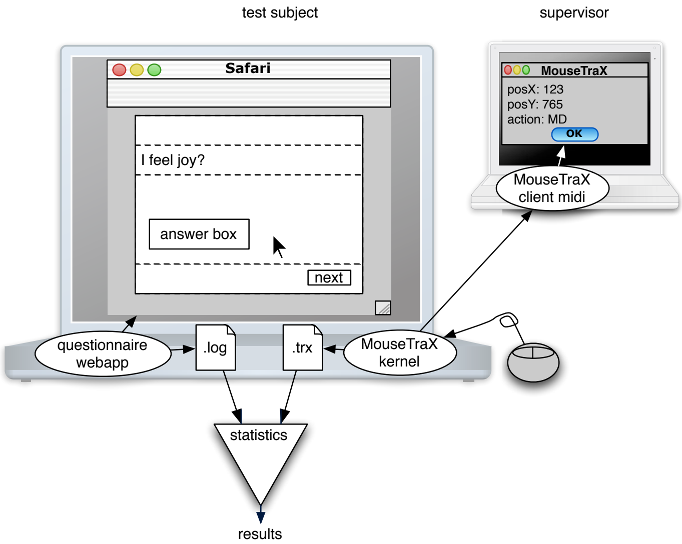


Figure 2.3: Experimental Overview:
The test subject's computer ran the questionnaire web application providing the questions for the user and writing clicking log-files (.log) for the answers given. The MouseTraX kernel also running on that machine took care of the mouse data, wrote the mouse tracks into log-files (.trx) and propagated the data to a supervising computer. The .trx and .log files were then analysed by statistics.

Chapter 3

Motivation of the Work

In her paper, Picard explained four different motivations, why it is interesting to give emotional abilities to machines [Trappl et al., 2003].

- Effectually emulate living beings.
- Make machines more intelligent.
- Understand emotions by reproducing models.
- Create machines that are more fun to interact with.

My main reason for this work was the interest in the last point. The other reasons reside in the field of humanoid machines and require deeper artificial intelligence and more psychological modelling than I used in this work. A human's reasoning contains more complex processing than what can be simulated right now, let alone more advanced and abstract psychological ideas (i.e. unconsciousness). Still, this work could be seen as another small step to create humanoid machines, because it should help the machines to sense emotions, something required for an emotional appearance.

This chapter goes deeper into the argument, why it is interesting to make machines that are more fun to interact with. It shows the present grievances in this field, which lead to the interest to do research in this field. It shall also give a hint of what kind of results could be expected, if we can measure the user state reliably and steadily.

3.1 Importance of Emotions in User Interaction

The influence of emotions on human behaviour (and the opposite effect of behaviour influencing emotion), are not fully researched and explained yet, but their effect on our interactions with the environment are not negligible (see Chapter 4). Therefore emotions affect our interaction with computers. A good example where emotions come into play is user frustration. Almost everyone knows situations, where a computer does not behave the way it is assumed to. When occurring repeatedly, the user gets frustrated and prefers to use different means to reach the goal. If there are alternatives, she might try these. If she is forced to use this system, she gets frustrated and dissatisfied in the long run. This situation does not represent a good and satisfying work flow and therefore should be avoided. A solution might be affective computing. In 2002, a study has shown that computers are not just able to provoke negative emotions, but also to alleviate strong negative user feelings [Klein et al., 2002]. This gives us anticipation that future interaction with computers will use emotional feedback and will make our everyday interaction with machines more fun.

The trend of using the computer also as a communication channel and not just as a calculator and data storage shows that we are in need of social and emotional interaction. HyperText Markup Language (HTML) is the best example for something that started out as an information publication media and then changed its meaning through the bigger user base. With the ability to generate dynamic content, new communication channels like forums and web-logs were invented enabling virtual societies and emotional contact. This seems to be a basic human need, even if not directly productive from the economic view. As such, forums, chats or instant messaging are disliked to be accessed at the workplace. This leaves an emotional gap, which could sometime be filled by the machines we are working with. Totally replacing the human-human interaction however is an utopian and dubious goal, but extending it should have positive effects. Imagine being greeted by your computer with a friendly "Wonderful morning, isn't it?" when blithely entering the office in the morning; imagine being told a comforting story, when obviously feeling sad. The very same things good office mates should deliver, if they are available. This may still be a vision, but the positive effects of basic emotion recognition by the computer are visible.

3.1.1 Emotion Influence on Work Efficiency and Results

Emotions in interaction do influence our whole affective state. This can have a positive (or negative) effect on our working results. Former studies show that interaction with a partner fitting to our mood requires much less concentration, is less irritating and leaves us more resources to focus on our real task [Nass et al., 2005]. Computers cannot understand our emotional state (as we humans still have not completely understood our emotional basis) and therefore always reply in the same way. This way may be more formal or informal, depending on the implementation and some preferences that might be set by the user (e.g. language, error messages, etc.). However, this interaction does not adapt to the user's affective state.

Attention and concentration are major factors related to accidents and mistakes. If users are less irritated by the communication with the system, they have more attention left for the main task and chances for mistakes and errors shrink [Eysenck, 2001]. This has, if all user-computer interaction becomes emotion aware, the advantage that errors and mistakes occur less. This might result in more bug-free programs, less error-prone reports and calculation and hopefully in less accidents resulting from human errors.

Another issue to be addressed is user confusion and helplessness. Even if this emotion is no basic emotion, it still influences our work, especially when we are interacting with unknown parts of systems. Buttons for "Help" and interactive assistants are already standard components in most larger software products. These help systems still require the users call for help. Another approach is in office software suites, that have interactive assistants trying to guess what the user is willing to do (write a letter, etc.) and then popping up. This often evokes the subjective feeling of popping up at the wrong time. Critical applications, those applications that pose the danger of loss for the user (e-banking, web-shops, hard-disk formatting, ...), have to guide novice users because of the possible loss of value. If new users do not get the needed support, they are endangered of refusing to use the application due to the fear of loss, if doing something wrong. And if they use the application, they may have a feeling of insecurity every time using it. An expert, however, gets annoyed if the help is too obtrusive and an obstacle for completing the task smoothly. Useless up-popping helpers are clearly obtrusive. A study on Internet shopping [Müller and Lockerd, 2001] showed that users usually hesitate before making decisions, such a pattern could also be a possible hint for insecurity or confusion. A system that recognises this automatically and only then becomes active may bridge the gap between novice and expert users and reduce occurring errors.

3.1.2 Emotion Influence on Health Factors

Emotions influence a big part of our personality and behaviour. In this sense emotions in the HCI can also have an influence on the user health. If the emotional interaction between the user and a system works well, it becomes fun to work with the system. This results in a better mood and a positive attitude towards the system. It has been shown that positive emotions can make people more resistant to the common cold [Cohen et al., 2003]. To explain the whole connection of psychosomatic illnesses is outside of the scope, but to sum it up one could say "Happy people are healthy people". In this sense it is also in the interest of employer to have healthy and happy employees. Not just that the working morale is higher, but also sickness leaves may become shorter when employees enjoy working at their machines.

3.1.3 Interest of Software Producers

Software producers want to have satisfied customers and should therefore be interested in making their systems react on the user emotions. When users are more satisfied and happy using a certain application, they also are more likely to buy a later version of this application and not to switch to competing software [Picard and Klein, 2002]. This binding of users could be achieved through emotion recognition in the software. If this extra feature works well, it makes the tool fun to work with and adds extra value to the customer. In a later buying decision this extra value might give the tool a critical advantage. This means that the user has built up an emotional relationship to her tool and therefore sticks to it - a typical example how emotions influence our decisions.

3.2 Summary

In this chapter I have shown different reasons, why the research in affective computing is important. These are reasons ranging from understanding how our emotions work, over building humanoid systems to the economic reasons of productivity and sales numbers. For the interested reader I recommend the article by Picard and Klein [Picard and Klein, 2002] that discusses parts of this topic.

Chapter 4

Psychological Background

To be able to understand the user's emotion, we need to understand how she thinks, how she experiences the interaction with the machine and how these things influence her in the long run. This chapter provides the needed background about communication between humans and machines and then focuses on emotions. I will give an overview about the different types of emotional states, schemes of emotion classification, emotion processing and impact and will end with different means to measure emotions.

4.1 Communication

The history of human communication is as old as humans are. Any kind of bidirectional interaction can be seen as communication in the wider sense. This means that communication requires both sides to react on the messages received through interaction. In this sense, interaction with animals can also be seen as communication [Picard and Klein, 2002]. Since we possessed these skills for a long time, we improved and extended them. We developed possibilities to distinguish different contents by small details and fine nuances. We grew up with these skills and use them our everyday life. We communicate not just with the words in our sentences, but also with cadence, gestures and mimics. All information we receive from the other communicator is processed in our brain and interpreted to enable emotional interaction.

4.1.1 Human-Human Interaction

Communication and emotion are tightly connected in humans. On one hand, emotions influence our behaviour and therefore also our interaction, on the other hand we have something that Picard calls "experiential emotional needs" [Picard and Klein, 2002]. We wish that the person we are communicating with understands our emotional state and responds to it. This makes us feel connected to others and leads us to companionship and security. A really illustrating example for the importance of emotional interaction is the communication between teachers and pupils, which strongly relies on emotional feedback. Everyone, who has been listening to an unemotional lecture, knows that those lectures are not just boring, but also difficult to understand. The teacher does not address the pupils' emotional needs in communication and therefore the content is not interesting. For the teacher on the other side, it is important to get emotional feedback from the students, to feel that they are interested, as well as to learn if they are confused or afraid of the taught matter. This is what makes "a good teacher" with good lectures and probably also good pupils.

Emotions are a basic part in all of our communication and not limited to human-human communication. People have emotional ties to many things, for example to their pets, toys, or other objects. Pets actively communicate with their holders and interact with the holder's moods and emotions [Picard and Klein, 2002]. According to Picard, we even tend to imagine emotional responses, if our communication partner does not provide them. Children tend to have an emotional binding to their toys. Toys can be children's friends, they often have names and according to children are like "all the other humans". Later such behaviour can be seen in adults giving names and talking to their plants, cars or computers.

4.1.2 Human-Computer Interaction

In general, the interaction between humans and computers follows the rules of human-human interaction [Picard and Klein, 2002]. Humans react emotionally on computer responses, just as if they were interacting with humans. A mismatch of attitudes between the communicating parties can lead to more negative responses in humans, no matter if the other party is human or a machine. Computers do not have the to adapt themselves to the attitude and emotional level of the communication partner. Their feedback is usually tried to be kept neutral, so that it fits most of the time. This removes the emotion from the interaction with computers, and changes in the user's emotional state are not reflected in computer responses. The situation is even worse, when the machine does not respond neutrally, but tries to simulate human-like features, as for example in navigation systems. These talk to you, but do not listen, which distracts more than a sterile and neutral interaction [Picard and Klein, 2002].

Further unresolved issues addressed by Picard et. al are ethical questions about interaction manipulation and privacy [Picard and Klein, 2002]. Both issues apply on human-human interaction just like on human-computer interaction. However, we do feel like we would have more influence on the people around us than on the computers. When communicating, we take the risk of being manipulated and the risk of disclosing private things. However, when communicating with humans, we are aware of that and usually adapt our communication to the level of trust in the other person. We talk more with a close friend, more shallow (small talk) with an unknown person. But where to rank our computer at work? Will this computer really be loyal and keep our secrets, because we trust it? Is this computer, that never showed any sympathy or antipathy really neutral towards me? As long as computers can be re-programmed by malicious people much easier than social engineering works on our friends, human-computer interaction cannot be as trustful as human-human interaction. A computer could even be programmed to use its sensors to read our emotions much better than a person in the same position could do. A malicious machine like for instance our cell phone could analyse our emotional state and leak it to people we do not want to be knowing (e.g. provider, identity-thieves, etc.). Here work has to be done to ensure our personal privacy. From this point of view, the interaction between two humans and the interaction between computers and humans are different.

4.2 Emotions

Emotions are a central part in human cognition. They are an important capability for our quick and effective reaction on our (hazardous) environment. They influence our perception of the environment and influence our thoughts, well-being and behaviour. In this section I will give a more detailed overview about emotions by defining them and defining their distinctions to other similar concepts of temperament and mood. Thereafter I will give a short overview about different emotional classifications, and finally explain how emotions can be measured.

4.2.1 Introduction to Human Emotion

Conscious reasoning requires words and ideas and is a slow process. This slow reasoning is a handicap when fast and unconscious reaction and reflexes on dangerous situations was needed since the most primitive life forms. Affective states enable us to process our environment unconsciously and faster. For example, negative emotions warn us that our goal may not be reached, whereas positive ones comfort us and tell us that we have reached them. Fear warns us that we are endangered and alerts the whole body to prepare for the "fight-or-flight"[1] situation. Our senses become sharper, adrenaline activates our muscles and circulation, and this all happens without active consideration. This improves our chances of survival.

There are different definitions of emotions, but most psychologists agree on four components common to all emotions [Dalgleish, 1998]:

- Emotions provoke physiological changes and an emotional expression. They influence our body by changes in heart rate, skin conductivity and similar. This combination is the emotional expression, which can range from shivering (fear) to vomiting (disgust).
- Emotions create a notion to take action.
  In this sense they influence our behaviour. Anger prepares us to fight, fear prepares us to to freeze or flee.

[1] The decision if we should fight against the imminent threat or if survival chances are higher if we flee.

- Emotions often start as unconscious experiences in the beginning.
  Emotions ”sneak in” to our consciousness. We do not actively think that the animal we see is a tiger and we therefore should be afraid, but instead we automatically (unconsciously) become afraid and then realise that there is a tiger.

- Emotions have a meaningful cognitive component.
  We compare what is happening outside with our own interests and motivation. For example, the death of a person does not affect us that much until we get to know that it was a dear friend.

According to Eysenck [Dalgleish, 1998], affective states can be distinguished by duration: Physiological changes and expressions (sometimes called *affect*) may last from seconds to minutes. Experienced *emotions* last from some minutes to hours. States lasting longer than that (hours to months) are called *moods*. *Emotional disturbances* can last from weeks to years; *personality* may be changing by the years or stay unchanged the whole life. Let us have a closer look at the concepts of temperament, mood and emotion.

Temperament (or Personality)

Temperament (or personality) is the most stable affective influence on our behaviour. It seems to have biological and neuro-psychologicial reasons, but how much it relies on our genes is not totally cleared yet [Dalgleish, 1998]. The personality is a stable basis for other emotions to grow on and it reflects the tendency of individuals to exhibit particular moods with great frequency [Nass et al., 2005].

Mood

Moods are similar to temperament. They do not either need an object to be based on. For example, we can be sad or joyful without having a specific reason why [Dalgleish, 1998]. Of course, moods are also provoked by specific events, but these events can be more subtle or a combination of smallest reasons (e.g. background music in the lift reminding us of our imminent summer holiday, ...). These small reasons create different light emotions, which then aggregate to a mood [Nass et al., 2005].

Emotion

Emotions are more short-lived than moods. They can change within seconds. They are - as already explained earlier - a basic system for communication in our body. They are reactions to events deemed relevant to our needs, goals or concerns. According to Benyon [Benyon et al., 2005], emotions do consist out of three components: subjective experience, physiological changes and behaviour.

4.2.2 Emotion Classifications

Emotions are common to all humans. All of us feel them in a similar way but possibly with different intensity. This makes them a part of our common life and our everyday language, but also makes the perception of the word "emotion" differ from person to person. For the precise scientific use, emotions have to be classified. There are two interesting models of emotion classification: The model of basic emotions and the model of valence/arousal.

Scheme of Basic Emotions

There are many different definitions about how many and which emotions are basic. The emotions that are shown in Figure 4.1 are according to Ekman [Ekman, 1994] basic emotions, because they obviously are independent in terms of culture or epoch. The reason for this universality is that they are based in the autonomous nervous system (ANS) and therefore provoke similar physiological reactions, that can easily be observed already in infants [Wade and Tavris, 1996]:

- Anger: A reaction on an obstacle on our path to complete a goal.
- Disgust: A reaction on something that does not comply with our moral and social expectations.
- Fear: A reaction on the possibility of not reaching a goal.

- Happiness: A reaction on the completion of a goal.
- Sadness: A reaction on the definitive knowledge that our goal was not completed.
- Surprise: A reaction on an unexpected event.

Figure 4.1: Basic Emotions.

Other schemes presented by Oatley and Johnson-Laird in 1987 [Eysenck and Keane, 2003] define the basic emotions of happiness, anxiety, sadness, anger and disgust.

Basic emotions are called so for certain reasons: They are invoked by universal factors (like reaching/missing a goal) and result in distinct and universal signals. Facial expressions of these emotions are recognised all around the world, independent of culture. They have clearly different physiological signals and even appear in primates. These emotions have a fast and clear activation and lead us to an automatic judgement and invocation of action (e.g. the "fight-or-flight" decision). This allows us to conclude that our communication and survival in former times relied on these emotions [Dalgleish, 1998].

Picard argues in her paper [Picard, 1997] that according to Damasio's work [Damasio, 1994] there are primary emotions (like fear) that trigger secondary emotions via further processing. As an example, a bang that first triggers fear can lead via cognition to grief when we realise the loss of a near relative. She also argues that some (in this case basic) emotions are pure and exclusive. This means that one specific emotion cannot be expressed (e.g. by mimics), when another emotion is being felt. Secondary emotions can be combined, because we can feel sadness and shame at the same time. Secondary emotions are self-concious feelings (e.g. shame or guilt) and develop later in our life.

Valence-Arousal Model

A simple way to classify emotions by using less variables is by a three-way model. This is common for experiments, where an emotional state is modelled by the variables of arousal, control and valence [Scheirer et al., 2001].

- **Arousal** is the intensity of the feeling, the excitement of the person.
- **Valence** measures if the feeling is positive or negative.
- **Control** tells if the feeling is in internal or external control.

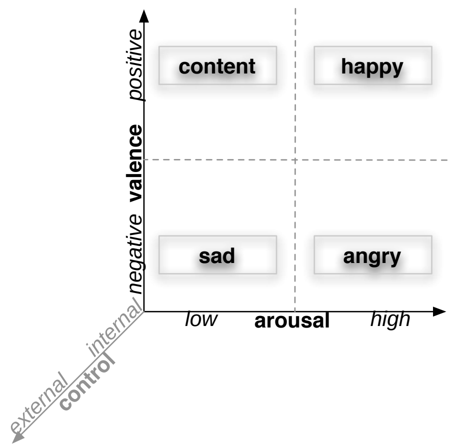


Figure 4.2: The Valence/Arousal Model.

In this work I only consider valence and arousal, but not control, which is also a part of the original model seen in Figure 4.2 [Picard, 1997].

4.2.3 Emotion Processing in the Human Body

The integral part of emotions is their influence on our cognition. Even if colloquially used "being emotional" stands for the opposite of "being rational", these two things belong together [Damasio, 1994]. Studies have shown a discrepancy in the question, if emotional and cognitive processing can happen without each other or not. On one hand, cognition is preceded by an affective reaction [Lazarus, 1982], on the other hand, emotional reactions can be triggered without prior cognition (for example in an life-threatening situation). This leads to a more diversified model on emotion processing with two different emotional circuits [Eysenck and Keane, 2003]. The amygdala[2] is seen as the central authority in processing emotions in the brain. Sensory information that is targeted to the thalamus[3] will be directed to the amygdala first. This can happen directly for fast decision making, which might be important for our survival. However, the signals also can also be directed via the cortex[4] to the amygdala, which enables us to have a considerate and appropriate reaction [LeDoux, 1996]. This explanation was regarded as sufficient for this study, even if emotional processing might also be influenced by moods, temperament and other factors. As long as the test persons show emotional reactions on the stimuli, this shallow model for emotion processing [Sloman, 2001] is good enough and the details are seen as irrelevant.

4.2.4 Emotion Impact on Human Behaviour

The impact of emotions was mostly studied in connection to learning effects. Theories have been developed saying that memory recall works best when the emotional state is the same as it was when learning. Similarly, it was shown that anxiety biases attention and perception [Eysenck and Keane,

[2] An almond shaped part of the human brain. It forms part of the limbic system. In humans and other animals, it is linked to both fear responses and pleasure [Wikipedia, 2005].

[3] The thalamus is a part of the brain, located in the center. It is thought of as a relay station for nerve impulses in the brain [Wikipedia, 2005].

[4] The cerebral cortex is the outermost layer of the brain. The human cerebral cortex is 2-4 mm thick and is highly folded [Wikipedia, 2005].

2003]. For example, the willingness to take hypothetical risks is stronger in positive mood. However, in an actual risk situation a positive mood makes us more cautious [Nass et al., 2005]. Nass et al. [2005] also have shown that there is a significant connection between the attention communication requires and the concordance of emotion levels of this communication. Even more, attention paid to thoughts and stimuli with relevance to the current situation is stronger, when the emotional background fits.

Results from emotional processing also include physiological changes in heart rate, skin conductivity or brain activity. Each basic emotion has an own set of facial muscle movement patterns, voice intonation or finger pressure. The emotion impact may differ from person to person and therefore should be personified. This process of personifying corresponds the time humans need to get to know a person and to correctly interpret these signals.

4.2.5 Emotion Measurement Methods

As already mentioned, emotions have an impact on our biometric values, which therefore can be used to measure emotion. For example heart rate, diastolic and systolic blood pressure, pulse, pupillary dilation, respiration, skin conductance and colour, temperature, facial expressions, voice intonation, gesture/movement, perspiration or muscle action potential can be used to measure emotion [Benyon et al., 2005]. The amplitude of the reaction may be ambiguous [Scheirer et al., 2001] and therefore should be learned by the software. Further clues from the context for the emotional state are situational variables; whether the user re-typed a word also bears clues about the affective state [Trappl et al., 2003].

Self-Assessment Method

Self-assessment is a subjective method, where the test subjects assess their own emotional status by questions or other means. A standard way to do this is via Self-Assessment Manikins (SAM): two examples for valence and arousal can be seen in Figure 4.3. These figures present a simple way to estimate the test subjects' state.

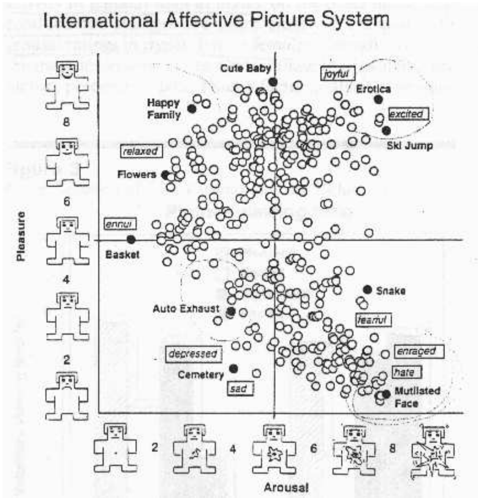


Figure 4.3: Self-Assessment Manikin:
An example of SAMs in use, here in Lang's International Affective Picture System. We can see the different locations of specific emotions and some distinct images marked by the position of emotions they provoke. The plotted observations show average responses to pictures shown to subjects by Lang [Kirsch, 1999]

The self-assessment scale seen in Figure 4.3 was developed by Bradley and Lang [Kirsch, 1997]. It has three major advantages. First, the SAMs are culture independent and easy to understand for everybody. Second, they are cheap and easy to use on a questionnaire. Third, as a combination of one and two, they have been used for a while and therefore an expertise has been developed.

These SAMs have two major drawbacks for use in user transparent emotion estimation. The first one is the obvious reason that filling out SAMs is an active task, which cannot happen in the background and therefore is not transparent. The user has to fill out a form actively. The second problem of self-assessment is the problem of any questionnaire: If a person answers consciously, she can consciously answer wrong. The motives for such wrong answering may range from feeling some kind of need to comply to the wanted test answer to the unwillingness to uncover ones true feelings, or the plain inability. This results in the dilemma that the subject assessment made by the person filling out a questionnaire does not necessarily match an objective assessment.

Physiological Measurement

A method for objective emotion measurement is via physiological changes. This method is more objective and it relies on the emotional impact on body functions (described in Section 4.2.4). A well-known example is the lie detector, which uses values of skin conductivity or blood pressure to detect stress in the subject.

The major advantage of this method is the expertise from a long deployment. Since this method measures test subjects' unconscious processes, it is hard but not quite impossible to manipulate. In future this method may become even more interesting, when it will be possible to attach it directly to a subject due to advancing technology. One example is the "Conductor's Jacket" presented by Bushko [2001].

The major disadvantage of this system is the handling. Compared to using SAMs on a questionnaire, this method is expensive and might distract the subjects by attached cables and sensors. This method cannot be implemented unnoticeably and unobstructively for the user [Scheirer et al., 2001].

Measurement by Mimics and Voice Changes

Further objective measures for emotional states are face and voice recognition named by Scheirer [Scheirer et al., 2001]. These are be examples for an unobtrusive and uninterfering method. Their disadvantage is the distance between sensor and subject. Longer distances between sensor and subject make detection harder since disturbances may occur. In case of face recognition shadows and surrounding light might disturb. In case of voice recognition, changes in the voice due to illness, humidity or other factors limit the results. Both methods are under development and might produce good results in future [Picard, 1997]. Especially voice recognition could become interesting, when voice controlling is more common.

Movement Measurement Method

The focus of this work is to show a new objective way of measuring emotional states by measurement of changes in the movement characteristics.

One influence of emotion on our body is caused by adrenaline and other substances influencing our muscle activity. We walk faster, if we are angry, slower if sad or more energised if feeling happy. A study [Scheirer et al., 2001] has shown that clicking patterns can be used to recognise user frustration. Test persons competed against each other in solving a puzzle game. The test subjects were surveilled via blood pressure and skin conductivity and their mouse clicking behaviour was registered. To induce frustration, response delays were simulated so that the testers felt the game being inresponsive and became frustrated. An analysis of the clicking behaviour showed that not all persons reacted on frustration with a high-density click pattern[5], but that these patterns only occurred after delay-problems. In this sense, a variable of high-density mouse clicks can be a user-dependant indicator for the affective state.

The advantages of using mouse movements to measure emotions are that first of all no special equipment is needed. If this method works with a standard mouse, it is possible to use any computer with a Graphical user interface (GUI) as a measuring instrument. The next advantage is the non-intrusiveness. Just like more expensive embedded sensors and chips, this system will actually be totally transparent for the user as she uses the mouse to control the computer. This makes it transparent for the user and therefore results less likely to be manipulated. Especially people spending lots of time at a computer could easily be analysed by this method combined with a learning algorithm. The third big advantage of this system is that it is directly connected to the user in an unobtrusive way, since the user directly operates the computer with the mouse. This physical connection is for example more frequent than the physical contact with humans and is therefore predestined for measuring data [Picard, 1997].

A disadvantage of this method is that it is new and not yet proved to be working universally and precisely. Another disadvantage might be the future outlook, which could bring a shift from the mouse to other input systems like speech commands. However, all moving input devices (mouse, stylus, touch-screen, etc.) should be eligible for this type of measurement.

[5] Multiple clicks within a short time.

4.3 Summary

In this chapter, the reader has been introduced to all the required psychological background knowledge to understand this work in the full extent. First, principles of communications were named and explained. We now know that emotions play an important part in our communication with machines. We have seen how emotions are processed and how they bias human behaviour. Not only emotions do this, but also moods and temperament; principles that have been explained now. We have seen, how emotions can be classified and that we can map our emotional state on the scales of arousal, control and valence. Finally, we have seen what different ways of measurement are commonly used and what their specific advantages and disadvantages are. The central method of this work - emotion estimation via mouse motion - has bee introduced and explained why it is expected to work, what advantages and disadvantages it has.

Chapter 5

Related Work

In this chapter, I will give an overview of research done in related fields. This shall provide a context of similar (solved) problems and show an entry point for interested readers. Even if most of the research listed here is in the field of HCI, the term "related" is used in a wider sense. I also listed interesting texts, that provided ideas for my work. First, I will name related models and laws from the field of HCI, then I will briefly describe some studies and other research works starting with the nearest related ones.

5.1 Cognitive Models, Principles and Laws

HCI researchers try to model the interaction between humans and computers in different ways. Fitts' law is a basic law, originating from times, when the field of HCI did not even exist in its current sense. It belongs to the same group with laws of Accot-Zhai and Hick. Another useful model is the Keystroke Level Model (KLM). All four laws and models will be described in this section.

5.1.1 Fitts' Law

Paul Fitts published in 1954 a law about motion control for calculation of time needed in rapid and directed movements. It is a simple but well suited model that can easily be tested and it applies to all different limbs (arms, legs, head, ...). First, it was used in ergonomics; later it showed the superiority of the mouse performance compared to other input devices and was therefore a major factor for XEROX to introduce the mouse as an input device [Wikipedia, 2005].

$$t_m = a + b \cdot log_2(\frac{D}{S} + 1) \tag{5.1}$$

t_m	time to move
a	experimental constant, regarded as reaction time
b	experimental constant, regarded as time per movement bit
D	current distance to the target
S	size of the target

Equation 5.1 shows Fitts' law in the Shannon form and is suitable for simple, one-dimensional hand movements. The constants a and b are empirical and depend on the circumstances (e.g. acceleration from mouse software, trained or untrained movement, etc.). Both can be determined empirically by fitting a line to the test data [Wikipedia, 2005]. As an example, $a+b \approx 100ms$ is valid for users moving the mouse to a specific target [Benyon et al., 2005].

Fitts' law brings some simple insights for HCI. Buttons and their responsive area should be reasonable big and have enough spacing in between. This makes it easier for the user to hit them when moving the mouse over long distances. Edges and corners are easier to reach, since the cursor stays on the screen, even when the user moves too far; pie menus[1] are more quickly to access than linear menus [Wikipedia, 2005].

5.1.2 Accot-Zhai Steering Law

Johnny Accot and Shumin Zhai discovered this law by derivation of Fitts' law and then afterwards validated it by experiments. It describes two-dimensional steering with the mouse and predicts the time it takes to follow a steering path with a pointing device. For example, the time it takes to navigate through hierarchical menus [Wikipedia, 2005].

[1]Menus that are laid out as a circle, where each menu item has a slice of the "pie".

$$t_m = a + b \int_C \frac{ds}{W(s)} \tag{5.2}$$

t_m	time to move
a	experimental constant, empirically determinable
b	experimental constant, empirically determinable
C	the path parametrised by s
$W(s)$	width of the path at s

The constants a and b in the equation 5.2 are again experimental constants that can be determined empirically by analysing test data. From this law we can derive, logically that the time needed for navigation is shorter, if the path is wider.

5.1.3 Hick's Law

Hick's law, presented by equation 5.3 is used to calculate the user decision time as a function of the number of choices. It explains the time users need to find entries in an alphabetically sorted menu. It is tightly knit to Fitts' law, since Fitts' law requires users to take (easy) decisions [Wikipedia, 2005].

$$t_d = b \cdot log_2(n+1) \tag{5.3}$$

t_d	time to decide
b	experimental constant, empirically determinable
$n+1$	number of choices plus the choice of not responding

5.1.4 Keystroke Level Model

The KLM is used for predicting user performance in short command sequences when interacting with a machine. It models one task by splitting it into elementary tasks. These elementary tasks consist of two parts: The *acquisition* phase that builds a mental plan of the task, and the *execution* phase where the user executes her mental plan. The KLM can only model the execution phase, because the acquisition phase depends on complex factors (e.g. reaction time, expertise, creativity). Therefore, more complex tasks cannot be modelled precisely. The model contains five physical and two supportive operators [Dix et al., 2004]:

K keystroking, including modifiers

B button-pressing on the mouse

P pointing, including the movement of the mouse

H homing, switching the hand between mouse and keyboard

D drawing line with the mouse

M mentally preparing for the action (acquisition); supportive

R system response, which might be ignored; supportive

With this set of basic operators we can model simple user actions as a sum of operations. The total time of an action is the sum of the times for all operations. The time for pointing can be calculated by Fitts' law, the other values can be measured empirically (examples for these times can be found in the work of Dix et al. [2004]).

5.2 Previous Research and Experimental Results

As a result of growing processing power research in affective computing became more intense in the last few years. We now can focus more on emotions as an important part of our communication. Here is a list of some interesting references to studies, experiments and papers.

5.2.1 Emotion Recognition by Mouse and Keyboard Data

Research on this very same topic is done by Philippe Zimmermann at the Swiss Federal Institute of Technology[2] as a part of his PhD studies. Before I started my work I consulted him on possibilities of results. He has not published any results until this work was finished and therefore I cannot name specific results. However, he told me that he has got some preliminary results with tendencies visible. His statement strongly supported my belief that this method can be used successfully [Zimmermann et al., 2003].

His experiment differs mainly in terms of size and means, due to time limitations in my work. The experiments performed by his subjects las-

[2] http://www.mmi.ethz.ch/zim/

ted around 1.5 to 2 hours including a neutral and a non-neutral[3] mood induction. The subjects were first completing an online shopping task and reporting their mood by a self-assessment questionnaire. Then, as a control run, subjects saw a neutral video and had to complete the task and a mood assessment. After this, a specific mood was induced and the same procedure was made again. The subjects were also connected to biometric instruments collecting control data (respiration, pulse, skin conductance level and corrugator[4] activity) about the emotional state [Zimmermann et al., 2003].

5.2.2 Affective Computing

A group around Rosalind Picard and Jonathan Klein at the MIT is focussing on the topic affective computing and has produced several studies, reports and results, which can be seen as introductory reading into the field of affective computing.

Picard reasons about the motivation to research into affective computing [Trappl et al., 2003], about ethical questions of computers interacting with humans emotions [Picard, 1997] and presents different methods to estimate user emotions for the computer [Bushko, 2001]. She also recommends learning algorithms adopting to single persons [Picard and Klein, 2002] and presents a clustering system for labelling measurements and rating the quality of emotion estimation via a Hidden Markov Model (HMM).

In the paper "Frustrating the User on Purpose" Scheirer et al. [2001] present a method to recognise user frustration via mouse interaction. They distinguish four different patterns of users' reactions on frustration by measuring the number of clicks done in response to delayed computer response. The subjects were told to win a price, if they completed a task quickly. During the experiment network delays were simulated, which frustrated the users and evoked different clicking behaviours. This shows that it is possible to measure emotional states by mouse data. However, this result is very specialised and not yet a proof for a general method. It works for

[3]positive valence & high arousal; negative valence & high arousal; positive valence & low arousal; negative valence & low arousal. See Section 4.2.2 for more information on this model

[4]A muscle on the forehead.

identification of frustration in consequence of reaction-on-click delays, but it might need to be adapted to identify frustration in other situations. For example, another strategy is probably needed to detect users' irritation by a virtual assistant.

Another interesting work in the field of affective computing and the internal handling of user emotions comes from Aaron Sloman [Sloman, 2001]. He argues that even shallow models of emotions (like "sad", "surprised" but without backing of by a complex model) are useful for representing users' emotional states. He also presents other more complicated models for internal representation and processing that artificial intelligence (AI) can rely on.

5.2.3 Emotional Interaction with Machines

An experiment on emotional interaction and its influence on reaction time in interaction between machines and humans was conducted by Nass et al. [2005]. The study's target was to examine the influence of emotional communication on driving safety, and its insights might be used for navigation systems. The experiment was conducted in a driving simulator, where the subjects sat for around 20 minutes and heard 36 questions and comments by a voice from the car. The car voice asked questions like "How do you think that the car is performing?" and said things like "My favourite part of this drive is the lighthouse." in two different emotional states (energetic and subdued). When the driver's emotion (happy or upset) matched the car voice emotion, attention levels were higher, drivers spoke more and had less accidents. This study showed that matching emotional interaction (happy&energetic or upset&subdued) between humans and computers is less distracting and more welcome to humans. This is a clear motivation for further research to make the interaction with machines more fun and supportive.

5.2.4 User Pointing Input Analysis

In their work "Hierarchical Parsing and Recognition of Hand-Scetched Diagrams" [Kara and Stahovich, 2004] Kara and Stahovic analyse speed and movement directions. The aim of their work was to develop a system that is able to recognise informal sketches without restraining the user. They developed algorithms for recognition of different symbols and a trainable shape recogniser. The recognition works without the user having to choose the symbol to draw first, but by immediately drawing on the canvas. This makes it especially easy for beginners to start drawing without longer training beforehand.

This work provides some interesting ideas for recognition of speed minima and direction changes in movements. For example arrows have very distinct gestures that can be recognised by semantics (if the user's intention is known). This recognition via semantics was relevant for this work in order to recognise patterns in the mouse movements.

5.3 Summary

This chapter presented related research and named possible sources for further information for the interested reader. Some of these sources influenced this work, so is for example Fitts' law a reason, why the movement speed could be interesting. Especially when the movement targets small targets like radio buttons, this measure could be interesting. The KLM tells us, that each action is preceded by an acquisition phase, something that might be possible to spot in mouse movements. In contrast, the works by Zimmermann, Picard and Nass provide the general environment of this work and therefore describe motivation and similar problems and unresolved issues. Especially the works by Rosalind Picard can be emphasised as suitable introduction to affective computing but also as starting point for further considerations on ethical questions.

Chapter 6

Statement of Research Question and Hypotheses

The central part of this work is the hypothesis that user emotions can be measured by mouse movements. In this chapter, I will state it as a research question and derive the hypotheses for the experiment. Thereafter, I will deliver a supporting hypothesis, which is needed for answering the research question.

6.1 Research Question

Are there significant differences between the user's different emotional states in regard to the mouse movements used to control the computer?

To be able to answer this question, we first have to define our use of *"emotional state"* and *"mouse movements"*. In an effort to minimise the number of independent variables, I decided to choose the model of valence/arousal for classifying emotional states. As the variable of control about the feelings should always be external (the emotions are actively induced into the subjects), I decided to not consider the level of control in this experiment. This means that the emotional state is modelled by a pair of arousal and valence values. I decided to introduce a third variable called "other" as a collection for variables that might not be covered by the scales of valence and arousal. This leads to the independent variables of **arousal**, **valence** and **other** with the levels **high** and **low** for each. More details to these independant variables follow in Section 7.2.1.

Mouse movements are minute motor activity, since they do not require the user to move more than the arm holding the mouse, often even less. These movements have to be context-unaware, which means that they cannot be dependent on the application or the actual task. The reason for this requirement is the wish to create a system working universally with any computer, any operating system and any application. Therefore we cannot rely on absolute positioning or the knowledge about prior actions. We have to classify the movements by different characteristics to answer the research question. I use the term "characteristics" since they still need to be operationalised into measurable variables. I have used following characteristics to answer the research question (more details in Section 7.2.2):

Acceleration The accelerations of the movement intervals.

Precision The precision and efficiency of the movement.

Smoothness The smoothness and uniformity of the movement.

Speed The average speed of the movement.

6.2 Hypotheses

The research question and the defined measurements lead us to three main hypotheses for this work (Table 6.1). In the leftmost column there are the independent variables and the corresponding main hypotheses (H1, H2, H3). The topmost row shows the expected dependant movement characteristic (encoded a to d). The combination of the main hypotheses and the dependant variables results then in the set of hypotheses form H1a to H3d.

Each hypothesis named in Table 6.1 has a corresponding null-hypothesis, that claims that the independent variable does not affect the dependant variable. Representative for all 12 hypothesis-pairs, I will state the first pair:

IV \ DV	acceleration	precision	smoothness	speed
arousal	H1a	H1b	H1c	H1d
valence	H2a	H2b	H2c	H2d
other	H3a	H3b	H3c	H3d

Table 6.1: Hypotheses Overview:
The independent variables (IV) are on the left, the dependent variables (DV) are on top. Each hypothesis has a corresponding null-hypothesis.

H1a There is a significant difference between the user's arousal level in respect to minute motor movement acceleration that can be measured by the mouse.

H1a$_0$ There is no significant difference between the user's arousal level in respect to minute motor movement acceleration that can be measured by the mouse.

6.3 Supporting Hypothesis

In order to be able to test these hypotheses, one more supporting hypothesis is needed. For the test, we need the subjects to respond to different moods in different ways. So we first have to make sure that we can induce different moods into test subjects. This has to be verified before focusing on the main hypotheses.

H0 Test subjects can actively be induced significantly different emotional states.

H0$_0$ Test subjects cannot actively be induced significantly different emotional states.

6.4 Summary

In this chapter the work's hypotheses and the research question have been introduced and justified. The central idea is to estimate the user's affective state by the mouse motion. To quantify the affective state, the dimensions of valence, arousal and other (all that is not clearly valence or arousal) have been introduced. The null-hypotheses have been stated, just like the supportive hypothesis that claims the capability of influencing the test subjects' emotional state by showing videos.

Chapter 7

Experimental Method

For validating the previously stated hypotheses, an experiment was designed, implemented, executed and evaluated. This chapter explains the first three parts of it, the results will follow in the next chapter. First, I will explain the basic background of signal analysis needed for the calculation of movement characteristics. Then I will state the experimental variables (independent and dependent variables), explain them in detail and operationalise them by define ways of measurement. The third part describes the design of the experiment. Thereafter, I will focus on the implementation details. Finally, the execution and preparatory data manipulation is explained.

7.1 Movement Variable Calculation Background

The calculation of the movement values is a straight forward activity. The mouse tracking software stores pairs of x-/y-coordinates and a time-stamp as a representation of the mouse movements at any time (see Figure 7.1). This representation is called mouse tracks. These mouse tracks make it easy to calculate movement characteristics like movement speed or acceleration with the help of trigonometry.

7.1.1 Logging Interval

An important decision for the calculation of the movement characteristics is the logging interval. There are two possibilities to obtain log entries. The

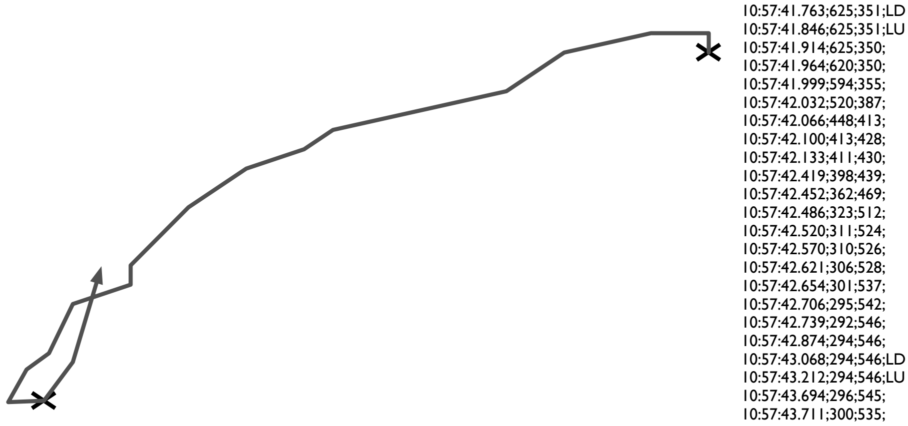


Figure 7.1: Schematised Mouse Tracks from the MouseTraX Log:
The line shows the mouse movement and is represented by the text lines.

first one is polling the mouse position every x seconds, resulting in a nice row of snapshots of what is going on. The second possibility is to log "on change" and create a log entry as soon as a mouse event happened.

The drawback of polling the mouse position is the high processor load needed for accurate logs. To get an appropriate picture of the user actions, polling every 10 milliseconds is required, because for example clickings last in average around 130 milliseconds. Such polling was measured on the experimental machine and resulted in a processor load of around 25%, which is far too high to be called unnoticeable for the user.

The second way of logging "on change"[1] leads to less processor load (around 1.5% on the testing machine). Furthermore, it leads to more precise mouse tracks, because entries are created, when the events really occur (with a measured delay of up to 5 milliseconds). The drawback of this method is that it is hard to define, when the mouse movement ceased. In contrast to the polling interval, we cannot find any zero values for the speed, since each logging entry differs from its predecessor and its successor.

A third approach is a combination of the polling- and the on-change-approach, that logs all events and also regularly polls if no events happen.

[1] On every event like "mouse button down", "mouse button up" or "mouse moved", a log entry is generated with the event type, mouse location and time-stamp.

This approach has the problem of blowing up the logs with redundant data.

7.1.2 Semantic Processing of Movements

Semantic processing of movements stands for the interpretation of the mouse tracks. The events ("mouse up", "mouse down", etc.) can clearly be recognised since this information is contained in the log file. The information, if the user stopped moving the mouse or only moves it at low speed, represents a problem when on-change-logging is used. Three options for semantic processing are available to solve this problem.

First, mouse movements can be regarded as one continuos movement, since the mouse never stops, at least according to the log entries. For the calculation of values depending on the movement in the previous interval, this model brings advantages, because valid and non-zero values are available for each interval. However, this model is *not* totally precise, as the user in reality might have stopped, with the mouse tracks claiming low speed.

The second model defines movements below a certain threshold speed as movement stops. This model still has the problem of not recognising *all* movement stops, but it recognises a good part of them. If we keep in mind, that we should have a log entry as soon as the mouse moved one pixel further, we can assume that we got a new log entry before the speed fell below threshold speed. This results in a better semantical analysis of the movement. Unfortunately, at this time no proven values for a useful threshold speed can be found. Still, this threshold does not seem to be critical as long as a reasonable value is chosen. Defining a too small threshold value results in false "movement stops", defining a too high one results in fewer movement stops than really occurred. If this is regarded as a critical problem, more research should be done.

Third, direction changes can be regarded as breaks in the movement. Smaller direction changes often occur, when the user draws the mouse imprecisely. Bigger changes occur by such imprecise movements, too, but they more likely represent a change of mind. If the user decides in the middle of a movement to head for another target, a break can occur. For this reason, a good threshold value can help to identify such breaks. Obviously, angles more than 90 degrees represent a change of direction, but what about changes of 45 degrees? As for the threshold for movement speed, no already-defined value was found. Also this value is not critical as long as chosen within reasonable bounds (0 - 90 degrees). If chosen too low, more breaks are interpreted into the movement than there really were, if chosen too high, less breaks are recognised.

7.2 Operationalisation and Definition of Variables

From the research question and the hypotheses we can easily derive the set of independent variables (arousal, valence, other) and dependent variables (movement acceleration/deceleration, precision, smoothness, speed) for the experiment. Let us have a more detailed look at them.

7.2.1 Independent Variable Operationalisation

I will use the term "independent variables" for the variables of "valence", "arousal" and "other" to prevent confusion. I am aware that these variables are not independent in H0, the supportive hypothesis. However, for the main hypotheses these variables are the independent variables and calling them independent throughout the work avoids changing names.

Independent Variable: Arousal

Arousal (ARO) is a measure for one's emotional excitement. High arousal indicates anger or happiness, low arousal indicates sadness or comfort.

Independent Variable: Valence

Valence (VAL) is a measure for the subjective way, how an emotion is felt. A positive valence (dummy-coded "high") stands for happiness or comfort, a negative valence (dummy-coded "low") stands for anger or sadness.

Independent Variable: Other

The variables of valence and arousal do not cover all basic emotions, therefore some other variables and combination of valence and arousal should also be used. There are three operators this independent variable, one of these is the level of disgust (*DIS*) with the levels low (delighted) and high (disgusted). Combinations of the valence/arousal scales can also be used as independant operators. The first combination (*VA1*) is positive valence and high arousal (joy) compared to negative valence and low arousal (sadness). The second one (*VA2*) is the combination of the opposites (angry vs. pleased).

7.2.2 Dependent Variable Operationalisation

There are no predefined and explicit ways to measure these variables, so I searched and chose ways to calculate them. Since possible correlation between the calculated movement characteristics were not known before the experiment, I decided to calculate as many characteristics as possible and then to analyse their relations in case of interesting results. Therefore, one dependent variable might then be represented by one or more operators (calculated values). One aim for the defined variables was to rely as little as possible on threshold values (since no values from experience were available) and to try to end up with clear and closed intervals for the variables.

Dependent Variable: Acceleration

Movement acceleration is a characteristic tightly connected with the speed of movements. It can be operationalised into movement acceleration (MA) and movement deceleration (MD). Faster acceleration or stronger deceleration might indicate higher confidence in one's own movement precision and faster muscle activity.

The calculation is done by using the acceleration formula (7.1) to calculate the acceleration at any position. From these values the average acceleration can be calculated.

$$a = \frac{v_1 - v_0}{t} \tag{7.1}$$

a	acceleration
v_1	end velocity
v_0	initial velocity
t	time interval

The total acceleration between two stops always sums up to zero, since the start and end speed both equal zero. The way to circumvent this problem is to split the values and calculate an average acceleration and an average deceleration. This results in the two operators MA (movement acceleration) and MD (movement deceleration), shown in formulae 7.2 and 7.3 with the ranges $0 < \text{MA,MD} < \infty$ where a lower value stands for less acceleration/deceleration.

$$MA = \frac{\sum_{i=0}^{n} a_i^+}{n} \tag{7.2}$$

$$MD = \frac{\sum_{i=0}^{n} a_i^-}{n} \tag{7.3}$$

a_i^+	actual acceleration
a_i^-	actual deceleration
n	number of intervals

Dependent Variable: Precision

Movement precision is tightly related to the movement efficiency. The more precise a movement is, the more efficient it can be. This means that efficiency requires precision, but not the other way round. A user may move the mouse precisely but totally inefficiently. This means that a discrepancy between precision and efficiency might be an indicator for the user's intentions.

The precision of a movement can be influenced by the attention, the level of focus on a task and the tiredness. So might anger result in an other movement precision than the feeling of contentedness. The efficiency of a movement may indicate if the user is in a hurry (and uses the mouse efficiently) or on the contrary is relaxed and does not care about extra mileage.

The precision of the mouse interaction can be operationalised in different ways. I chose two definitions (shown in Figure 7.2): The user makes precise movements, if the ratio of clicks performed to the clicks needed to hit a target is low (CN), or the precision is high, when targets are hit directly without moving beyond (ON). Both values relate to Fitts' law, assuming that the user does not focus on precision and therefore moves the mouse in a normal manner.

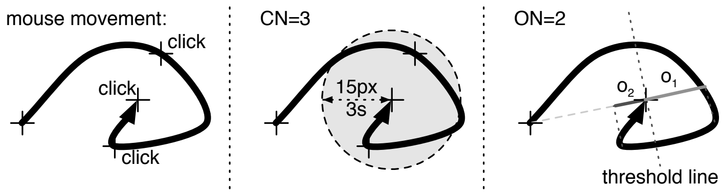


Figure 7.2: Movement Precision:
The leftmost parts shows the user's real movement and clicks. The second image shows CN, the collection of all clicks that are within time and space range (15 pixel and 3 seconds in this case). The third part shows the transformation into one-dimensional movement and counting of overshots (ON).

Click Number To calculate the click number (CN) used to produce one useful click, all log entries are searched for clicks lying near each other. This proximity is fulfilled, if two requirements are met: Proximity by time and proximity by geometry. There was no useful information about how to choose these values, because they also depend on the experiment design. This means that they have to be defined, when the experiment is planned. The click number resides in a range from 1 to infinity, less clicks standing for higher precision.

Overshot Number The calculation of the overshot number (ON) requires a transformation of the two-dimensional mouse movement into a one-dimensional movement along the axis of the ideal movement (see Figure 7.2). From this one-dimensional movement it is then a simple task to count the number of times, when the mouse was moved over the target and its threshold line[2]. The ideal value of highest precision is zero, the highest unlimited.

The efficiency of movement can be operationalised and measured in different ways, from which I chose three (shown in Figure 7.3): First, the relation between the real movement distance to the ideal movement distance (ME). Second, the target-orientedness of the movement (MT) and third, the maximum distance moved too far over the target (OL).

[2]The threshold line is a line going through the endpoint lying perpendicular to the start-end connection line).

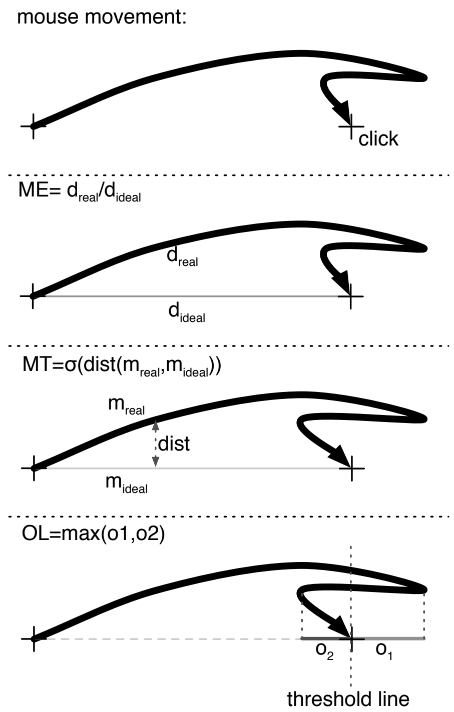


Figure 7.3: Movement Efficiency:
The topmost part shows the real movement and clicking behaviour, the second shows how the mouse efficiency (ME) is measured. The third part shows the calculation of the movement targeting (MT) by calculation of the standard deviation between the real movement and the ideal movement. The fourth part shows the transformation into a one-dimensional movement and then the measurement of the maximum overshot (OL).

Movement Efficiency Movement efficiency of a mouse track is calculated by the difference between the direct (ideal) and the real movement length. This results (formula 7.4) in the value of ME (movement efficiency) in the range $1 \leq \text{ME} < \infty$ with a result of one meaning perfect efficiency.

$$ME = \frac{\sum_{i=1}^{n}\sqrt{(x_i - x_{i-1})^2 + (y_i - y_{i-1})^2}}{\sqrt{(x_n - x_0)^2 + (y_n - y_0)^2}} \tag{7.4}$$

x_i x-coordinate at the position i
y_i y-coordinate at the position i
n number of intervals

Movement Targeting The target-orientedness of a movement (MT) can be calculated by different means. Possibilities of calculation (see Figure 7.4) range from covered area (if a square is laid around the movement), the covered angle of the movement (measured from the start point) or the width of the movement corridor. All these methods describe a movement, but are neither unambiguous nor really characteristic. A more characteristic method is the calculation of the standard deviation of the movement from the ideal (average) movement (see Figure 7.3). The big drawback of this calculation is that inefficiency in the dimension of movement (e.g. the user starts off 180° into the wrong direction) is not covered by it, but by the variable of ME. The range of MT is $0 \leq \text{MT} < \infty$ and the lower the value is, the more efficient was the mouse moved on the direct connection.

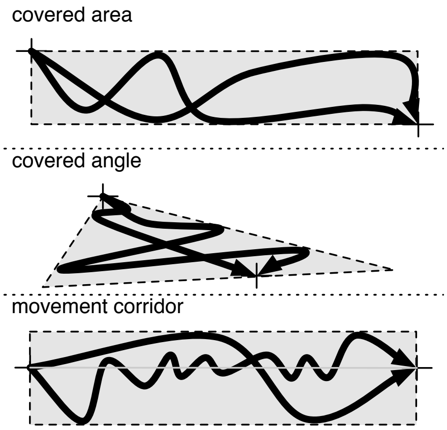


Figure 7.4: Movement Targeting Ideas:
Here we can see the problems of the ambiguity and the non-characteristicness of the different ways to calculate the movement targeting. The first method fits the movement into a square (whereof the area can be calculated), the second one measures the angle needed to cover the movement from the start point. The third method calculates a movement corridor along the movement direction. All these methods are not unambiguous, like the images show.

Overshot Length The overshot length (OL) can be calculated by transforming the mouse movement into an one-dimensional movement and then searching the maximum distance moved too far over the target, called the target overshot (see Figure 7.3). This distance can be calculated via distance formula (7.5) between the current point and the threshold-line (see Figure 7.3).

$$dist(p, l) = \frac{(a \cdot x_i + b \cdot y_i + c)}{\sqrt{a^2 + b^2}} \tag{7.5}$$

p	the point, defined as $p = (x_i \vert y_i)$
l	the line, defined as $l : ax + by = c$

For this calculation it is important, that the initial distance must not be regarded as overshot. The measurement of overshots starts when the mouse moved the first time over the threshold-line. The reason for choosing the maximum instead of the average overshot is that the values between different movements differ more when the maximum and not the average is used. The range of OL (seen in formula 7.6) is $0 < \text{OL} < \infty$. The best score is zero, which stands for hitting the target directly.

$$OL = Max_{i=j}^{n}(dist(p_i, t)) \tag{7.6}$$

p_i	point at index i
j	index, where the threshold-line is first crossed
n	number of intervals
t	threshold-line; line through the movement end point perpendicular to the start-end connection line
$dist(p, l)$	distance function (formula 7.5)
$Max_{i=a}^{b}(x_i)$	maximum function $\forall x_i \vert a \leq i \leq b$

Dependent Variable: Smoothness

The smoothness and uniformity of the movement are other possible indicators for the emotional state. If a person is indecisive, she might stop in the movement, reconsider and change direction. The uniformity of a movement might be influenced by the arousal. We can imagine, that a low arousal might produce a more uniform movement than high arousal does. Movement smoothness is operationalised by the number of movement breaks (MB), the uniformity (MU) by standard deviation from the average speed.

Movement Breaks To calculate the number of breaks in a movement (MB), we first have to define "a movement". This definition's problem arises from the impossibility of knowing the intention of the user. If we encounter a movement break[3] in the mouse tracks, we can only assume a mental change of task[4] if this movement break was a click. If it only was a stop within a longer movement, it could have occurred because the user had to re-place the mouse when getting out of range, because the user was reconsidering which choice to go for, or the user changed the task. Even a click is no final prove for such a change of task, since it might occur accidentally or might be a imprecise click. Still, to define a movement as the action between two clicks is the only reasonable possibility. The calculation itself is then straight-foreward by counting the breaks in a click-to-click mouse track. The range of this variable lies in $0 \leq \text{MB} < \infty$, where 0 stands for the movement not containing any breaks.

Movement Uniformity The uniformity of a movement measures how much the speed within a movement varies between intervals. The value is therefore nearly related to the average speed and the acceleration of a movement. The measurement of this value can be done by calculating the standard deviation of the speed. The calculation of MU can be seen in formula 7.7 and the values of MU will lie in the range $0 \leq \text{MU} < \infty$. The lower this value is, the more uniform a movement was.

$$MU = \sqrt{\frac{\sum_{i=1}^{n}(v_i - \overline{v})^2}{n}} \tag{7.7}$$

v_i	speed at interval i
$\overline{v}$	average speed
n	number of intervals

Dependent Variable: Speed

A typical characteristic for a movement is its (average) speed. For mouse movements and actions we can define two simple measures for movement

[3] Movement breaks are all movements below a certain threshold speed, all movements turning over a certain angle and all clicks.

[4] The situation, when the user completed one task (like selecting a word, pressing a button, etc.) and acquires a new task. See the section about KLM (5.1.4) for more information.

speed. The first operator is the average speed of movement (MS), the second one is the duration of clicks (CD). They might give a hint about the user's arousal. A sad person might be moving the mouse slower than an angry (or busy) person; same might apply for tiredness.

Clicking Duration The clicking duration (CD) can easily be calculated as the time difference between the mouse-down and the mouse-up event. This variable ranges between 0 and ∞. Higher values indicate that the user pressed the mouse button for a longer time.

Movement Speed The average movement speed (MS) is also a rather simple calculation (formula 7.8), where we divide the total mileage by the time needed for it. This results in a value between 0 and ∞ representing the speed of the mouse motion.

$$MS = \frac{\sum_{i=1}^{n} v_i}{n} \tag{7.8}$$

v_i	speed at interval i
$\overline{v}$	average speed
n	number of intervals

7.3 Experimental Design

After the dependent and independent variables have been operationalised and ways of measurement have been defined, it is time to look at the test design used for validation of the hypotheses.

7.3.1 Experimental Structure

The basic structure of the experiment is simple: Evaluate the affective state of the test subject and try to statistically relate it with her mouse movements. The first structuring decision was, that the affective state of the subjects should be induced, instead of relying on whatever emotional state test subject is in when arriving at the experiment.

One main problem of the experiment was to create a short experiment, since I had to rely on voluntary testers and could not provide any remuneration (except of a symbolic chocolate bar). Another central point was that at least some part of the experiment had to be done at a computer for the obvious reason that the mouse movements needed to be recorded. One possibility here would have been to use a task like Zimmermann used in his work [Zimmermann et al., 2003], for example using a web-mail interface, and to induce different emotions via sound, pop-up images or blinking backgrounds. As this approach would need too much time, I decided only to make an online questionnaire (so that the mouse movements can be logged) and to induce the moods between the different parts by videos. This led to the decision to control all affective states the subjects reach during the experiment. Extreme emotions should be neutralised in the beginning.

Independent Variable Manipulation

The next decision was that only two affective states with a big contrast should be induced. This means that if one state has low arousal, the other one has to have high arousal; same applies on valence. The first idea was to focus on anger and contentedness. The reason is that anger is easy to spot by biometric tools [Healey and Picard, 1998] and therefore maybe also might be easier to spot by movements. Healey argued that high vs. low arousal is easy to recognise, but a difference in valence scale is harder to find. A limitation for this idea came from a paper by Gross and Levenson [Gross and Levenson, 1995]. In their paper focussing on emotion elicitation by films, they argue that it is fairly easy to induce the emotions of amusement, disgust and sadness, but that the emotion of anger is rather hard to induce to reach a certain intensity.

This lead to the decision that the videos should try to induce happiness (high arousal/positive valence) and sadness (low arousal/negative valence), as only affective states after the neutral state. The groups should be equally split so that half of the subjects start with the negative video, the other half with the positive one.

Experimental Layout

In order to receive enough test subjects and test data, I decided to use a cross-over design with one group being induced at first happiness and then sadness, the other group should get the opposite treatment. A main reason for this procedure was to alleviate a learning, effect which could come into play when subjects get used to the testing system and the movements. To familiarise the test subjects with the system, they should get some questions (age, gender, experience, etc.) in a neutral state before the real test. The layout of the experiment can be seen in Figure 7.5.

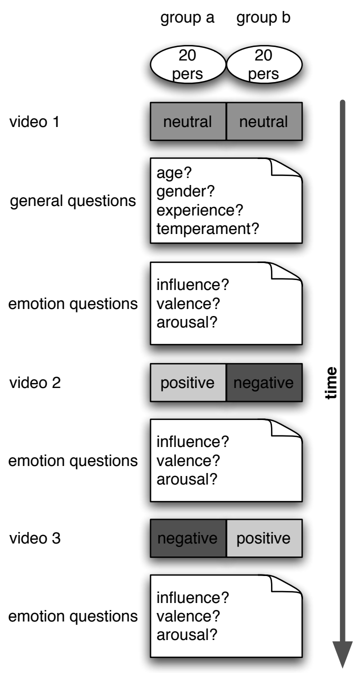


Figure 7.5: Experimental Layout:
The experiment (proceeding from top to the bottom) had two groups with 20 subjects each, cross-over design. First all subjects are tried to be neutralised in case of being in extreme moods when starting the experiment. Thereafter, some general self-assessment questions were asked. Then two blocks with video and self-assessment had to be completed.

Since every test subject was induced into both states, a number of 40 test persons was regarded as sufficient for the test. This was mainly because of difficulties to find test persons, when no real remuneration can be granted. Still, 40 sets of data provide a good first glimpse on what could be possible. The distribution to the treatment was by a pseudo-random number generator running in the background. It was limited to balance the groups to end up with 20 persons in each group. The subjects should, when doing the test, not be aware that the mouse movements are logged. They were therefore told that the test is about estimation of emotional impact by different media items and that they were chosen to estimate the effect of videos. After the experiment, before choosing if they want to submit their data, they then were informed about the real intention of the experiment.

The questions in the questionnaire (which can be found in Appendix A) were used for self-assessment by the subjects. They would cover the different dimensions of the emotional state and also control, if the videos had their expected impact on the test persons. In order to avoid learning effects, the movements between answers and navigation had to be non-repetitive.

7.4 Experiment Implementation

The experiment was implemented as a Java[5] web-application running on a Resin web server[6] on a 12" G4 867MHz Apple PowerBook. The test subjects used Safari[7] to access the webapp questionnaire. There were a couple of advantages for this set-up: First of all, it relied on the available systems and enabled the whole experiment to be done in one single session, by placing the subjects at the machine, without extra questionnaires and interrogations. Furthermore, this system was totally portable, because also the webserver ran on it. This fact made it easier to find test persons and ensured that no frustrating delays occurred. The web application took care of the random assignment of the test persons into the appropriate groups. It also logged the clicks from the experiment, mostly as control data to ensure that the measurement was exact and to crop the experimental data from the total mouse-tracking data.

[5]http://www.java.com
[6]http://www.caucho.com/
[7]Apples standard web browser for OS X.

To elicit the emotional states, three videos were used. The first and neutral one was self-made, lasted 37 seconds and showed the iTunes-Visualizer with Vanessa Mae's song "I'm a Doun". The intention of this video was to neutralise test subjects, so that extreme emotions were damped before the experiment started. The negative video showed a 42 seconds scene from the film "Ice Age"[8] provoking the emotion of sadness, because it shows the loss of dear ones. The positive video was a 67 second scene from a "Wallace and Gromit" short film[9] and should evoke joy and happiness. A major problem was to find short films that evoke emotions without long introduction to the scene.

7.4.1 Independent Variable Measurement

To even out possible problems of ineffective films, I decided to pose the emotional questions reflexive to the prior emotional state. As an example, the self-assessment questions looked like "The media item made me feel ... than before. (Sadder: 1 - Happier: 7)". This should ensure that even small influences by the video should be reported. How precise the subjects finally answered this question is not clear.

The measurement of all these independent variables (ARO, VAL and OTHER) happened in scale with seven ordered levels. According to Morgan et al. [2004] this amount of levels enables us to assume a normal distribution.

7.4.2 Questionnaire Page Layout

To ensure that the subjects read the questions carefully and that no learning effects occured in the mouse movement, all items that should be clicked (like answers or navigation) were distributed randomly in the questionnaire window. The web page was sized small enough to ensure that no scrolling was needed and that the whole navigation was possible by point-and-click. It was split into four different sections (see Figure 7.6).

[8]The scene, where the mammoth sees the caveman paintings of the mammoth family with a young mammoth. Around minute 50 in the film.

[9]Found on "Wallace and Gromit: Cracking Contraptions", called "The Tellyscope".

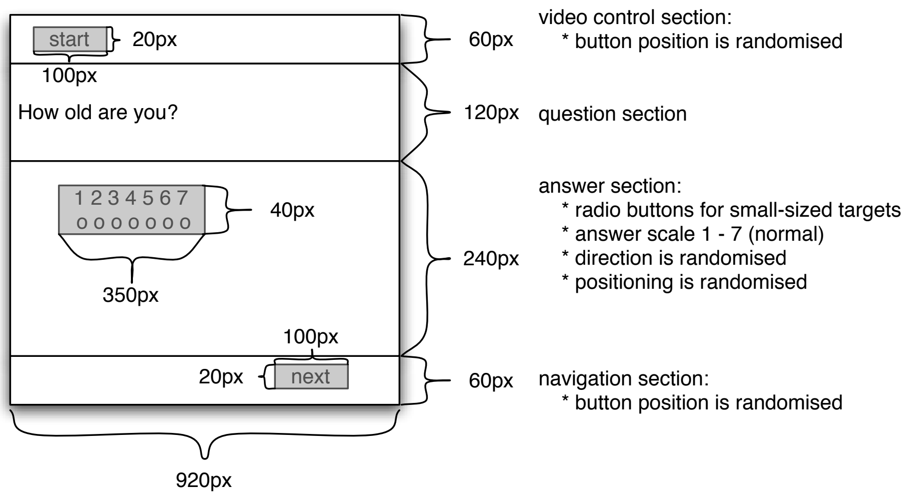


Figure 7.6: Questionnaire Page Layout:
The video section is just used, when videos have to be shown, the question and answer sections are only visible on question pages.

The items on the pages were intended to be big enough to be comfortable but still small enough to require precision when clicking. For this reason radio buttons were used for the answers instead of standard links. According to Fitts' law this makes it harder to hit them directly from long distances and makes movements on them slower.

Video Detection A key issue in the evaluation of the mouse movements was to split the mouse tracks when a new mood was induced to prevent erroneous calculation results. Since there was no direct communication channel between the testing webapp and the tracking software, this had to be solved by indirect communication. The difficulty comes from the possibility that subjects move the windows in use, which then would leave the problem of not normalised raw data. For this reason, the topmost section of questionnaire pages was dedicated to video-navigation. The only times the user was supposed to click into this area, was to start a video. This could not be restricted, but when looking at the result data, users did not click there in other situations. This means that the splitting of the mouse tracks was easily done by searching clicks in the top region on the y-axis. This worked even though both clicking logs were not synchronised on possible window displacements.

Directed Movement Detection For some movement characteristics it is essential, that the person has a clear target when performing the movement. For example, it does not make sense to calculate the movement targeting if the user does not have a clear target. The problem with a questionnaire is that the person answering might be insecure about the answer and reconsider while moving the mouse to one answer. This would result in unrepresentative data. The only movements we can assume that the user has a clear target before the movement, are the movements not clicking on answers. As there was always only one possibility for the next action, all navigation movements should have been clearly targeted. For this reason, the general navigation got an own dedicated area at the bottom of the window. Unfailingly directed movements could easily be spotted in the tracking data by the area where they ended, while navigation and answers could still be pseudo-randomly distributed.

7.5 Experiment Execution

The experiment was executed on campus of Chalmers TH, test subjects were mainly students but also employees on campus. This means that the sample is not representative for general population, because computer expertise and age distributions are not representative. However, this is seen as a work for a proof of concept, where it is important to show, that the execution is possible in general.

The used mouse was an optical two-button-and-scroll-wheel mouse. The scroll-wheel was not used in the experiment. Additionally, there was no mouse acceleration, so that the logging data represented the users' full movements. However, the surface, where the mouse was moved on, was different in the experiments. This disturbing factor was considered by a question in the questionnaire. The experiments were done in different places, but no relevant problems occurred. The experiment log can be found in the appendix, Section B.1).

The procedure of the experiment was as follows: People were approached with the question for help in a scientific study containing emotions and processing. The subjects were told that the experiment took around 10 minutes and did not contain anything really scary. Further they were told that the intention of the experiment was to measure the emotional influence of different media types and that they should rate videos. After completing the experiment, each subject was explained the real intention of the experiment and given the possibility to throw away the test data, if they did not agree on the real terms. All test persons agreed and therefore got a chocolate bar and had the chance to win a dinner for two. After all 40 experiments were completed, this voucher was given to a random test subject.

7.6 Experimental Data Preprocessing

After the experiment, the tracking data was cropped so that only relevant data from the experiment was used. After this, it was verified to be semantically correct. One data set was found, where the user illegally applied the back-button of the browser. This data set was dropped from further processing, because the mouse tracks were scrambled.

For the calculation of dependant variables some parameters were undefined. These parameters were calculation interval, semantic processing and other limitations to the dependent variables.

7.6.1 Calculation Interval

When taking the decision about the logging interval (see Section 7.1.1) in favour of the logging on-change approach, the main reason was that the application should be unnoticeable. If we remember, the logging of the mouse position by polling required much more processor performance. The second reason for choosing logging on change was its finer resolution of events with a minimum of log entries.

7.6.2 Semantic Processing

The way to do semantic processing (see Section 7.1.2) was a combination of splitting movements by threshold speed and threshold angle. I decided so because of viewing the whole tracking data as just one big movement is too inaccurate. When the threshold values are used, at least some stops can be recognised. Some false positives are still better than not recognising any breaks at all.

The value for the threshold speed was defined as *2 pixels per second*. The reason for this value was that I decided to regard log intervals longer than reaction time as breaks in the movement. Since the reaction time varies from person to person and between different states, the half of the average reaction time[10] can be taken as a good minimum time. As theoretically each pixel length moved should be logged, we get a threshold speed of two pixels per second. Like already mentioned before, I did not regard this value as critical; that is why it was chosen deliberately.

The threshold angle was defined as *45 degrees*, a direction change that still seems to mark a change of intention. If the mouse is not moved precisely on a surface, if it has sensor problems, is unclean or has an oscillation along the movement direction might occur. This would result in many wrongly interpreted movement breaks. To prevent this, the movement co-ordinates were smoothed by an average filter (window size 3) before beinging split by movement angles. As a result of this smoothing, the threshold angle is in reality even more than 45 degrees.

7.6.3 Variable Limitations

Limitations apply for the calculation of some of the previously stated dependent variables. First, I have to state that I assumed that no dragging occurred in the movements. Since dragging means different muscle tension it could result in different movement values. Second, some calculations needed limitations on the movement data.

[10]Average reaction time is around one second.

Clicking Aggregation

Imprecise clicks had to be aggregated to calculate the variable of clicking number (CN). From the design of the experiment it was not a time critical application, and so the time threshold for consecutive clicks could be chosen high enough and was defined as *three seconds*. The second criteria of geometric proximity can be deviated from the questionnaire layout. In Figure 7.6, we can see that the nearest two clickable items ever get is 20 pixels, which is between answer radio button and "next" button. Therefore, the proximity threshold was defined with *15 pixels*. We have to keep in mind that two clicks were only then combined into one clicking action, when they were adjoint and within both threshold values.

Movement Direction

Some movement variables require a movement, where the test subject has a clear target since the beginning of the movement. These movements I refer to as "targeted movements". An example for such a move is the movement from the definitive answer to the navigation. In this questionnaire the only movements where we can be sure that the subject did not change her mind during the movement are the ones ending with a click on a navigation button. These occur after the definite answer and can easily be recognised by the movement end in the navigation section.

For the variables (movement breaks MB, overshot number ON and overshot length OL) it is nonsense to calculate them on movements, where the subject changed her mind. Even if they could be used as a sign of indecisiveness, so is the influence on the end value is too big for even a small change. OL is the maximum overshot length and moving the mouse into the wrong direction would result in an inappropriately high. Indecisiveness could also influence other variables (MT, MS, etc.), and therefore this limitation was imposed hoping that movement precision can be calculated more accurately.

7.6.4 Data Processing

After all the parameters were defined the data could be processed. This processing consisted out of two parts and was done by python scripts (see documentation in Appendix C). First, the data was split at the positions of the videos.

The splitting of the mouse tracks was important for the statistical analysis, as the different emotional states should be compared. The video controls had a distinct position (see 7.6) that could easily be found in the tracks. Splitting along those positions resulted in three chunks of data that only had to be labelled according to the experiment direction for that person (positive-first or negative-first).

Then the movement characteristics for each relevant movement were calculated. Finally, the average values for these movement characteristics were calculated for each of the three parts of each test person.

7.7 Summary

In this chapter, the experimental method was explained and the different variables were derived into operators for the measurement. The three independent variables (IV) are represented by five operators (ARO, VAL, DIS, VA1, VA2). The four dependent variables have been operationalised into eleven movement values (CD, CN, MA, MB, MD, ME, MS, MT, MU, OL, ON). This listing can be seen in Table 7.1. The experimental crossover design with 20 persons in either group was explained, along with the test course of three different videos (negative, neutral, positive) and self-assessment after each video. The processing of the data was explained from the initial cropping over the semantic processing, where movements are split by breaks of speed or angle and where clicks are aggregated, to the calculation of the operators.

variable	operator	type	min	max	comment
independent variables					
arousal	ARO	normal	1	7	reflexive question
valence	VAL	normal	1	7	reflexive question
other	DIS[a]	normal	1	7	reflexive question
”	VA1[b]	normal	1	7	absolute question
”	VA2[c]	normal	1	7	reflexive question
dependent variables					
acceleration	MA	normal	$0 <$	$< \infty$	
”	MD	normal	$0 <$	$< \infty$	
precision	CN	normal	1	$< \infty$	
”	ON	normal	0	$< \infty$	targeted movements
”	ME	normal	1	$< \infty$	
”	MT	normal	0	$< \infty$	
”	OL	normal	0	$< \infty$	targeted movements
smoothness	MB	normal	0	$< \infty$	targeted movements
”	MU	normal	0	$< \infty$	
speed	CD	normal	$0 <$	$< \infty$	
”	MS	normal	$0 <$	$< \infty$	

Table 7.1: Experiment Variables and Operators.

Note. Targeted movements are all those movements where we can expect the test subject to have a clear target since the beginning of the movement. These are all movements to the ”next” button in the navigation section, right after the definite answer to a question was clicked.

[a] delight vs. disgust

[b] positive valence/high arousal (joy) vs. negative valence/low arousal (sadness)

[c] negative valence/high arousal (anger) vs. positive valence/low arousal (content)

Chapter 8

Experimental Results

This chapter presents the statistical analysis of the experimental data. The results were received in three statistical procedures. First, some descriptive statistics about the test sample will be shown. Second, the supportive hypothesis will be analysed and results are presented with the answer, if the videos were capable of manipulating the test subjects' emotional state. Third, I will present the results for the question, if there is a significant difference in mouse movements for different emotions. Finally, one more analysis between the low arousal film and the high arousal film is made. The complete tables with the raw data can be found in the appendix (Appendix B).

In Figure 8.1 we can see the first three different tools used. The first statistical tool is a one-way ANOVA used to show differences in the means of the variables with the films as the independent variable. The first t-Test is used to compare the changes of mouse motion variables within a person to see if the personal reactions on different affective states correlate. The second t-Test compares then the means of the different emotional states with the means of the other group.The fourth tool is hard to schematise as it bases on the surveillance of the first analysis.

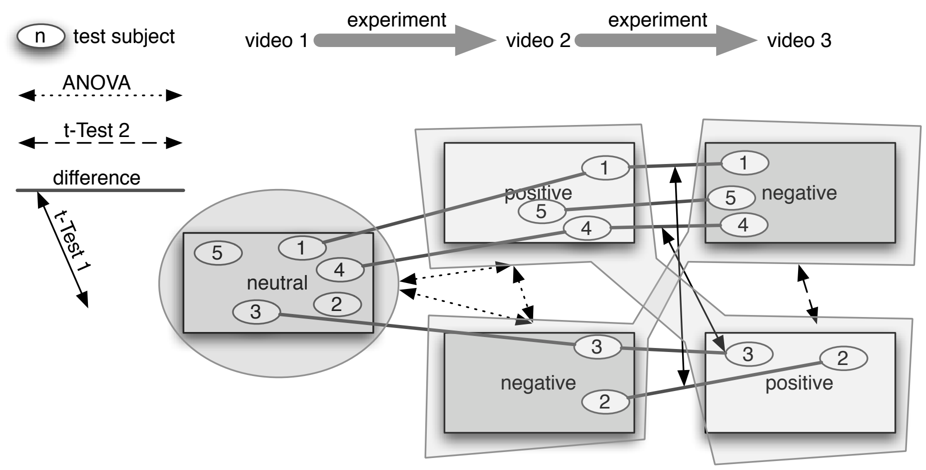


Figure 8.1: Statistical Analyses:
The different arrows show the different analyses. The ANOVA compares the means by film as independent variable. The first t-Test compares the differences of movement characteristics with the differences in affective states as independent variables, the second t-Test compares the groups of different emotional states directly with each other.

8.1 Descriptive Statistics

In total, 40 persons completed the experiment, whereof 39 data sets were usable (N = 39). Due to a mistake in the distribution algorithm, these 39 persons were split into two groups with $N_{negativefirst} = 22$ and $N_{positivefirst} = 17$ for the cross-over design. From these 39 persons were 17 female and 22 male and the average age (M_{age}) was within the range of 20 to 25 years. The histogram for M_{age} can be seen in Figure 8.2. The other descriptive values were all measured on a scale from 1 to 7 and the coding of the values can be found in the appendix, Section A.2. With an average computer expertise of $M_{exp} = 5.8205$ (7 standing for "using the computer all the time") and a feeling of being in control of the computer of $M_{con} = 5.1026$ (7 is "always in control"), the sample was also rather experienced in terms of computer use (fig. 8.2). We can also see that the general temperament of the test persons was quite normally distributed around the average value of M_{tem} =3.4615. To the question, if the subjects usually get frustrated by the system they use, the answers were quite normally distributed with a mean value of M_{fru}

= 3.6410. To the question, if the subjects preferred to communicate with a computer instead of humans, the average of M_{gee} = 2.1795 showed that most still prefer interacting with people.

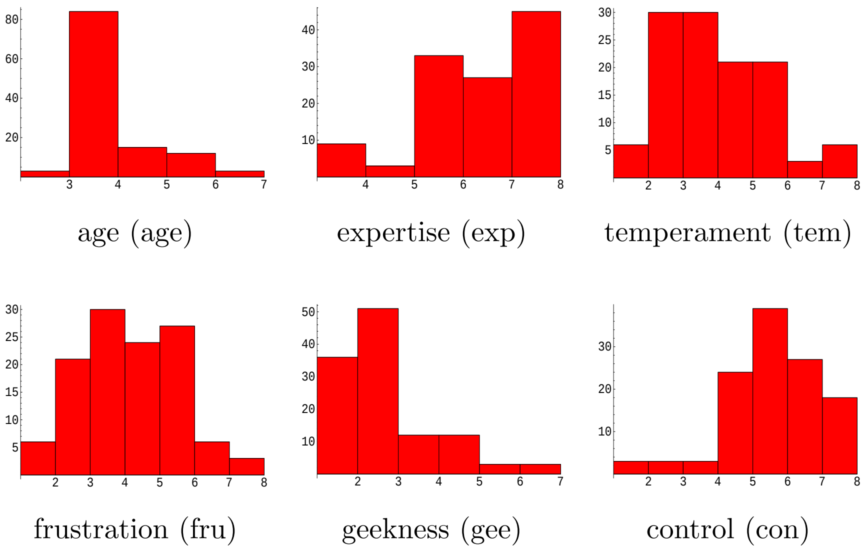
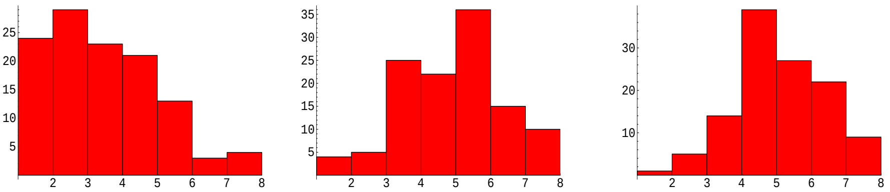


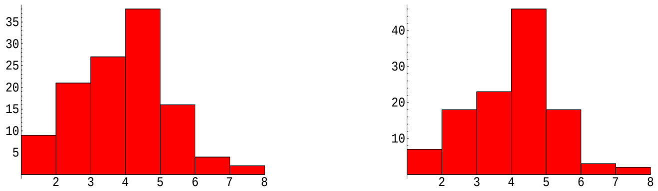
Figure 8.2: Descriptive General Statistics:
The histograms for the variables age, experience, temperament, frustration, geekness and control. Scales were with levels from 1 (bar between 1 and 2) to 7 (bar between 7 and 8). Levels with no occurrence were dropped in the histograms.

In the self-assessment part of the questionnaire the questions about the emotional state (see Appendix A, Section A.3) were asked with a scale of 1 to 7. The histograms can be seen in Figure 8.2. Here we see that the overall emotional state of the subjects seemed to be skewed towards "feeling great" with a mean value of M_{VA1} = 2.9573. The impact on the valence scale was quite normally distributed, with a light skewing towards "feeling happier" after seeing the films (M_{VAL}) = 4.4188. In the question about feeling angrier, the answers were normally distributed and had a mean value of M_{VA2} = 4.6068 (with 7 representing "more pleased"). In the question about disgust the answers were normally distributed with a mean value of M_{DIS} = 3.4359. The question for arousal received answers with a mean value of M_{ARO} = 3.5727 and a normal distribution.

Between these self-assessment questions, also some control questions about the environment and effects of the films were asked with a dicho-



great vs. bad (VA1)   sad vs. happy (VAL)   angry vs. pleased (VA2)



delighted vs. disgusted (DIS)   relaxed vs. excited (ARO)

Figure 8.3: Descriptive Statistics Self-Assessment:
The histograms for the variables of valence, arousal, disgust and the two valence/arousal combinations. The scales were from 1 to 7.

tomous scale ("yes" coded as 1 and "no" coded as 0). To the question, if the environment or the questionnaire irritates the subjects, the mean values of $M_{env} = 0.2393$ (environment) and $M_{irr} = 0.1026$ (questionnaire) show that they did not feel irritated. Also the questions about the questionnaire distracting the test subjects ($M_{dist} = 0.2735$) and feeling comfortable ($M_{com} = 0.8803$) show that the subjects felt comfortable doing the test. The average of $M_{val2} = 0.4615$ to the question about the subjects feeling neither happy nor sad shows that slightly more people felt in a non-neutral emotional state. To the questions about the videos influencing the subjects the values of $M_{in1} = 0.2650$ ("The media item did not influence me at all") and $M_{in2} = 0.7521$ ("The media item managed to influence my emotional state.") show that the subjects were aware of the effects of the videos.

Finally, the calculated mouse values were analysed. The histograms can be seen in Figure 8.4. Most of the values show a Poisson distribution. The average clicking number was $M_{CN} = 1.0907$ with an average duration of $M_{CD} = 132.514$ per click. The average movement acceleration was $M_{MA} = 0.0141$ with a deceleration mean of $M_{MD} = 0.0055$ pixels per square millisecond. The average speed was $M_{MS} = 0.1636$ pixels per millisecond and showed a uniformity (standard deviation) of $M_{MU} = 0.2196$. The average movement efficiency was calculated $M_{ME} = 1.1455$ with a movement targeting (standard deviation from the ideal connection) of $M_{MT} = 5.0692$ pixels. On average, each movement had $M_{MB} = 2.7194$ breaks and shot $M_{ON} = 0.8368$ times over the target by $M_{OL} = 21.2666$ pixels.

8.2 Emotion Induction by Films (H0)

For this test, the data was split into three groups of 39 data sets (N=39) each, according to the film that was shown before recording the answers. The independent variable (FILM) had intended three different levels that were dummy coded:

1 Negative film: low arousal, negative valence.

2 Neutral film: average arousal, neutral valence.

3 Positive film: high arousal, positive valence.

Table B.2 in Appendix B contains the complete set of collected data that was analysed by a one-way ANOVA. The result can be seen in Table 8.1.

self-assessment

variable	M_{neg}	M_{neu}	M_{pos}	var	f-ratio	sig
VA1	3.8974	2.4359	2.5385	33%	12.4925	<0.0001**
VAL	3.0256	4.8718	5.3590	20%	52.4968	<0.0001**
VA2	3.4359	5.1026	5.2821	16%	40.0406	<0.0001**
DIS	4.4615	2.9744	2.8718	66%	24.6067	<0.0001**
ARO	4.0769	2.7949	3.8462	64%	14.0100	<0.0001**

mouse movements

variable	M_{neg}	M_{neu}	M_{pos}	var	f-ratio	sig
CD	129.8200	137.5830	130.1390	19%	0.7292	0.4844
CN	1.1039	1.0703	1.0980	90%	1.9620	0.1452
MA	0.0170	0.0101	0.0150	137%	4.2683	0.0163*
MB	2.5159	3.0366	2.6055	59%	2.7372	0.0690
MD	0.0058	0.0049	0.0058	102%	3.2715	0.0415*
ME	1.1430	1.1456	1.1479	23%	0.0493	0.9518
MS	0.1713	0.1456	0.1739	55%	3.7944	0.0253*
MT	5.2820	4.4941	5.4314	78%	1.4095	0.2484
MU	0.2290	0.1970	0.2326	46%	4.2828	0.0160*
OL	21.1785	19.9975	22.6238	58%	0.2538	0.7762
ON	0.8347	0.8675	0.8081	70%	0.2182	0.8042

Table 8.1: Film Impact on Self-Assessment and Mouse Movements.
Note. The value of variance is the percentage that the variances between groups vary at the maximum.
$* p < .05$ $**p < .01$

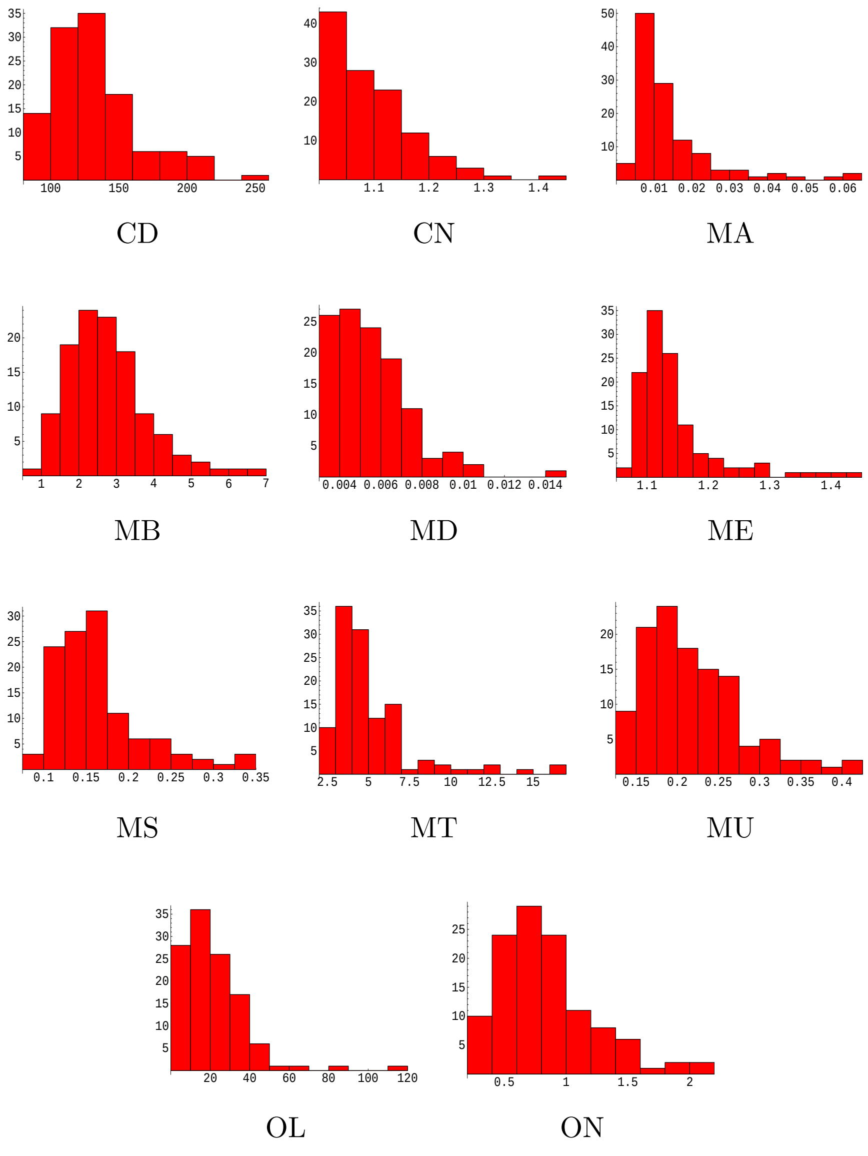


Figure 8.4: Descriptive Statistics Mouse Movements:
The overall histograms for the variables of click duration (CD), click number (CN), movement acceleration (MA), movement breaks (MB), movement deceleration (MD), movement efficiency (ME), movement speed (MS), movement targeting (MT), movement uniformity (MU), overshot length (OL), overshot number (ON).

These results allow us to conclude that the films did have an impact on all self-assessment variables, because all of them show highly significant differences ($p = 0.00$). The negative film showed highest arousal levels followed by the positive film ($M_{neg} = 4.08$, $M_{neu} = 2.79$, $M_{pos} = 3.85$, $F_{ARO} = 14.01$). Disgust levels of the negative film were the highest, the neutral and positive film showed similar, lower means ($M_{neg} = 4.46$, $M_{neu} = 2.97$, $M_{pos} = 2.87$, $F_{DIS} = 24.61$). Subjects felt in average best after seeing the neutral and positive film ($M_{neg} = 3.90$, $M_{neu} = 2.44$, $M_{pos} = 2.54$, $F_{VA1} = 12.49$). The level of anger was highest after seeing the negative film and similarly lower for the other two films ($M_{neg} = 3.44$, $M_{neu} = 5.10$, $M_{pos} = 5.28$, $F_{VA2} = 40.04$). The levels of valence matched to the film intentions because the negative film triggered the lowest valence scores and the positive film triggered the highest scores ($M_{neg} = 3.03$, $M_{neu} = 4.87$, $M_{pos} = 5.36$, $F_{VAL} = 52.50$). However, we see that some of the variances are not homogenous (e.g. DIS and ARO show a rather big difference of over 60%). According to Morgan et al. [2004], ANOVA is robust enough, in case that the number of subjects in each group is the same, a requirement it fulfilled.

It also shows that the films had an influence on the mouse movements, however this influence seems to be limited to MA, MD, MS and MU. Movement acceleration was lowest in the neutral video ($M_{neg} = 0.02$, $M_{neu} = 0.01$, $M_{pos} = 0.02$,$F_{MA} = 4.27$; $p = 0.02$). The movement deceleration was as well the lowest for the neutral video ($M_{neg} = 0.01$, $M_{neu} = 0.01$, $M_{pos} = 0.01$, $F_{MD} = 3.27$; $p = 0.04$). The average speed of the movement was, like the acceleration and deceleration, the lowest for the neutral video ($M_{neg} = 0.17$, $M_{neu} = 0.15$, $M_{pos} = 0.17$, $F_{MS} = 3.79$; $p = 0.03$) and movement uniformity was best for the neutral film ($M_{neg} = 0.23$, $M_{neu} = 0.20$, $M_{pos} = 0.23$, $F_{MU} = 4.28$; $p = 0.02$). Here we can see that the variances were not homogenous at all with an error of 45% for MU and over 100% for the acceleration and deceleration variables.

The conclusion from this analysis is that the supportive hypothesis (H0) has been validated and the shown films did influence the test subjects. The null hypothesis ($H0_0$) can be rejected. The size of the impact may be rather negligible in some cases, but at least the self-assessment variables seem to be influenced, so that we can use the different obtained states as independent variables for the next analyses.

8.3 Emotion Change on Movement Influence

In the second and main analysis the data was subjected to four independent between-group comparisons for differences in mean values (t-Test). Basis for this test were the four independent variables of arousal (ARO), disgust (DIS), valence (VAL) and the combined scale of valence and arousal (VA2). For each of these comparisons all data sets were split into two groups: "Higher" and "lower". This splitting was done according to the self-assessment answers to the questions and resulted in answers from 1 to 3 being coded lower (1) and answers from 5 to 7 were coded higher (2). Data rows with answer 4 (the middle value) were ignored. The reason for this was that the questions were asked reflexive and there the middle answer stood for no change of the affective state.

Since the answers were asked reflexive (in comparison to the feeling before the video), also the mouse movements were regarded in comparison to the movements before the video. Obviously, this comparison was just possible between the positive and the negative video, because for the first video there was no preceding data to compare with.

As an example, one test subject watched first the neutral video, then the positive video and then the negative one. After the positive video she answered that she felt happier; then the difference between her movement variables between positive and neutral was calculated and used in the "higher" group of valence (VAL_{higher}). If she then answered that she felt worse after watching the negative video, then the difference between her movements after the positive and her movements after the negative video were used in the valence group "lower" (VAL_{lower}).

8.3.1 Arousal (ARO)

When grouping the mouse movements according to the independent variable of arousal, the resulting groups had the sizes $N(ARO)_{lower} = 19$ and $N(ARO)_{higher} = 21$ (see the raw data in Table B.3). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.2):

name	M_{lower}	M_{higher}	var_{lower}	var_{higher}	df	t	sig	eff.size
ΔCD	-2.8211	-3.4695	73.0016	257.5780	31.1015	0.1616	0.8727	0.0497
ΔCN	0.0284	0.0124	0.0066	0.0037	33.3419	0.7015	0.4878	0.2253
ΔMA	0.0071	0.0044	0.0002	0.0002	37.9163	0.6079	0.5469	0.1910
ΔMB	-0.2239	-0.4259	1.1110	1.4010	37.9933	0.5712	0.5713	0.1798
ΔMD	0.0006	0.0002	0.0000	0.0000	36.4013	0.7206	0.4757	0.2294
ΔME	0.0198	0.0232	0.0115	0.0037	27.8711	-0.1206	0.9049	-0.0392
ΔMS	0.0139	0.0125	0.0016	0.0009	33.5691	0.1302	0.8972	0.0418
ΔMT	0.2431	0.6489	1.9992	2.1238	37.8011	-0.8933	0.3773	-0.2824
ΔMU	0.0202	0.0141	0.0031	0.0022	35.5215	0.3785	0.7073	0.1208
ΔOL	-0.5852	-4.7303	484.3690	356.4810	35.7046	0.6361	0.5288	0.2030
ΔON	-0.0832	-0.1538	0.0658	0.2827	29.4486	0.5426	0.5915	0.1664

Table 8.2: Arousal Impact on Mouse Movements.
Note. No significant differences were found.
Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.
* $p < .05$ **$p < .01$

In this test, no significant differences between mouse movements with higher arousal and lower arousal were found. According to these values, the set of null-hypotheses with arousal as independent variable ($H1a_0$, $H1d_0$, $H1c_0$, $H1d_0$) was confirmed.

8.3.2 Disgust (DIS)

When grouping the mouse movements according to the independent variable of disgust, the resulting groups had the sizes $N(DIS)_{lower} = 30$ and $N(DIS)_{higher} = 18$ (see the raw data in Table B.4). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.3):

In this test, no significant differences between mouse movements with delight versus disgust were found. According to these values, the set of null-hypotheses with disgust (other) as independent variable ($H3a_0$, $H3b_0$, $H3c_0$, $H3d_0$) was confirmed.

8.3.3 Valence (VAL)

When grouping the mouse movements according to the independent variable of valence (VAL), the resulting groups had the sizes $N(VAL)_{lower} = 30$ and

name	M_{lower}	M_{higher}	var_{lower}	var_{higher}	df	t	sig	eff.size
ΔCD	-1.4737	-5.0550	72.3313	397.7100	20.7676	0.7234	0.4775	0.2581
ΔCN	0.0073	0.0422	0.0038	0.0067	28.6559	-1.5568	0.1305	-0.4979
ΔMA	0.0058	0.0041	0.0002	0.0002	38.3238	0.3892	0.6993	0.1136
ΔMB	0.0773	-0.3809	0.8914	1.4991	29.1211	1.3632	0.1833	0.4338
ΔMD	0.0003	0.0007	0.0000	0.0000	21.5214	-0.6389	0.5296	-0.2249
ΔME	0.0186	0.0027	0.0082	0.0032	45.8707	0.7516	0.4561	0.2004
ΔMS	0.0073	0.0181	0.0010	0.0016	30.4155	-0.9842	0.3328	-0.3090
ΔMT	0.2057	0.3544	2.0752	2.5190	33.2040	-0.3251	0.7471	-0.0994
ΔMU	0.0096	0.0216	0.0020	0.0037	27.8268	-0.7265	0.4736	-0.2345
ΔOL	1.4829	0.1782	416.1020	807.1050	27.5960	0.1703	0.8660	0.0551
ΔON	-0.0987	-0.0194	0.2090	0.3103	30.5867	-0.5095	0.6141	-0.1597

Table 8.3: Disgust Impact on Mouse Movements.

Note. No significant differences were found.

Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.

* $p < .05$ **$p < .01$

$N(VAL)_{higher} = 33$ (see the raw data in Table B.5). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.4):

name	M_{lower}	M_{higher}	var_{lower}	var_{higher}	df	t	sig	eff.size
ΔCD	-4.2050	-5.6191	148.6270	306.3870	57.2689	0.3748	0.7092	0.0930
ΔCN	0.0163	0.0109	0.0061	0.0037	54.9872	0.3055	0.7611	0.0780
ΔMA	0.0039	0.0041	0.0001	0.0002	59.5933	-0.0706	0.9439	-0.0176
ΔMB	-0.3793	-0.1041	1.7625	1.0427	54.3372	-0.9155	0.3640	-0.2338
ΔMD	0.0004	0.0004	0.0000	0.0000	46.5672	-0.0740	0.9413	-0.0191
ΔME	0.0066	0.0059	0.0084	0.0039	50.5451	0.0314	0.9751	0.0081
ΔMS	0.0119	0.0129	0.0013	0.0011	58.9616	-0.1071	0.9151	-0.0271
ΔMT	0.3811	0.4547	2.1358	2.8627	60.8517	-0.1851	0.8537	-0.0464
ΔMU	0.0133	0.0158	0.0030	0.0021	56.7326	-0.1945	0.8465	-0.0495
ΔOL	-0.3376	-0.5907	667.8360	479.0220	57.1348	0.0418	0.9668	0.0106
ΔON	0.0010	-0.0620	0.3151	0.1800	53.7944	0.4989	0.6199	0.1275

Table 8.4: Valence Impact on Mouse Movements.

Note. No significant differences were found.

Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.

* $p < .05$ **$p < .01$

In this test, no significant differences between mouse movements with positive valence and negative valence were found. According to these values, the set of null-hypotheses with valence as independent variable ($H2a_0$, $H2b_0$, $H2c_0$, $H2d_0$) are confirmed.

8.3.4 Valence-Arousal Combination: Anger (VA2)

When grouping the mouse movements according the independent combination of valence and arousal (VA2), the resulting groups had the sizes $N(VA2)_{lower} = 19$ and $N(VA2)_{higher} = 31$ (see the raw data in Table B.6). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.5):

name	M_{lower}	M_{higher}	var_{lower}	var_{higher}	df	t	sig	eff.size
ΔCD	-3.8484	-3.1926	195.7030	162.5270	35.4732	-0.1664	0.8688	-0.0496
ΔCN	0.0363	0.0090	0.0041	0.0038	36.8958	1.4821	0.1468	0.4365
ΔMA	0.0070	0.0045	0.0002	0.0002	40.6002	0.5975	0.5535	0.1707
ΔMB	-0.3926	0.0164	2.0905	0.9493	28.1074	-1.0906	0.2847	-0.3485
ΔMD	0.0005	0.0004	0.0000	0.0000	23.5279	0.3118	0.7580	0.1055
ΔME	0.0122	0.0153	0.0025	0.0074	47.8690	-0.1621	0.8719	-0.0417
ΔMS	0.0139	0.0114	0.0017	0.0011	32.3600	0.2150	0.8311	0.0658
ΔMT	0.6521	0.3170	1.9119	2.4629	41.9530	0.7897	0.4342	0.2231
ΔMU	0.0156	0.0140	0.0041	0.0021	29.2928	0.0947	0.9252	0.0299
ΔOL	1.6547	-1.2097	933.2840	338.4830	26.1174	0.3697	0.7146	0.1209
ΔON	0.0200	-0.0279	0.3714	0.1984	29.7987	0.2972	0.7684	0.0933

Table 8.5: Anger Impact on Mouse Movements.
Note. No significant differences were found.
Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.
* $p < .05$ **$p < .01$

In this test, no significant differences between mouse movements with anger and contentedness were found. According to these values, the set of null-hypotheses with anger (other) as independent variable ($H3a_0$, $H3b_0$, $H3c_0$, $H3d_0$) are confirmed.

8.4 Emotion and Movement Correlation

Since the second analysis did not bring any relevant statistical correlation, I tried another way of analysis. The second analysis based on the aspect that the questions were asked reflexive and that each affective state was only described in comparison to the preceding one. That resulted in a precise but narrow point of view of the questions. It is not clear, if all test subjects answered the questions in this reflexive sense. Therefore, another set of between-group comparison of different means (t-Test) was made. This time, all these questions were regarded as an absolute measure of the emotional state. This resulted in five different tests with the variables of arousal

(ARO), disgust (DIS), valence (VAL) and both combined scales (VA1 and VA2). For each of these comparisons all data sets were split into two groups: High and low. The splitting was done according to the self-assessment answers to the questions and resulted in answers from 1 to 3 being coded low (1) and answers from 5 to 7 coded high (2). Data from sets with answer 4 (the middle value) was ignored.

Since the questions now were not regarded as reflexive, the different mouse movement variables could also be compared without special processing. The raw data for these tests can be found in the appendix (B).

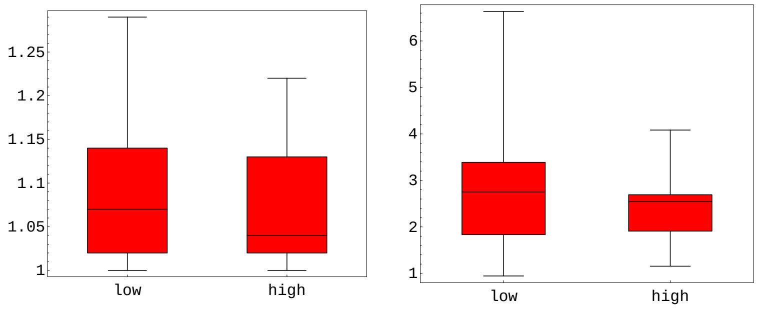
8.4.1 Arousal (ARO)

When grouping the mouse movements according to the independent variable of arousal, the resulting groups had the sizes $N(ARO)_{low} = 48$ and $N(ARO)_{high} = 23$ (see the raw data in Table B.7). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.6).

name	M_{low}	M_{high}	var_{low}	var_{high}	df	t	sig	eff.size
CD	131.7590	127.9210	1327.5800	807.6900	74.1582	0.5237	0.6020	0.1144
CN	1.0663	1.1065	0.0042	0.0076	50.8825	-2.2028	0.0322*	-0.5411
MA	0.0129	0.0137	0.0001	0.0002	44.3979	-0.2918	0.7718	-0.0744
MB	3.0325	2.3600	1.3231	0.6749	76.1451	3.0277	0.0034**	0.6500
MD	0.0050	0.0056	0.0000	0.0000	46.6729	-1.3544	0.1821	-0.3405
ME	1.1595	1.1309	0.0074	0.0030	76.9848	1.8044	0.0751	0.3787
MS	0.1487	0.1631	0.0016	0.0025	54.1030	-1.3474	0.1835	-0.3256
MT	4.5552	5.0003	6.7935	4.9875	70.9508	-0.8095	0.4210	-0.1804
MU	0.2039	0.2222	0.0031	0.0037	60.3094	-1.3485	0.1825	-0.3163
OL	18.5784	22.0904	127.9220	516.0000	39.7256	-0.7992	0.4289	-0.2102
ON	0.8623	0.7806	0.1312	0.1961	54.9737	0.8590	0.3941	0.2067

Table 8.6: Arousal Impact on Mouse Movements.
Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.
* $p < .05$ ** $p < .01$

When grouping by arousal, the analysis showed significantly different mean values for the clicking number (CN) ($M_{low} = 1.07$, $M_{high} = 1.11$, $t(CN) = -2.20$; $p = 0.03$; effect size = -0.5) and the movement breaks ($M_{low} = 3.03$, $M_{high} = 2.36$, $t(MB) = 3.03$; $p = 0.00$; effect size = 0.65) between the two groups. According to Morgan et al. [2004], both values here show a typical effect size. The box-whisker-plots for both values can be seen in Figure 8.5.



CN MB

Figure 8.5: Box-Whisker-Plot: CN and MB by high/low ARO.
The left box shows the clicking numbers (CN), the right one shows the movement breaks (MB) for the low (relaxed) and high (excited) levels of variable arousal (ARO).

The other variables all showed no significant difference between the groups. This leads us to the conclusion, that the null-hypotheses $H1b_0$ and $H1c_0$ can be rejected; H1b and H1c have been verified, just like the null-hypotheses of $H1a_0$ and $H1d_0$.

8.4.2 Disgust (DIS)

When grouping the mouse movements according the independent variable of disgust, the resulting groups had the sizes $N(DIS)_{low} = 57$ and $N(DIS)_{high} = 22$ (see the raw data in Table B.8). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.7):

name	M_{low}	M_{high}	var_{low}	var_{high}	df	t	sig	eff.size
CD	131.5950	126.7750	1193.8000	937.3010	42.8392	0.6046	0.5486	0.1438
CN	1.0707	1.1114	0.0046	0.0081	30.7646	-1.9199	0.0642	-0.5446
MA	0.0135	0.0125	0.0001	0.0001	33.5803	0.3268	0.7459	0.0879
MB	2.9626	2.2661	1.2700	0.5777	56.5016	3.1611	0.0025**	0.6698
MD	0.0051	0.0056	0.0000	0.0000	26.4442	-0.9595	0.3460	-0.3041
ME	1.1541	1.1332	0.0067	0.0035	52.3408	1.2592	0.2136	0.2751
MS	0.1502	0.1650	0.0015	0.0032	28.5730	-1.1264	0.2694	-0.3361
MT	4.5817	5.1138	6.0573	6.1405	37.9708	-0.8572	0.3967	-0.2158
MU	0.2060	0.2242	0.0029	0.0046	31.5650	-1.1254	0.2689	-0.3141
OL	19.6512	20.7476	172.5020	573.5930	26.0266	-0.2033	0.8405	-0.0653
ON	0.8477	0.7851	0.1417	0.1989	33.1931	0.5832	0.5637	0.1579

Table 8.7: Disgust Impact on Mouse Movements.
Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.
* $p < .05$ **$p < .01$

The analysis for different means between the two groups of disgust produced one significant difference for the variable of movement breaks (M_{low} = 2.96, M_{high} = 2.27, t(MB) = 3.16; p = 0.00; effect size = 0.67) with a typical effect size [Morgan et al., 2004]. The box-whisker-plot for MB can be seen in Figure 8.6.

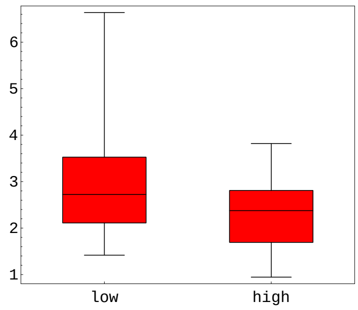


Figure 8.6: Box-Whisker-Plot: MB by high/low DIS.
The left box shows the movement breaks (MB) for the low levels (delighted), the right box for the high levels (disgusted) of variable DIS.

The other variables did not produce significantly different means, which allows us to conclude, that we can reject the null-hypothesis of $H3c_0$ and verify the hypotheses of $H3a_0$, $H3b_0$, H3c and $H3d_0$.

8.4.3 Valence (VAL)

When grouping the mouse movements according the independent variable of valence (VAL), the resulting groups had the sizes $N(VAL)_{low}$ = 34 and $N(VAL)_{high}$ = 61 (see the raw data in Table B.9). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.8):

The analysis of the two groups of valence (positive and negative) did not result in any significant differences between the means. This allows us to conclude, that all the null-hypotheses for valence as independent variable ($H2a_0$, $H2b_0$, $H2c_0$, $H2d_0$) have been verified in this test.

name	M_{low}	M_{high}	var_{low}	var_{high}	df	t	sig	eff.size
CD	129.9570	131.4370	686.7110	1119.0200	82.6629	-0.2385	0.8121	-0.0476
CN	1.0959	1.0759	0.0065	0.0047	59.3712	1.2204	0.2271	0.2740
MA	0.0131	0.0134	0.0001	0.0001	65.5514	-0.1521	0.8796	-0.0330
MB	2.6342	2.8651	0.9505	1.3690	79.1839	-1.0284	0.3069	-0.2090
MD	0.0054	0.0053	0.0000	0.0000	51.3121	0.3859	0.7012	0.0912
ME	1.1470	1.1458	0.0055	0.0048	64.2434	0.0810	0.9357	0.0177
MS	0.1622	0.1566	0.0028	0.0022	61.5891	0.5148	0.6085	0.1141
MT	5.0631	4.7768	5.6430	7.0486	74.9616	0.5396	0.5911	0.1119
MU	0.2177	0.2134	0.0042	0.0035	63.0364	0.3181	0.7515	0.0700
OL	20.3491	20.0948	399.8770	177.4350	49.6707	0.0664	0.9473	0.0159
ON	0.8943	0.8422	0.2364	0.1274	53.1633	0.5480	0.5860	0.1279

Table 8.8: Valence Impact on Mouse Movements.

Note. No significant differences were found.

Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.

* $p < .05$ **$p < .01$

8.4.4 Valence-Arousal Combination: Joy vs. Sadness (VA1)

When grouping the mouse movements according the independent combination of valence and arousal (VA1 - joy vs. sadness), the resulting groups had the sizes $N(VA1)_{low} = 76$ and $N(VA2)_{high} = 20$ (see the raw data in Table B.11). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.9):

name	M_{low}	M_{high}	var_{low}	var_{high}	df	t	sig	eff.size
CD	132.0210	138.1950	1126.7200	1086.9100	30.2107	-0.7422	0.4637	-0.1846
CN	1.0821	1.1245	0.0067	0.0074	28.7527	-1.9794	0.0574	-0.5117
MA	0.0141	0.0175	0.0001	0.0002	26.1945	-1.0192	0.3174	-0.2868
MB	2.7550	2.5692	1.1202	0.6711	37.5242	0.8451	0.4034	0.1830
MD	0.0053	0.0063	0.0000	0.0000	24.4133	-1.5911	0.1245	-0.4835
ME	1.1442	1.1589	0.0045	0.0056	27.6820	-0.7989	0.4311	-0.2134
MS	0.1626	0.1802	0.0028	0.0034	27.8504	-1.2305	0.2288	-0.3269
MT	4.9700	6.3369	7.1513	11.1876	25.7452	-1.6910	0.1029	-0.4843
MU	0.2165	0.2470	0.0037	0.0049	27.0814	-1.7799	0.0863	-0.4849
OL	22.0122	20.1943	344.3590	139.7920	46.6517	0.5356	0.5948	0.1044
ON	0.8362	0.9513	0.1405	0.2354	25.2817	-0.9864	0.3333	-0.2880

Table 8.9: Joy Impact on Mouse Movements.

Note. No significant differences were found.

Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.

* $p < .05$ **$p < .01$

The analysis of the two groups of joy vs. sadness (VA1) did not result in any significant differences between the means of the mouse movement variables. This allows us to conclude, that all the null-hypotheses for valence as independent variable ($H3a_0$, $H3b_0$, $H3c_0$ and $H3d_0$) have been verified in this test.

8.4.5 Valence-Arousal Combination: Anger vs. Contentedness (VA2)

When grouping the mouse movements according the independent combination of valence and arousal (VA2 - anger vs. contendedness), the resulting groups had the sizes $N(VA2)_{low} = 20$ and $N(VA2)_{high} = 58$ (see the raw data in Table B.11). When running the analysis of mean difference (t-Test) on these two groups, following results were found (Table 8.10):

name	M_{low}	M_{high}	var_{low}	var_{high}	df	t	sig	eff.size
CD	126.5440	130.9240	537.2530	1061.0200	46.5009	-0.6519	0.5177	-0.1436
CN	1.1155	1.0712	0.0070	0.0046	28.2359	2.1423	0.0409*	0.6135
MA	0.0159	0.0132	0.0002	0.0001	26.4910	0.8276	0.4153	0.2486
MB	2.4409	2.8915	0.6561	1.4176	48.8225	-1.8836	0.0656	-0.4068
MD	0.0060	0.0051	0.0000	0.0000	22.8417	1.3489	0.1906	0.4642
ME	1.1337	1.1499	0.0026	0.0061	50.4263	-1.0554	0.2963	-0.2250
MS	0.1704	0.1528	0.0039	0.0017	24.8998	1.1768	0.2504	0.3723
MT	5.3633	4.6878	6.2527	6.2275	32.9945	1.0424	0.3048	0.2706
MU	0.2322	0.2084	0.0055	0.0028	25.9334	1.3272	0.1960	0.4055
OL	23.4916	18.8025	568.6600	145.2720	22.4368	0.8430	0.4081	0.2959
ON	0.8679	0.8441	0.2510	0.1395	26.6525	0.1946	0.8472	0.0582

Table 8.10: Anger Impact on Mouse Movements.
Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.
$* p < .05$ $** p < .01$

The analysis of the two groups of anger vs. contentedness (VA2) produced one significant difference for the variable of clicking number ($M_{low} = 1.12$, $M_{high} = 1.07$, $t(CN) = 2.14$; $p = 0.04$; effect size = 0.61) with a typical effect size [Morgan et al., 2004]. The box-whisker-plot for CN can be seen in Figure 8.7.

The other variables did not produce significantly different means, which allows us to conclude, that by this analysis we can reject the null-hypothesis of $H3b_0$ and verify the hypotheses of $H3a_0$, H3b, $H3c_0$ and $H3d_0$.

8.5 Low Arousal Film vs. High Arousal Film

If we look back to Section 8.2 we can see that the films performed differently, than they were expected. The neutral film turned out to be the least arous-

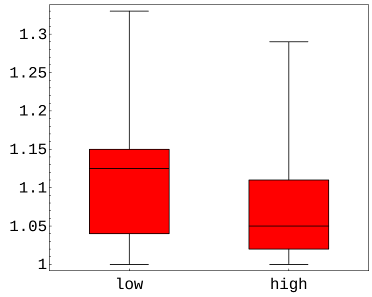


Figure 8.7: Box-Whisker-Plot: CN by high/low VA2.
The left box shows the clicking numbers (CN) for the low levels (angry), the right box for the high levels (content) of variable VA2.

ing film, the other two films (positive and negative) seem to produce pretty similar arousal results. We can also see, that there have been significant differences in the operators of movement speed and related measures. Significance that could not really be found in any of the analyses made, which leaves the logical conclusion, that the wrong films have been compared. The conclusion, that the positive and negative film influenced arousal similarly, but the neutral film did not influence the level of arousal the same way. Thus, the neutral film should be compared to the other film with opposed impact.

The second interesting thing is the high variance between the mouse characteristics between different persons. These two problems have been addressed in the last analysis. In this one the groups were built by the film shown beforehand. In Section 8.2 we have shown that the neutral film has significant lower arousal values. To address the high variance between subjects in how the mouse is moved, subjects should be compared to themselves. For this reason the positive film, which produced the middle average arousal value (however close to the one from the negative film), was used as reference value. By getting such a reference value, the change of the mouse characteristics could be calculated as a direct comparison. This was done by two ways. First, by calculating the difference (d) between the values of the positive film seen by one person and the values of the neutral (or negative) film film seen by the same person. This produced the average difference between the mouse characteristics of the positive and the neutral (or negative) film by Formulae 8.1 and 8.2. Second, the same direct comparison was made by calculating the factor (f) of the positive film divided by the neutral (or negative) (Formulae 8.3 and 8.4).

$$dMA_{low} = MA_{pos} - MA_{neu} \tag{8.1}$$

$$dMA_{high} = MA_{pos} - MA_{neg} \tag{8.2}$$

$$fMA_{low} = \frac{MA_{pos}}{MA_{neu}} \tag{8.3}$$

$$fMA_{high} = \frac{MA_{pos}}{MA_{neg}} \tag{8.4}$$

MA	representative for all operators
dMA	difference of MA
MA_*	the MA values for the film represented by $*$, one of following: neg, neu or pos

Analysing the resulting data (raw data see Section B.13) produced a huge amount of results, where in general the variance was much more homogenous and the distribution was a nicer normal distribution. The interesting results produced can be seen in Table 8.11.

name	M_{low}	M_{high}	var_{low}	var_{high}	df	t	sig	eff.size
fCN	1.0262	0.9954	0.0052	0.0033	72.6485	2.0836	0.0407*	0.4718
dMA	0.0049	-0.0020	0.0001	0.0003	65.3436	2.0638	0.0430*	0.4674
dMB	-0.4311	0.0896	1.2588	1.2297	75.9896	-2.0613	0.0427*	-0.4668
dMD	0.0009	-0.0001	<0.0001	<0.0001	57.0895	3.2651	0.0019**	0.7394
dMS	0.0283	0.0026	0.0007	0.0011	71.4186	3.7701	0.0003**	0.8538
dMT	0.9373	0.1494	2.8980	2.9775	75.9861	2.0299	0.0459*	0.4597
dMU	0.0356	0.0036	0.0008	0.0023	62.1245	3.6006	0.0006**	0.8154

Table 8.11: Film Arousal Impact per Person:
Note. The prefix "d" at the dependent operators stands for the difference to the arousal of the middle film. The prefix "f" stands for the factor between the movement value in the stronger film and the same person's movement value in the middle film.
Note. Due to heterogeneous variances the degrees of freedom (df) are not integer values.
$*$ $p < .05$ $**p < .01$

The mean factor of the clicking number (CN) is higher for the low arousal than for higher arousal ($M_{low} = 1.0262$, $M_{high} = 0.9954$, $t(fCN) = 72.6485$; $p = 0.0407$; effect size $= 0.4718$), which means that in absolute numbers the subjects needed less clicks after seeing the neutral video. The differences between acceleration (M_{low} = 0.0049, M_{high} = -0.0020, t(dMA) = 65.3436; p = 0.0430; effect size = 0.4674) and deceleration means (M_{low} = 0.0009, M_{high} = -0.0001, t(dMD) = 57.0895; p = 0.0019; effect size = 0.7394) are also higher for the neutral film, which means that absolute acceleration and deceleration was lower for the subjects after watching the neutral video. This also suits to the lower speed and better movement uniformity, measured by the higher differences between the average speeds (M_{low} = 0.0283, M_{high} = 0.0026, t(dMS) = 71.4186; p = 0.0003; effect size = 0.8538) and their uniformity (standard deviation) (M_{low} = 0.0356, M_{high} = 0.0036, t(dMU) = 62.1245; p = 0.0006; effect size = 0.8154) for the low arousal film. The mean differences when comparing the movement targeting (M_{low} = 0.9373, M_{high} = 0.1494, t(dMT) = 75.9861; p = 0.0459; effect size = 0.4597) show, that in absolute numbers the mouse movements after seeing the negative film with higher arousal varied significantly more from the ideal movement. The number of movement breaks, however, was higher for movements after seeing the film provoking lower arousal, as the comparison of the mean differences in movement breaks (M_{low} = -0.4311, M_{high} = 0.0896, t(dMB) = 75.9896; p = 0.0427; effect size = -0.4668) shows.

According to Morgan et al. [2004], the differences in movement speed (dMS) and the differences in movement uniformity (dMU) both show a larger than typical effect size. The other effects showed medium effect size. The box-whisker-plots for these operators can be seen in Figure 8.8.

The other variables all showed no significant difference between the groups. This leads us to the conclusion, that the null-hypotheses $H1b_0$ and $H1c_0$ can be rejected; H1b and H1c have been verified, just like the null-hypotheses of $H1a_0$ and $H1d_0$.

8.6 Summary

In this chapter I, presented the results by the statistical analysis of the data. Four different tests were made, one one-way ANOVA with the film as the independent variable and three different groups of t-Tests. The one-way ANOVA showed significant differences between the self-assessment an-

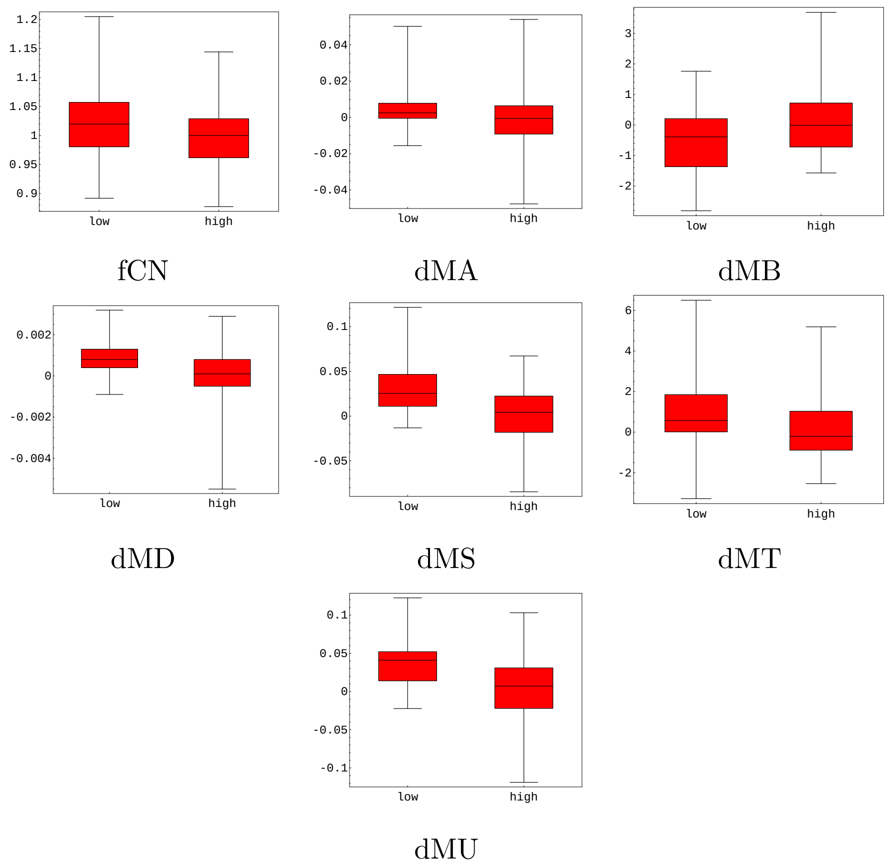


Figure 8.8: Box-Whisker-Plots for Arousal Grouped by Films.

The Box-Whisker-Plots for the calculated differences and factors (fCN, dMA, dMB, dMD, dMS, dMT, dMU) between the neutral film with lower valence and the negative film with higher valence compared to the positive film.

swers depending on the films shown. It also showed significant correlation between the films shown and the mouse movement speed characteristics (MS, MA/MD, MU). The first group of t-Tests regarded the self-assessment and the mouse values reflexively and used four independent variables (ARO, DIS, VAL, VA2). In this test, no significant differences between the groups were found. The second group of t-Tests regarded the self-assessment as absolute and also compared the mouse movement values directly. Five independent variables (ARO, DIS, VAL, VA1, VA2) were used in this group, which produced some significant differences between means for ARO, DIS and VA2 in the mouse variables of MB and CN. The third group of t-Tests compared the per-person change of mouse motions on the basis of the shown videos. Here, the two videos, where the subjects' arousal level reacted most (neutral and negative video), were used to create two groups with equal amount of subjects. These two groups showed significant differences in the operands of (CN, MA, MD, MS, MU, MT and MB). A summary of the validated and rejected hypotheses can be found in Table 8.12.

hypothesis test	film H0	arousal H1a - H1d	valence H2a - H2d	other H3a - H3d
FILM	MA,MD,MS,MT	-	-	-
ΔARO	-	-	-	-
ΔDIS	-	-	-	-
ΔVAL	-	-	-	-
ΔVA2	-	-	-	-
ARO	-	CN,MB	-	-
DIS	-	-	-	MB
VAL	-	-	-	-
VA1	-	-	-	-
VA2	-	-	-	CN
FILM-ARO	-	CN,MA,MB, MD,MS,MT,MU	-	-
	validated	validated	-	validated

Table 8.12: Hypotheses Validation Overview.

We can here see, that the support hypothesis was validated in the test grouping by film with the help of the measures of MA, MD, MS an MT. Furthermore this hypothesis was validated in the same test by all the self-assessment operators (ARO, DIS, VAL, VA1, VA2). The hypothesis that different levels of arousal lead to significantly different mouse motions could be validated. The same applies on the influence of the other independent operators representing the collecting scale (other). The influence of valence could not be proven, therefore H2 is rejected, whereas H0, H1 and H3 are accepted.

Chapter 9

Conclusions

In the previous chapters we have seen the experiment set-up, execution and the results. In this chapter I will try to interpret these results, estimate their effect and limitations. In the second part of this chapter I will criticise and discuss problems in this work and describe their influence on the results.

9.1 Interpretation of the Results

The experiment has validated some of the hypotheses (H0, H1b, H1c, H3b, H3c), but what does this mean in respect to the research question? In short, the experiment has shown that the videos in the experiment influenced the emotional state of the subjects and that different levels movement precision and smoothness seem to have a significant difference for different levels of arousal and other emotional dimensions. We have also seen that a video, that made the subjects in average feel less aroused, made the subjects move the mouse slower and more uniform with stronger targeting. This means that the mouse can be used as a measurement tool for emotional states. Let us have a closer look at that.

9.1.1 Interpretation of Descriptive Statistics

The descriptive statistics listed in Section 8.1 show that the sample of testing persons was not totally representative for the general public. But regarding this work as a proof of concept this should not influence the positive proof.

The fact, that this study was executed at an academic site influenced not just the age distribution of the subjects but also the expertise the subjects had with computers. The low number of subjects reporting that they sometimes get angry at the computer and that they usually prefer to communicate with humans shows that these subjects still were "ordinary" people and no geeks.

9.1.2 Interpretation of Film Influence on Affective State

If we have another look at Table 8.1, we can see that the films influenced all of the self-assessment variables and a few of the mouse movement variables (movement speed, movement uniformity, movement acceleration and deceleration). This means that the induction of emotions by the videos did work and that we can state the supportive hypothesis (H0) as *validated*. The more important question is how and how much did the films influence the subjects? Did they influence the subjects enough to provoke changes in the mouse movement patterns - in case that such relation exists - so that statistical type II errors (β) did not occur? We see that the negative film evoked negative feelings and made the subjects feel worse, sadder, more disgusted but also more excited and more angry than the other films. The positive film made people feel better, happier, delighted and pleased. It also made the test subjects feel more relaxed than the negative film, something that was not intended by the design. Finally, the performance of the neutral film was similar to the positive film, with the exception, that it made people feel more relaxed. This means that the films did not perform as expected, as the neutral film triggered the feeling of comfort, the sad film triggered anger and the positive triggered contentedness.

The influence of the films on the mouse movement characteristics seems to be limited on the movement speed characteristics (acceleration/deceleration, average speed and uniformity). These four values show significant differences between the different films, even if the variances differ quite a lot (at least 45%). This means that the subjects differ strongly in the way and speed they move the mouse.

On the other hand, all values do not show significance. In general we can see that the variances are rather wide spread, for some of the self-assessment variables and the mouse movement variables alike. One possible explanation for this may be that the films did not provoke exactly the same distinct feelings in the different subjects. So does the variable of arousal show big differences of variance, which could mean that some subjects reacted strong in the arousal dimension (and became really happy/angry or sad/calm), others did not. The negative film (loss of mammoth child) could not just provoke feelings of sadness but also anger towards the shown hunters. The positive film, on the other hand, was not extremely exciting as it did not show any extreme sports, only a funny but rather calm scene.

We can conclude, that the films succeeded in evoking different emotional states in the subjects, however that these states were not the states that were intended. The films had too little impact. The difference between expectation of emotional impact and real impact might mean that the films manipulated the test persons less than intended. The bottom line is that wrong films were used for the induction.

9.1.3 Interpretation of Emotional Influence on Mouse Motion

The second analysis where mouse movements were compared per person did not show any significant results. The mouse movements were compared to the mouse movements of the same person grouped by the relative change of the emotional state. One possible reason for not finding any results in this analysis is the poor performance of the videos in emotion elicitation. Because the differences of the movement characteristics are compared per subject, it is important that a subject reacts strongly on a film. If a subject is already in good mood, she might already move the mouse in a specific manner. If a positive film shown makes her then feel better, the change of the mouse movement characteristics may be negligibly small. If the films shown have a strong impact, the (emotional) changes per person can be expected to be bigger and therefore possible changes of movement characteristics also should be bigger.

Another problem of the second analysis was that it focused on the emotions triggered by the positive and the negative film. The first analysis of the data, however, has shown that these two films did not differ much in the variable of arousal, which was the only variable that seemed to produce differences in the mouse movements. Here a comparison between the neutral film with another one would have made more sense, but could not be done because of the experiment design. Instead, analysis number four tried to cover this issue.

The third analysis, where the self-assessment of states was interpreted in a wider sense, showed some significant differences between the movement characteristics for the different emotional states. Arousal seemed to influence the smoothness and precision of movements. Both characteristics also seemed to be influenced by the other variables of disgust and anger.

The fourth analysis showed a strong correlation between lower arousal and mouse movement speed and precision characteristics. The film that induced significantly lower arousal also made the subjects move the mouse slower, accelerate and decelerate slower leading to a more uniform movement. It also showed that the subjects moved the mouse more directly to the target and hitting it with less clicks after watching the lower arousal film. In contrast, the higher arousal film made the subjects move the mouse with significantly less breaks. For this analysis we have to keep in mind, that the grouping was done by the film and not the real arousal values. This was because the films performed badly.

Impact of Arousal

The insight that arousal influences the ways a user moves the mouse is a core result in this study. At the same time, it is one of the most expected results to be found. Already Healey argued that arousal is much easier to spot than changes in valence [Healey and Picard, 1998]. The reason for this seems to be obvious: Changes of our arousal measure *how strongly* we feel for something (e.g. prepare for the flight-or-fight scenario), whereas the valence influences more *how* we feel *towards* something.

This can also be seen, that higher arousal makes us move the mouse faster with higher acceleration values. This leads to a less precise (uniform and less targeted) movement, that does not follow the ideal connection as good, as movements made in a state of lower arousal.

The question, why arousal influences the variables of the clicking number and the movement breaks is more difficult to answer. The analysis has shown that users with lower arousal (relaxed) need in average less clicks to perform one click on a small target ($M_{low} = 1.07$, $M_{high} = 1.11$). This could be a consequence of the alertness of the body which makes the movements less precise when preparing the body of taking actions as fast as possible instead of as precise as possible. The differences in movement breaks ($M_{low} = 3.03$, $M_{high} = 2.36$) might come from the lower urge of completing tasks and therefore slower movements when feeling relaxed.

Another explanation for the higher clicking number with higher arousal values comes from Scheirer et al. [2001] who found out that patterns of high click density occur after frustrating events in interaction. They observed that these patterns do not occur with every user but if, then only after frustrating effects. Frustration triggers high arousal and this raised arousal level might influence the mouse movement, which would suit my observations.

Impact of Disgust and Anger

The results showed that more delighted (lower level of disgust) test subjects had significantly more breaks in their movement ($M_{low} = 2.96$, $M_{high} = 2.27$). Here we have to keep in mind that the variance of both means was varying strongly. One possible explanation is that the test subjects misinterpreted the question and regarded "more delighted" as a synonym for "more comfortable" or "more relaxed" and therefore used this as another scale for arousal.

Similar thoughts might be applicable for the combined scale of valence and arousal (VA2), which measured the level of anger versus the level of contentedness. The significant differences of means can be seen in the movement variable of the clicking number, which is lower for more pleased subjects ($M_{low} = 1.12$, $M_{high} = 1.07$). Being a combined scale of arousal and valence, the results may depend on the differences in the arousal scale, since we have seen that valence has no visible impact at all. The combination of lower clicking numbers for more pleased subjects fits exactly to the results found on the pure arousal scale.

9.1.4 Conclusion

The results from the experiment show one thing clearly: The level of arousal has a significant correlation to the movement precision and smoothness. The groups with lower arousal showed significantly more precise and smooth movements. The interesting point is that the neutral film, which had the lowest arousal scores also had the lowest scores for the movement speed, acceleration/deceleration and uniformity. This could be seen as a hint that low arousal influences motion speed variables, but that this correlation was not found directly due to a type II error (β) coming from the between-subjects heterogeneity in the mouse movements.

There are two interesting questions to the results: Why did the different emotional states influence some movement variables, but not all? And why were all the speed related variables not influenced by the affective states, when they were influenced by the films?

In my opinion the answer to both questions lies in the quality of the films and the between-subject variances in moving the mouse. Even if some mouse movement variables are not related to the emotional state, so is there significant correlation showing that the mouse movement speed variables relate to the emotional state. As mentioned before, the videos did not fulfil the expectations and were weaker in emotion elicitation than intended.

Another explanation to these questions comes from the high variances between user performance in regard of mouse motion values. It is quite possible that the differences in mouse movement speeds between different persons are higher than the change of movement speed evoked by different emotional states. Especially differences between experienced users and novices might be rather big and influence comparisons across experience groups.

Since this work was seen as a proof-of-concept to show a new and cheap way to obtain information about users' emotional states, I conclude that it was successful. The results prove statistically that significant differences in the movement characteristics can be measured by the mouse. Hence, this study opens the door to deeper research into the field in order to make emotion measurement via mouse movements a cheap, reliable and objective way to measure user emotions.

9.2 Limitations of the Experiment

Since this experiment produced interesting results, it is important to ask, how valid and reliable these results are. This question is difficult to answer because in my opinion no major logical errors have occurred. However I state, that some non-critical errors have occurred during the experiment:

- Experiment execution errors.
- The videos did not elicit the expected emotions.
- Few and imprecise questions.
- Imprecision of the mouse tracks.
- Signal analysis problems.

Execution errors The experiment log can be found in the appendix in Section B.1. During execution of the experiment two errors ocurred. The first error was that the algorithm of distribution of test subjects to the two groups was buggy and assigned 22 persons into one group and 18 into the other, instead of 20 into both. Since the groups were not compared directly, this should be no critical mistake.

The second mistake was that the absolute coordinates logged by the tracker were not synchronised with the relative coordinates of the webserver. This means that the clicks used to recognise the user action of playing the video might not be found when pre-processing the mouse tracks, if the browser window with the questionnaire was moved out of the expected range. Luckily enough, this did not happen and so all data could be analysed without problems.

Videos The videos did, as we saw before, induce different emotional states in the test subjects. However, was the negative video intended to induce sadness, but in fact induced ambiguous negative feelings. Some test subjects seemed to become angry, some sad. The positive video was intended to induce the feeling of joy with high arousal and positive valence. Instead it seemed to induce a feeling of content, with a lower arousal than expected. This different outcome does not mean that the planned variables were not measurable, but it means that the affective states were less intense than planned and that more intense videos (extreme sports, tear-jerkers, etc.) probably would elicit more intense movement variables and therefore better results.

Questions Apart from the typos in some of the questions, it seems that some questions were not precise enough and they therefore were answered in a different way than expected. Here it might help to ask multiple questions to define one variable, so that subjects get reminded to consider their emotional state and the answers. Another non-critical mistake was that the age groups in the questionnaire were overlapping (e.g. "15-20" and "20-25"). This could have led to inaccurate data about the subject's age, but since this was a complementary question, it is negligible.

Measurement Imprecision The precision of measurement of the mouse tracks is obviously dependent on the processor load. A full processor load may lead to delays in the logging. By comparison of the clicking logs from both applications involved in the experiment (web-server and MouseTraX) we could see, that some entries differed by 3 to 10 milliseconds. This does influence the quality of the results but should, as it is random noise, be taken care of by the statistical tools.

Statistical Problems Some of the semantic pre-processing before applying statistics was based on thresholds (see Section 7.1.2) that had to be defined deliberately. These thresholds seemed to be not critical, but further studies into this direction might help finding better thresholds leading to better result quality.

Another statistical problem is to meet the prerequisites for the used analysis tools. ANOVA requires homogenous variances, a requirement that was somehow met. Same discrepancies of variance occurred for some of the t-Tests, which should be considered when regarding the results. Another sign for caution is the fact that there were significant differences in the means of movement speed characteristics when grouped by film, but that no significant differences of characteristics were found, when grouping by one of the self-assessment questions.

9.3 Proposals of Improvement and Additional Work

When more work based on this project is planned to be done, some improvements should help avoiding the problems discussed above to receive better results.

videos For a similar experiment, better videos should be used. For instance videos of extreme sports experiences and tear-jerkers should trigger more intense affective states.

questions The questions should be worked over and made more precise and maybe redundant.

threshold values For the statistical preparation, the data has to be manipulated and cleaned. This needs threshold values that are deliberately chosen. Some further research and testing should help finding empirical thresholds.

variables Some of the variables should be redefined. For example, the variable of expertise (e.g. experts vs. novices) could be chosen as an independent variable. This could address the problem of high variances in movement speed. In the same sense, new movement characteristics could be created. Combinations of present variables (e.g. movement targeting in relation to movement speed) could deliver new insights. Furthermore, it could be interesting to weight the importance of variables by answers about how irritating the surrounding environment is.

thoroughness A longer rerun of the experiment that features more videos and affective states could help finding more detailed results. Focus on the per-person differences (e.g. by long-term observation, learning algorithms, neuronal networks, etc.) could bring new insights.

9.4 Summary

In this chapter, I have shown the conclusions of the conducted experiment results. The central result is that different levels of arousal correlate significantly with the mouse movement speed, acceleration, uniformity, precision and smoothness. This means that the mouse can be used to measure affective states of the user, even if the measure for valence in not discovered yet. Furthermore, I showed limitations to the results and discussed the errors made. Finally, I proposed a set of improvements for follow-up experiments.

Chapter 10

Outlook and Recommendations

This last chapter covers the future outlook and recommendations after completion of this work. I will not cover the outlook or feature requests for the software here. These can be found in the documentation (Chapter C) instead. In this chapter I will start with covering interesting items for further research. Then, I will discuss briefly open issues that represent interesting problems related to this work. I will end this chapter with an outlook on what future might bring.

10.1 Follow-up Research

This research work covers a small part of the big field of affective computing. Huge areas, like the processing of the knowledge about users' emotional states and how to influence these, have stayed untouched. Also the area of recognition of emotions by mouse motions is far from being completely discovered. So for example, the detection of positive and negative valence is still an open issue, just like definition of precise measures to detect different emotions.

Some reasonable follow-up experiments became pretty obvious when completing this work, and I want to state them here (see also the proposals of improvements in Section 9.3):

Arousal Detection As I have concluded in Section 9.1.4, arousal levels can be distinguished by different values of movement precision. Indicators seem to suggest, that arousal can also be measured by movement speed characteristics (MS, MA/MD and MU). Therefore I recommend further research into this direction by comparing changes of movement speed characteristics per subject, instead of between groups.

Valence Detection To detect the positive and negative valence we need to find new ways to measure how a person feels an emotion. It probably requires a creative idea, how to measure, if the user is in a positive or negative state right now. Further advances in field of psychology may help to find a solution.

Mood Recognition Since moods are similar to emotions, but last longer, they also might be measurable by this method. This could be done by creating an application that not just measures the mouse motions, but also creates a movement profile for the user by clustering. Such a program might be capable of detecting accumulations and tendencies of specific movement values and might be able to detect temporary shifts in the moods.

Movement Characteristics Evaluation A question closely related to this work is the question about how well different movement characteristics measure what they should. It would be an interesting task to test, how accurately characteristics like movement breaks or clicking number really represent what actually happened. This is tightly related to the question of signal analysis and how it is possible to recognise in the mouse tracks, if the user stopped to move the mouse or just moved it slowly. Answering this question experimentally could give new and interesting clues about how human actions can be analysed and would probably contribute to more precise estimations of emotional states.

10.2 Open Issues

One big open issue is the ethical question, if it is OK for machines to tamper actively with human emotions. Somehow they already now influence us since they, for example, drive us mad. Does this give machines the right or obligation to also try to alleviate these emotions? This question should be discussed, because the field of affective computing becomes more important. Is emotional manipulation, as it is already used in cinema, marketing or politics and by other people including our friends, good or bad? Does such tampering with human emotions by machines contradict Asimov's first law of robotics ("A robot may not harm a human being, or, through inaction, allow a human being to come to harm." [Wikipedia, 2005])?

Tightly connected is the question, if it is useful to give machines emotions. For us humans, emotions are an integral part and one reason why we still exist. Would it therefore not be useful to give similar enhancements to machines? What would be the results of such an upgrade to machines? Would this mean that we first need to get the interest of our computer at the workplace, before we can start working? What influence would this have on our culture? Picard did not go deep into this question, but stated one important thing: Computers that can be critical to human survival (e.g. aeroplane computers), should not have emotions, and computers with emotions should not be critical for human survival [Picard, 1997]. How far this request can be fulfilled and in how far artificial intelligence and logic play a role in this decision needs further discussion. Interesting input into this direction come from texts by Isaac Asimov, author of the three laws of robotics, and other more commercial dealings with the topic. Some of these are Stanley Kubrick's "2001: A Space Odyssey", 20th Century Fox' film "I, Robot" or Philip Kerr's book "The Grid".

10.3 Future Outlook

Picard argues in her article [Picard, 1997] that for creative computers two parts are needed. A mind that can be simulated via rules and a bodily part that influences the attention of the mind or bias decisions by biochemical flows. This would lead to creative and non-decision-impared computers. Since rule-based systems can be rendered into un-decidable problems, emotions can help to resolve such stale-mate situations.

Until we reach such an intelligent and humanoid machine it still might take some time, but the direction is clear. Work is done on both, the artificial intelligence and the affective computing track. Both tracks do not just head for a humanoid machine as a target, but also bring us new insights on how we work as humans, since they simulate and try to reconstruct our human way of functioning. The byproducts of both tracks might be implemented in our surrounding machines and environment hoping that our life thus becomes easier. If the target of an easier life will ever be met, is another question. I guess that it is safe to say that our lives of interacting with machines will become enriched and probably also more contradictive after machines learn to have an own and "free" will.

10.4 Summary

In this chapter I have shown some of the future perspectives, where affective computing might head to with refined movement characteristics calculations and clustering algorithms. I have named unresolved issues that need discussion, such as privacy, and given a short glimpse on what might come next. I also named some topics that could be interesting to work on as next steps to enhance the results shown in this work and to enable emotion measurement via mouse motions, like for example refining threshold values and closer observation of user intentions and mouse movements.

Appendix A

Experimental Variables

Here you can find the legend of the experimental variables. These consist out of four type of variables. First, there are assigned values like ID, or the group, where the subject belongs to. Then, there are the variables for m the questionnaire: the descriptive variables that contain age, gender or experience and then the self-assessment variables. The self-assessment variables were repeated after each video in each part of the test and provided the subjects the possibility to estimate their subjective emotional state. Last, there are the mouse movement variables which were calculated for each part of the test.

A.1 Assigned Variables

These variables have been set by the web application and are used to define the test subject and the positions in the experiment.

abb.	name	column	type	values	description
no	number	1	ID	1 - 40	test person id.
dir	direction	2	dichotomous	neg: 1 pos: 2	negative or positive video first.
FILM	film	10	nominal	negative: 1 neutral: 2 positive: 3	the film shown

Table A.1: Legend of the Assigned Experiment Variables.

A.2 Descriptive Variables

These variables are general information that describes the experimental sample. No analysis was made on the basis of these variables.

abb.	name	column	type	values
gen	gender	3	dichotomous	female: 1 male: 2
"I am ... ."				
age	age	4	normal	00-15: 1 15-20: 2 20-25: 3 25-30: 4 30-35: 5 35-50: 6 50 or older: 7
"I am ... years old."				
exp	expertise	5	normal	never: 1 all the time: 7
"I use the computer ... ."				
tem	temperament	6	normal	never: 1 always: 7
"I ... get angry on machines/computers."				
fru	frustration	7	normal	never: 1 always: 7
"I ... get frustrated by the system that I use."				
gee	geekness	8	normal	never: 1 always: 7
"I ... prefer communicating with computers to communicating with humans."				
con	control	9	normal	never: 1 always: 7
"I feel that I am ... in control of the computer and not the other way round."				

Table A.2: Legend of the Descriptive Experiment Variables.

A.3 Self-Assessment Variables

These variables were used as basis to verify or falsify the hypotheses. These were self-assessment values and subjective answers. The capitalised variables are the operators for the independent variables.

abb.	name	column	type	values
VA1	overall	11	normal	great: 1 bad: 7
"I feel ... "				
in1	influence	12	dichotomous	false: 0 true: 1
"The media item did not influence me at all."				
VAL	valence	13	normal	sadder: 1 happier: 7
"The media item made me feel ... than before."				
env	environment	14	dichotomous	false: 0 true: 1
"I feel irritated by the environment."				
VA2	angrier	15	normal	angrier: 1 more pleased: 7
"The media item made me feel ... than before."				
in2	influence	16	dichotomous	false: 0 true: 1
"The media item managed to influence my emotional state."				
DIS	disgust	17	normal	more delighted: 1 more disgusted: 7
"The media item made me feel ... than before."				
val2	valence	18	dichotomous	false: 0 true: 1
"I feel neither happy nor sad."				
irr	irritation	19	dichotomous	false: 0 true: 1
"I felt irritated by the media item."				
com	comfort	20	dichotomous	false: 0 true: 1
"I feel comfortable."				
dist	distract	21	dichotomous	false: 0 true: 1
"This questionnaire distracts me."				
ARO	arousal	22	normal	more relaxed: 1 more excited: 7
"The media item made me feel ... ."				

Table A.3: Legend of the Self-Assessment Variables.

A.4 Mouse Movement Variables

These are the operators for the dependent variables and were calculated by the algorithms presented in Section 7.2.2.

abb.	name	column	type	values
CD	Clicking Duration	29	normal	0 - ∞
CN	Clicking Number	27	normal	1 - ∞
MA	Movement Acceleration	26	normal	0 - ∞
MB	Movement Breaks	28	normal	0 - ∞
MD	Movement Deceleration	24	normal	0 - ∞
ME	Movement Efficiency	23	normal	1 - ∞
MS	Movement Speed	32	normal	0 - ∞
MT	Movement Targeting	31	normal	0 - ∞
MU	Movement Uniformity	30	normal	0 - ∞
OL	Overshot Length	25	normal	0 - ∞
ON	Overshot Number	33	normal	0 - ∞

Table A.4: Legend of the Mouse Movement Variables.

Appendix B

Raw Data

In this part of the appendix you will find the different tables with raw and cleaned data.

B.1 Experiment Log

Following log shows all notable incidents that occurred while test subjects completed the experiment.

2005-05-12 19:20 Test computer goes in sleep mode as battery is empty. Test continued when computer was woken up.

2005-05-13 10:23 Test subject used browser back button. Total data set was dumped.

2005-05-13 12:39 Test restarted after the first video, as the subject did not watch it. Initial data dumped.

2005-05-13 16:45 Test subject forgot to watch video, showed by different means, resulting in extra (invalid?) mouse data.

B.2 Raw Descriptive Experiment Data

The following table (B.2) contains the raw data from the general part of the experiment, which is the important part for the descriptive statistics. For the meaning of the values see Section A.2.

NO	DIR	gender	age	expertise	temperament	fustration	geek	control
1	2	1	3	3	2	1	1	4
2	2	1	3	7	2	3	2	5
3	1	1	3	5	1	2	1	7
4	2	2	3	6	4	4	1	7
5	1	2	3	6	4	4	2	5
6	2	2	3	7	3	6	6	5
7	2	1	3	7	4	6	1	4
8	2	2	3	5	3	3	4	5
9	1	2	3	5	2	2	2	6
11	1	2	3	7	5	5	4	6
12	1	2	6	7	2	2	1	6
13	2	2	3	5	3	4	2	5
14	2	2	3	6	6	5	5	5
15	1	1	3	6	7	1	1	7
16	2	2	4	7	4	5	2	4
17	1	2	3	7	2	3	2	5
18	1	2	4	5	1	2	2	4
19	1	1	4	4	7	7	4	1
20	1	1	4	7	5	5	1	4
21	2	2	4	6	5	5	3	5
22	2	2	3	6	5	5	2	5
23	1	2	3	5	3	3	3	4
24	2	1	5	7	3	2	1	6
25	1	1	5	7	4	4	2	7
26	2	1	5	7	3	4	2	7
27	2	1	3	5	4	5	2	6
28	1	1	3	7	3	4	1	6
29	1	1	3	7	2	3	3	5
30	1	2	3	6	2	3	2	2
31	1	2	3	5	3	3	1	5
32	2	2	3	5	4	4	2	5
33	1	2	5	7	3	2	4	6
34	2	2	3	6	2	3	2	6
35	1	1	3	3	5	5	1	3
36	1	1	3	7	5	5	2	4
37	1	1	2	3	5	3	1	4
38	1	1	3	5	3	3	3	6
39	1	2	3	6	2	2	2	7
40	2	2	3	5	2	4	2	5

Table B.1: Raw Descriptive Experiment Data:

Note. DIR 1 stands for the negative film first, 2 for the positive film first.

B.3 Experiment Data Grouped by Film

The following table (B.2) contains the raw data from the experiment; sorted, cleaned and grouped by the film.

B.3.1 Experiment Data by Films pt.1: Negative

no.	VA1	VAL	VA2	DIS	ARO	ME	MD	OL	MA	CN	MB	CD	MU	MT	MS	ON
1	2	3	3	4	4	1.152	0.0082	20.3774	0.019	1.04	2.6364	141.83	0.319	10.3792	0.2706	1.4545
2	4	3	5	3	2	1.4295	0.0048	4.6451	0.0175	1.04	1.5833	105.59	0.1912	4.4915	0.1378	0.25
3	1	4	4	4	2	1.1637	0.0073	41.2074	0.0453	1.15	3	124.42	0.2453	6.0336	0.1857	0.7857
4	3	4	4	4	4	1.1044	0.0103	20.9857	0.0554	1.2	1.7778	90.61	0.3831	4.0335	0.2564	0.4444
5	4	4	3	4	4	1.0929	0.0036	24.3042	0.0119	1.14	1.8	138.88	0.1518	3.5696	0.1124	0.2
6	4	3	4	5	4	1.0983	0.0054	16.9971	0.0082	1.11	3.4545	112.13	0.2196	4.4749	0.1736	0.7273
7	3	4	4	4	4	1.1024	0.0035	4.7708	0.0051	1.07	1.3636	115.07	0.1707	3.1096	0.1195	0.7273
8	3	5	5	3	2	1.1236	0.0057	8.1056	0.0221	1.21	3.5714	141.85	0.2491	6.5171	0.1735	0.2857
9	3	2	3	5	5	1.0966	0.0039	20.494	0.0074	1	2.6667	90.18	0.187	3.4569	0.1224	0.7778
11	5	3	3	5	5	1.2197	0.006	32.5621	0.0079	1.15	1.9091	115.06	0.2564	4.1145	0.137	0.3636
12	2	3	4	4	4	1.1017	0.003	9.3992	0.0061	1	2.2727	191.25	0.1667	4.67	0.1236	0.8182
13	1	4	4	4	4	1.1676	0.0045	9.989	0.0133	1.11	2.25	178.26	0.1928	4.5814	0.1684	0.8333
14	4	2	2	5	3	1.1057	0.0061	21.1031	0.0131	1.04	1.3	91.89	0.229	4.084	0.1601	0.6
15	6	1	2	7	4	1.2319	0.0146	19.3301	0.0609	1.33	2.9091	143.97	0.4166	12.9223	0.3335	1
16	5	3	4	5	5	1.1002	0.0062	4.217	0.0222	1.17	1.1538	133.89	0.2708	5.3767	0.1438	0.4615
17	2	3	3	5	4	1.0803	0.0044	116.5162	0.0079	1.14	2.5	87.16	0.1857	5.0456	0.1602	0.75
18	4	4	4	4	4	1.153	0.0079	26.8796	0.011	1	3.6	106.11	0.2581	6.717	0.2309	0.9
19	3	6	6	2	6	1.1189	0.0052	12.5021	0.0164	1.04	2.6667	214.79	0.185	4.4892	0.1232	0.8889
20	5	3	4	5	4	1.2769	0.007	25.855	0.0115	1.11	3.0833	124	0.299	11.3757	0.2369	2.1667
21	5	3	4	4	4	1.0867	0.0039	40.0207	0.0282	1.04	3.0769	139.17	0.1745	4.153	0.1625	0.8462
22	5	3	3	6	5	1.0842	0.0053	11.6503	0.0138	1.13	1.6923	127.03	0.2246	4.4566	0.1644	0.6923
23	4	4	4	4	4	1.1374	0.005	20.8681	0.0111	1.04	2.8	109.38	0.2106	4.1829	0.1497	1
24	2	4	4	4	4	1.1711	0.0098	17.2899	0.0399	1.03	2.5385	115.07	0.2932	8.026	0.2786	0.8462
25	5	2	3	4	4	1.0933	0.0042	9.6985	0.0069	1.07	2.5	144.38	0.1809	3.234	0.115	0.4
26	7	1	3	3	4	1.1159	0.0079	39.223	0.0262	1.04	2	102.71	0.3213	6.9775	0.1737	0.9091
27	5	3	3	5	4	1.1203	0.0034	5.1562	0.0046	1.07	1.75	104.97	0.1653	5.2952	0.1125	0.6667
28	6	1	1	4	4	1.1422	0.0044	15.0317	0.008	1	1.4444	153.46	0.2057	6.6359	0.1517	0.7778
29	3	3	4	5	5	1.1135	0.0049	10.3121	0.0083	1.04	2.5455	81.83	0.2097	4.6694	0.155	0.7273
30	2	3	4	4	4	1.1405	0.0043	38.0682	0.0061	1.11	3.5	191.06	0.1874	4.327	0.154	0.7857
31	6	3	4	4	3	1.2002	0.0065	17.5166	0.0138	1.06	4.0909	115.21	0.2343	3.116	0.1852	1.4545
32	5	1	2	6	5	1.1997	0.0075	8.2437	0.0163	1.19	2.6667	125.31	0.2448	4.2396	0.234	0.6667
33	3	3	3	4	4	1.1472	0.0043	5.6359	0.0098	1.15	4	135.52	0.159	2.4085	0.1145	2.125
34	3	3	4	4	4	1.1153	0.0045	35.4535	0.0079	1.04	2.4	113.14	0.18	3.1909	0.1236	0.6
35	7	4	3	4	4	1.0892	0.0062	37.6813	0.0414	1.2	4	165.61	0.2511	5.9819	0.1866	1.5
36	5	3	2	5	5	1.2449	0.0091	18.9981	0.0231	1.22	3.8182	110.85	0.3591	6.1551	0.2763	1.9091
37	5	2	2	6	5	1.128	0.0049	18.4589	0.0136	1.07	2.5556	152.7	0.1651	5.7106	0.1541	0.6667
38	4	2	3	6	5	1.1341	0.0035	11.3257	0.0079	1.04	2.8333	146.9	0.1372	3.3914	0.1092	0.6667
39	2	3	4	5	3	1.0912	0.0045	10.3795	0.0062	1.29	0.9444	143.61	0.2036	6.3488	0.1715	0.2778
40	4	3	3	5	5	1.1008	0.0051	14.7093	0.0096	1.17	1.4667	138.12	0.2473	4.055	0.1405	0.6

Table B.2: Experiment Data by Films pt.1: Negative

B.3.2 Experiment Data by Films pt.2: Neutral

NO	VA1	VAL	VA2	DIS	ARO	ME	MD	OL	MA	CN	MB	CD	MU	MT	MS	ON
1	1	4	4	4	4	1.1484	0.0093	86.6157	0.0254	1.02	4.4444	153.84	0.3574	8.2892	0.2728	1.3889
2	4	5	5	5	3	1.1228	0.0043	1.2649	0.0074	1.07	2	99.84	0.1448	3.3874	0.1229	0.5
3	1	5	7	2	7	1.1495	0.0045	10.5802	0.008	1.02	3.5263	127.02	0.1635	3.8452	0.1338	1.0526
4	2	5	4	4	4	1.0726	0.0065	23.3979	0.0216	1.16	2.2083	94.79	0.2532	3.2839	0.206	0.7083
5	5	5	5	5	3	1.1057	0.0035	3.9897	0.0047	1.02	2.8095	142.83	0.143	2.6403	0.1109	1
6	4	4	4	4	4	1.1384	0.005	31.4745	0.0126	1.09	3.1053	128.65	0.1994	3.6575	0.1374	0.7895
7	4	4	4	4	4	1.1496	0.0044	25.2695	0.0081	1.12	3.45	134.96	0.1702	2.8567	0.1374	0.35
8	1	5	5	3	3	1.3875	0.0058	20.8765	0.0113	1	3.1333	126.2	0.2719	6.039	0.1625	1.3333
9	2	5	5	3	2	1.1218	0.003	11.9002	0.0041	1.02	2	109.47	0.1388	2.6041	0.0928	0.8125
11	2	5	5	3	3	1.0973	0.0043	28.0612	0.0064	1.05	3.5333	116.53	0.1953	3.3681	0.1171	0.9333
12	2	6	6	1	4	1.154	0.0034	26.5768	0.0136	1	5.2105	183.12	0.1506	3.2748	0.1112	0.9474
13	1	5	5	3	2	1.1253	0.0031	8.9782	0.0046	1.05	3.2353	183.33	0.1495	3.223	0.1111	0.5294
14	2	5	5	3	3	1.1425	0.0034	15.3648	0.0069	1	3.0588	104.27	0.1553	3.3507	0.0964	0.7647
15	1	4	4	4	2	1.1968	0.0064	9.4995	0.0083	1.17	1.8333	147.54	0.2398	9.581	0.2163	0.8333
16	1	7	7	1	1	1.0911	0.0062	4.9978	0.0108	1.07	2.1111	209.02	0.2487	3.873	0.1641	0.8333
17	2	5	6	2	2	1.0915	0.0037	21.2479	0.0088	1.02	3	91.81	0.1555	3.4357	0.1373	1.1053
18	2	5	5	3	3	1.2601	0.0052	22.1278	0.0076	1.05	4.875	115.5	0.1806	4.0583	0.1526	1.9375
19	3	4	4	7	5	1.1039	0.0052	14.6944	0.0077	1	2.1176	217.49	0.206	4.3035	0.1412	0.7059
20	5	7	7	1	1	1.334	0.0071	32.0881	0.021	1.2	2.5882	130.57	0.3159	14.9974	0.244	1.0588
21	4	3	4	3	3	1.1305	0.0033	6.8945	0.0084	1.02	3.2105	160.74	0.1306	2.8011	0.1049	1.2632
22	3	5	5	2	3	1.1351	0.005	35.6271	0.0077	1.1	3.0588	136.65	0.1882	4.26	0.1447	0.8824
23	3	5	5	3	2	1.1356	0.004	14.731	0.0067	1.07	3.0667	102.02	0.1547	2.873	0.1133	0.6
24	1	4	4	4	4	1.1105	0.0058	19.3191	0.0199	1.05	2.0588	121.09	0.2482	6.5182	0.1899	0.6471
25	1	5	5	5	3	1.0904	0.0039	50.5508	0.0053	1.05	1.4286	162.93	0.1891	3.6397	0.12	0.4286
26	1	6	5	4	3	1.1133	0.006	8.9725	0.0088	1.05	1.8824	122.41	0.2701	5.5704	0.1467	0.7059
27	3	5	6	3	3	1.1077	0.0031	19.4585	0.0057	1	2.0588	116.63	0.1702	3.0877	0.0954	0.8235
28	2	7	7	1	1	1.1043	0.0046	30.5823	0.0067	1	4.6429	191.86	0.1909	4.3819	0.1546	1
29	2	5	6	1	2	1.1434	0.0044	20.2	0.0074	1.02	2.0526	94.67	0.1763	3.8852	0.1346	0.3158
30	1	5	4	3	2	1.2762	0.0038	8.9962	0.008	1.17	3.3889	205.69	0.1758	4.9242	0.1413	0.9444
31	4	3	4	3	3	1.1344	0.0053	21.652	0.0088	1.14	5.6471	134.38	0.1673	2.7623	0.1371	1.3529
32	3	5	5	3	1	1.1726	0.007	10.7359	0.0314	1.16	5.2222	132.14	0.2449	5.2766	0.2019	0.8889
33	2	5	6	3	3	1.1866	0.0039	12.1218	0.0085	1.17	4.1579	139.37	0.1464	2.5823	0.1098	0.8947
34	1	6	7	1	1	1.0843	0.006	7.7825	0.0125	1.07	2.1875	104.82	0.2114	3.0976	0.1551	0.75
35	7	5	5	2	2	1.109	0.0058	11.3788	0.0104	1.14	2.7241	179.84	0.2187	6.065	0.1588	0.7241
36	3	3	3	3	4	1.0951	0.0067	19.3321	0.0091	1.12	2.3684	114.35	0.237	5.1522	0.1799	0.6316
37	1	6	6	2	1	1.1684	0.0038	18.7782	0.0061	1.05	4.5	137.69	0.1526	3.5612	0.1442	1.25
38	2	3	4	4	4	1.1336	0.0039	30.6136	0.0117	1.09	3.0769	148.79	0.1744	3.2987	0.1122	1.1538
39	1	5	5	2	2	1.1678	0.0037	8.3651	0.0053	1.09	1.6429	137.44	0.1726	7.4809	0.1304	0.4286
40	5	4	6	2	2	1.0847	0.0056	24.8059	0.0082	1.05	1.8125	105.45	0.2261	3.9834	0.1361	0.5625

Table B.2: Experiment Data by Films pt.2: Neutral

B.3.3 Experiment Data by Films pt.3: Positive

no.	VA1	VAL	VA2	DIS	ARO	ME	MD	OL	MA	CN	MB	CD	MU	MT	MS	ON
1	1	5	4	4	4	1.1369	0.0104	31.312	0.0162	1.07	1.75	133.69	0.4221	12.7968	0.3321	1.0833
2	3	5	5	3	5	1.1098	0.0049	12.6105	0.0105	1.04	2.5	108.75	0.192	3.6034	0.162	0.5
3	1	5	5	3	5	1.1981	0.0058	28.7783	0.0113	1.04	4.0833	126.14	0.1952	4.1936	0.1596	1.5833
4	2	5	5	3	3	1.083	0.0073	20.7004	0.0305	1.21	1.7692	84	0.3239	3.2981	0.2073	0.6923
5	4	4	4	4	4	1.0668	0.0045	38.3266	0.011	1.21	1.2857	139.56	0.2025	4.5356	0.159	0.4286
6	4	5	5	4	4	1.1315	0.0061	30.5419	0.0102	1.15	2.7333	116.9	0.2515	5.5048	0.1873	0.8
7	4	4	4	4	4	1.0952	0.0046	20.4963	0.0083	1.07	2.0833	130.37	0.2134	3.9629	0.1392	0.3333
8	4	4	4	4	4	1.1419	0.0058	5.7581	0.01	1.07	2	133.42	0.2711	6.0516	0.1611	0.6
9	2	6	6	1	2	1.1202	0.0034	6.7887	0.006	1	2.6923	99.21	0.1429	3.0658	0.1099	0.5385
11	3	5	6	3	3	1.1038	0.0057	10.0809	0.0333	1.11	2.3636	124.93	0.2431	5.4407	0.1827	0.2727
12	2	6	6	2	4	1.1218	0.0038	13.4356	0.0138	1	2.4	193.81	0.1541	4.0897	0.1427	0.8
13	1	7	6	2	2	1.1458	0.0053	15.5588	0.041	1.11	2.8462	168.81	0.1905	3.6318	0.1354	0.7692
14	3	7	6	3	6	1.1092	0.004	13.3185	0.0094	1.04	1.5385	95	0.1729	3.3092	0.1056	0.4615
15	3	4	4	4	4	1.3704	0.0091	31.9821	0.0132	1.41	1.9231	143.84	0.2977	16.0828	0.3378	0.6154
16	4	5	4	5	4	1.0809	0.0053	19.64	0.008	1.04	2.25	136.36	0.2297	3.3611	0.151	0.9167
17	1	6	6	2	3	1.2872	0.0043	45.9658	0.0104	1	1.5	88.46	0.1839	4.6303	0.1552	0.4167
18	2	6	6	2	3	1.196	0.0061	32.4603	0.008	1.11	6.6364	102.83	0.1942	4.6305	0.1887	1.1818
19	4	5	6	2	2	1.1494	0.0047	29.2471	0.0072	1	2.7778	210.15	0.1837	4.9068	0.1395	0.8889
20	2	6	7	1	6	1.4092	0.0078	44.2034	0.021	1.07	2.6364	136.69	0.3299	16.5669	0.3041	1.3636
21	3	3	4	3	5	1.2716	0.0034	4.5012	0.0073	1	3.4167	150.7	0.1377	3.339	0.1159	0.5
22	3	6	6	2	3	1.1131	0.0082	21.6903	0.0133	1.14	2.3846	127.59	0.3108	6.0481	0.2092	0.9231
23	4	5	4	3	5	1.1214	0.0054	19.4755	0.0175	1.11	1.6667	104.5	0.2177	5.5942	0.1599	0.5833
24	2	6	5	4	4	1.1148	0.0066	25.0718	0.017	1.04	1.9231	117.71	0.2908	8.8441	0.243	0.6923
25	1	7	5	4	3	1.1448	0.006	6.3805	0.0172	1.11	1	145.84	0.2603	6.6561	0.1374	0.6364
26	1	7	7	1	1	1.1041	0.0075	12.217	0.0117	1.07	1.4167	107.14	0.3338	4.5654	0.1809	0.5833
27	2	5	5	3	5	1.1123	0.0032	2.5916	0.0041	1	2.1	108.74	0.1573	4.3607	0.1105	0.6
28	3	3	5	3	4	1.0827	0.0042	7.498	0.0074	1.03	3.0909	146.65	0.2145	6.0351	0.1669	1.3636
29	2	5	6	2	4	1.13	0.0054	8.7342	0.0152	1	3.5833	80.25	0.2236	3.7578	0.1369	1
30	1	5	6	4	5	1.1691	0.0038	12.5887	0.0111	1.07	2.6923	136.25	0.1817	5.7935	0.1525	0.8462
31	3	5	5	3	3	1.12	0.006	41.0467	0.0091	1.07	3.8889	116.6	0.2122	2.9084	0.151	0.6667
32	4	5	5	4	4	1.1669	0.0088	20.5073	0.0158	1.21	6.3571	127.77	0.2646	4.291	0.2326	1.5714
33	3	6	6	2	4	1.1159	0.0049	32.09	0.0214	1.11	3.3	156.07	0.206	3.0902	0.1362	0.8
34	1	7	7	2	4	1.0992	0.0061	12.714	0.0124	1.19	2.1818	106.66	0.2399	3.1073	0.1555	1.5455
35	7	4	4	4	4	1.2115	0.0066	27.9802	0.0079	1.23	2.8	246.88	0.2671	9.3072	0.1877	1.2
36	2	7	6	2	2	1.0855	0.0074	47.8797	0.021	1.29	3.7778	114.61	0.2719	3.6164	0.1918	1.7778
37	2	6	6	2	2	1.2036	0.0047	18.7934	0.0107	1.04	1.75	143.29	0.1929	6.0587	0.2045	0.75
38	1	7	7	2	7	1.1108	0.0057	9.6525	0.0619	1	2.4444	137.11	0.216	2.5459	0.1376	0.4444
39	2	4	4	4	4	1.1297	0.005	30.3425	0.0082	1.29	1.7857	121.42	0.2115	4.202	0.1711	0.4286
40	2	6	4	2	5	1.1043	0.0066	69.3677	0.0161	1.07	2.2857	106.71	0.2679	4.0426	0.1407	0.3571

Table B.2: Experiment Data by Films pt.3: Positive

B.4 Experiment Data Manipulated by Reflexive Arousal

The following table (B.3) shows the experiment data sorted and cleaned, grouped by the arousal change compared to before the film.

NO	ARO	ΔME	ΔMD	ΔOL	ΔMA	ΔCN	ΔMB	ΔCD	ΔMU	ΔMT	ΔMS	ΔON
2	1	0.3197	-0.0001	-7.9654	0.0070	0.0000	-0.9167	-3.1600	-0.0008	0.8881	-0.0242	-0.2500
3	1	0.0142	0.0028	30.6272	0.0373	0.1300	-0.5263	-2.6000	0.0818	2.1884	0.0519	-0.2669
4	1	0.0104	0.0008	-2.6975	0.0089	0.0500	-0.4391	-10.7900	0.0707	0.0142	0.0013	-0.0160
8	1	-0.0183	-0.0001	2.3475	0.0121	0.1400	1.5714	8.4300	-0.0220	0.4655	0.0124	-0.3143
9	1	0.0236	-0.0005	-13.7053	-0.0014	0.0000	0.0256	9.0300	-0.0441	-0.3911	-0.0125	-0.2393
11	1	-0.1159	-0.0003	-22.4812	0.0254	-0.0400	0.4545	9.8700	-0.0133	1.3262	0.0457	-0.0909
13	1	0.0205	0.0022	6.5806	0.0364	0.0600	-0.3891	-14.5200	0.0410	0.4088	0.0243	0.2398
14	1	-0.0035	0.0021	7.7846	0.0037	0.0000	-0.2385	-3.1100	0.0561	0.7748	0.0545	0.1385
17	1	0.2069	-0.0001	-70.5504	0.0025	-0.1400	-1.0000	1.3000	-0.0018	-0.4153	-0.0050	-0.3333
18	1	0.0430	-0.0018	5.5807	-0.0030	0.1100	3.0364	-3.2800	-0.0639	-2.0865	-0.0422	0.2818
19	1	0.0305	-0.0005	16.7450	-0.0092	-0.0400	0.1111	-4.6400	-0.0013	0.4176	0.0163	0.0000
22	1	-0.0220	0.0032	-13.9368	0.0056	0.0400	-0.6742	-9.0600	0.1226	1.7881	0.0645	0.0407
25	1	0.0515	0.0018	-3.3180	0.0103	0.0400	-1.5000	1.4600	0.0794	3.4221	0.0224	0.2364
26	1	-0.0092	0.0015	3.2445	0.0029	0.0200	-0.4657	-15.2700	0.0637	-1.0050	0.0342	-0.1226
31	1	0.0658	0.0012	-4.1354	0.0050	-0.0800	-1.5562	-19.1700	0.0670	0.3537	0.0481	0.1016
31	1	-0.0802	-0.0005	23.5301	-0.0047	0.0100	-0.2020	1.3900	-0.0221	-0.2076	-0.0342	-0.7878
36	1	-0.1594	-0.0017	28.8816	-0.0021	0.0700	-0.0404	3.7600	-0.0872	-2.5387	-0.0845	-0.1313
37	1	0.0756	-0.0002	0.3345	-0.0029	-0.0300	-0.8056	-9.4100	0.0278	0.3481	0.0504	0.0833
39	1	-0.0766	0.0008	2.0144	0.0009	0.2000	-0.6985	6.1700	0.0310	-1.1321	0.0411	-0.1508
2	2	-0.0130	0.0006	11.3456	0.0031	-0.0300	0.5000	8.9100	0.0472	0.2160	0.0391	0.0000
3	2	0.0344	-0.0015	-12.4291	-0.0340	-0.1100	1.0833	1.7200	-0.0501	-1.8400	-0.0261	0.7976
9	2	-0.0252	0.0009	8.5938	0.0033	-0.0200	0.6667	-19.2900	0.0482	0.8528	0.0296	-0.0347
11	2	0.1224	0.0017	4.5009	0.0015	0.1000	-1.6242	-1.4700	0.0611	0.7464	0.0199	-0.5697
14	2	-0.0333	0.0006	-2.0463	0.0025	0.0400	-1.5203	-9.2700	0.0176	-0.0415	0.0092	-0.3032
16	2	0.0193	0.0009	-15.4230	0.0142	0.1300	-1.0962	-2.4700	0.0411	2.0156	-0.0072	-0.4552
19	2	0.0150	0.0000	-2.1923	0.0087	0.0400	0.5491	-2.7000	-0.0210	0.1857	-0.0180	0.1830
20	2	0.1323	0.0008	18.3484	0.0095	-0.0400	-0.4469	12.6900	0.0309	5.1912	0.0672	-0.8031
21	2	0.1411	0.0001	-2.3933	-0.0011	-0.0200	0.2062	-10.0400	0.0071	0.5379	0.0110	-0.7632
22	2	-0.0289	-0.0029	-10.0400	0.0005	-0.0100	-0.6923	-0.5600	-0.0862	-1.5915	-0.0448	-0.2308
23	2	-0.0160	0.0004	-1.3926	0.0064	0.0700	-1.1333	-4.8800	0.0071	1.4113	0.0102	-0.4167
27	2	0.0046	0.0001	-16.8669	-0.0016	0.0000	0.0412	-7.8900	-0.0129	1.2730	0.0151	-0.2235
29	2	-0.0299	0.0005	-9.8879	0.0009	0.0200	0.4929	-12.8400	0.0334	0.7842	0.0204	0.4115
30	2	0.0286	-0.0005	-25.4795	0.0050	-0.0400	-0.8077	-54.8100	-0.0057	1.4665	-0.0015	0.0605
32	2	0.0328	-0.0013	-12.2636	0.0005	-0.0200	-3.6904	-2.4600	-0.0198	-0.0514	0.0014	-0.9047
36	2	0.1498	0.0024	-0.3340	0.0140	0.1000	1.4498	-3.5000	0.1221	1.0029	0.0964	1.2775
37	2	-0.0404	0.0011	-0.3193	0.0075	0.0200	-1.9444	15.0100	0.0125	2.1494	0.0099	-0.5833
38	2	0.0005	-0.0004	-19.2879	-0.0038	-0.0500	-0.2436	-1.8900	-0.0372	0.0927	-0.0030	-0.4871
38	2	-0.0233	0.0022	-1.6732	0.0540	-0.0400	-0.3889	-9.7900	0.0788	-0.8455	0.0284	-0.2223
40	2	-0.0035	-0.0015	-54.6584	-0.0065	0.1000	-0.8190	31.4100	-0.0206	0.0124	-0.0002	0.2429
40	2	0.0196	0.0010	44.5618	0.0079	0.0200	0.4732	1.2600	0.0418	0.0592	0.0046	-0.2054

Table B.3: Experiment Data by Reflexive Arousal.

B.5 Experiment Data Manipulated by Reflexive Disgust

The following table (B.4) shows the experiment data sorted and cleaned, grouped by the disgust change compared to before the film.

NO	DIS	ΔME	ΔMD	ΔOL	ΔMA	ΔCN	ΔMB	ΔCD	ΔMU	ΔMT	ΔMS	ΔON
2	1	0.3197	-0.0001	-7.9654	0.0070	0.0000	-0.9167	-3.1600	-0.0008	0.8881	-0.0242	-0.2500
2	1	-0.0130	0.0006	11.3456	0.0031	-0.0300	0.5000	8.9100	0.0472	0.2160	0.0391	0.0000
3	1	0.0344	-0.0015	-12.4291	-0.0340	-0.1100	1.0833	1.7200	-0.0501	-1.8400	-0.0261	0.7976
4	1	0.0104	0.0008	-2.6975	0.0089	0.0500	-0.4391	-10.7900	0.0707	0.0142	0.0013	-0.0160
8	1	-0.0183	-0.0001	2.3475	0.0121	0.1400	1.5714	8.4300	-0.0220	0.4655	0.0124	-0.3143
9	1	0.0236	-0.0005	-13.7053	-0.0014	0.0000	0.0256	9.0300	-0.0441	-0.3911	-0.0125	-0.2393
11	1	-0.1159	-0.0003	-22.4812	0.0254	-0.0400	0.4545	9.8700	-0.0133	1.3262	0.0457	-0.0909
12	1	0.0201	0.0008	4.0364	0.0077	0.0000	0.1273	2.5600	-0.0126	-0.5803	0.0191	-0.0182
13	1	0.0205	0.0022	6.5806	0.0364	0.0600	-0.3891	-14.5200	0.0410	0.4088	0.0243	0.2398
14	1	-0.0333	0.0006	-2.0463	0.0025	0.0400	-1.5203	-9.2700	0.0176	-0.0415	0.0092	-0.3032
17	1	0.2069	-0.0001	-70.5504	0.0025	-0.1400	-1.0000	1.3000	-0.0018	-0.4153	-0.0050	-0.3333
18	1	0.0430	-0.0018	5.5807	-0.0030	0.1100	3.0364	-3.2800	-0.0639	-2.0865	-0.0422	0.2818
19	1	0.0150	0.0000	-2.1923	0.0087	0.0400	0.5491	-2.7000	-0.0210	0.1857	-0.0180	0.1830
19	1	0.0305	-0.0005	16.7450	-0.0092	-0.0400	0.1111	-4.6400	-0.0013	0.4176	0.0163	0.0000
20	1	0.1323	0.0008	18.3484	0.0095	-0.0400	-0.4469	12.6900	0.0309	5.1912	0.0672	-0.8031
21	1	0.1411	0.0001	-2.3933	-0.0011	-0.0200	0.2062	-10.0400	0.0071	0.5379	0.0110	-0.7632
22	1	-0.0220	0.0032	-13.9368	0.0056	0.0400	-0.6742	-9.0600	0.1226	1.7881	0.0645	0.0407
23	1	-0.0160	0.0004	-1.3926	0.0064	0.0700	-1.1333	-4.8800	0.0071	1.4113	0.0102	-0.4167
26	1	0.0118	0.0004	27.0060	0.0145	-0.0300	0.5833	-4.4300	-0.0125	2.4121	-0.0072	0.3258
26	1	-0.0092	0.0015	3.2445	0.0029	0.0200	-0.4657	-15.2700	0.0637	-1.0050	0.0342	-0.1226
27	1	0.0046	0.0001	-16.8669	-0.0016	0.0000	0.0412	-7.8900	-0.0129	1.2730	0.0151	-0.2235
28	1	-0.0595	-0.0002	-7.5337	-0.0006	0.0300	1.6465	-6.8100	0.0088	-0.6008	0.0152	0.5858
29	1	0.0165	0.0005	-1.5779	0.0069	-0.0400	1.0378	-1.5800	0.0139	-0.9116	-0.0181	0.2727
31	1	-0.0802	-0.0005	23.5301	-0.0047	0.0100	-0.2020	1.3900	-0.0221	-0.2076	-0.0342	-0.7878
33	1	-0.0313	0.0006	26.4541	0.0116	-0.0400	-0.7000	20.5500	0.0470	0.6817	0.0217	-1.3250
34	1	0.0149	0.0001	4.9315	-0.0001	0.1200	-0.0057	1.8400	0.0285	0.0097	0.0004	0.7955
36	1	-0.1594	-0.0017	28.8816	-0.0021	0.0700	-0.0404	3.7600	-0.0872	-2.5387	-0.0845	-0.1313
37	1	0.0756	-0.0002	0.3345	-0.0029	-0.0300	-0.8056	-9.4100	0.0278	0.3481	0.0504	0.0833
38	1	-0.0233	0.0022	-1.6732	0.0540	-0.0400	-0.3889	-9.7900	0.0788	-0.8455	0.0284	-0.2223
40	1	0.0196	0.0010	44.5618	0.0079	0.0200	0.4732	1.2600	0.0418	0.0592	0.0046	-0.2054
6	2	-0.0332	-0.0007	-13.5448	-0.0020	-0.0400	0.7212	-4.7700	-0.0319	-1.0299	-0.0137	-0.0727
9	2	-0.0252	0.0009	8.5938	0.0033	-0.0200	0.6667	-19.2900	0.0482	0.8528	0.0296	-0.0347
11	2	0.1224	0.0017	4.5009	0.0015	0.1000	-1.6242	-1.4700	0.0611	0.7464	0.0199	-0.5697
14	2	-0.0035	0.0021	7.7846	0.0037	0.0000	-0.2385	-3.1100	0.0561	0.7748	0.0545	0.1385
15	2	0.0351	0.0082	9.8306	0.0526	0.1600	1.0758	-3.5700	0.1768	3.3413	0.1172	0.1667
16	2	0.0193	0.0009	-15.4230	0.0142	0.1300	-1.0962	-2.4700	0.0411	2.0156	-0.0072	-0.4552
16	2	-0.0102	-0.0009	14.6422	-0.0028	-0.0300	0.1389	-72.6600	-0.0190	-0.5119	-0.0131	0.0834
17	2	-0.0112	0.0007	95.2683	-0.0009	0.1200	-0.5000	-4.6500	0.0302	1.6099	0.0229	-0.3553
20	2	-0.0571	-0.0001	-6.2331	-0.0095	-0.0900	0.4951	-6.5700	-0.0169	-3.6217	-0.0071	1.1079
22	2	-0.0289	-0.0029	-10.0400	0.0005	-0.0100	-0.6923	-0.5600	-0.0862	-1.5915	-0.0448	-0.2308
27	2	0.0080	0.0002	2.5646	0.0005	0.0700	-0.3500	-3.7700	0.0080	0.9345	0.0020	0.0667
29	2	-0.0299	0.0005	-9.8879	0.0009	0.0200	0.4929	-12.8400	0.0334	0.7842	0.0204	0.4115
32	2	0.0328	-0.0013	-12.2636	0.0005	-0.0200	-3.6904	-2.4600	-0.0198	-0.0514	0.0014	-0.9047
36	2	0.1498	0.0024	-0.3340	0.0140	0.1000	1.4498	-3.5000	0.1221	1.0029	0.0964	1.2775
37	2	-0.0404	0.0011	-0.3193	0.0075	0.0200	-1.9444	15.0100	0.0125	2.1494	0.0099	-0.5833
38	2	0.0005	-0.0004	-19.2879	-0.0038	-0.0500	-0.2436	-1.8900	-0.0372	0.0927	-0.0030	-0.4871
39	2	-0.0766	0.0008	2.0144	0.0009	0.2000	-0.6985	6.1700	0.0310	-1.1321	0.0411	-0.1508
40	2	-0.0035	-0.0015	-54.6584	-0.0065	0.1000	-0.8190	31.4100	-0.0206	0.0124	-0.0002	0.2429

Table B.4: Experiment Data by Reflexive Disgust.

B.6 Experiment Data Manipulated by Reflexive Valence

The following table (B.5) shows the experiment data sorted and cleaned, grouped by the valence change compared to before the film.

NO	VAL	ΔME	ΔMD	ΔOL	ΔMA	ΔCN	ΔMB	ΔCD	ΔMU	ΔMT	ΔMS	ΔON
1	1	0.0151	-0.0022	-10.9346	0.0028	-0.0300	0.8864	8.1400	-0.1031	-2.4176	-0.0615	0.3712
2	1	0.3197	-0.0001	-7.9654	0.0070	0.0000	-0.9167	-3.1600	-0.0008	0.8881	-0.0242	-0.2500
6	1	-0.0332	-0.0007	-13.5448	-0.0020	-0.0400	0.7212	-4.7700	-0.0319	-1.0299	-0.0137	-0.0727
9	1	-0.0252	0.0009	8.5938	0.0033	-0.0200	0.6667	-19.2900	0.0482	0.8528	0.0296	-0.0347
11	1	0.1224	0.0017	4.5009	0.0015	0.1000	-1.6242	-1.4700	0.0611	0.7464	0.0199	-0.5697
12	1	-0.0523	-0.0004	-17.1776	-0.0075	0.0000	-2.9378	8.1300	0.0161	1.3952	0.0124	-0.1292
14	1	-0.0035	0.0021	7.7846	0.0037	0.0000	-0.2385	-3.1100	0.0561	0.7748	0.0545	0.1385
15	1	0.0351	0.0082	9.8306	0.0526	0.1600	1.0758	-3.5700	0.1768	3.3413	0.1172	0.1667
16	1	0.0193	0.0009	-15.4230	0.0142	0.1300	-1.0962	-2.4700	0.0411	2.0156	-0.0072	-0.4552
17	1	-0.0112	0.0007	95.2683	-0.0009	0.1200	-0.5000	-4.6500	0.0302	1.6099	0.0229	-0.3553
20	1	-0.0571	-0.0001	-6.2331	-0.0095	-0.0900	0.4951	-6.5700	-0.0169	-3.6217	-0.0071	1.1079
21	1	-0.1849	0.0005	35.5195	0.0209	0.0400	-0.3398	-11.5300	0.0368	0.8140	0.0466	0.3462
21	1	0.1411	0.0001	-2.3933	-0.0011	-0.0200	0.2062	-10.0400	0.0071	0.5379	0.0110	-0.7632
22	1	-0.0289	-0.0029	-10.0400	0.0005	-0.0100	-0.6923	-0.5600	-0.0862	-1.5915	-0.0448	-0.2308
25	1	0.0029	0.0003	-40.8523	0.0016	0.0200	1.0714	-18.5500	-0.0082	-0.4057	-0.0050	-0.0286
26	1	0.0118	0.0004	27.0060	0.0145	-0.0300	0.5833	-4.4300	-0.0125	2.4121	-0.0072	0.3258
27	1	0.0080	0.0002	2.5646	0.0005	0.0700	-0.3500	-3.7700	0.0080	0.9345	0.0020	0.0667
28	1	0.0379	-0.0002	-15.5506	0.0013	0.0000	-3.1985	-38.4000	0.0148	2.2540	-0.0029	-0.2222
28	1	-0.0595	-0.0002	-7.5337	-0.0006	0.0300	1.6465	-6.8100	0.0088	-0.6008	0.0152	0.5858
29	1	-0.0299	0.0005	-9.8879	0.0009	0.0200	0.4929	-12.8400	0.0334	0.7842	0.0204	0.4115
30	1	-0.1357	0.0005	29.0720	-0.0019	-0.0600	0.1111	-14.6300	0.0116	-0.5972	0.0127	-0.1587
31	1	0.0658	0.0012	-4.1354	0.0050	-0.0800	-1.5562	-19.1700	0.0670	0.3537	0.0481	0.1016
32	1	0.0328	-0.0013	-12.2636	0.0005	-0.0200	-3.6904	-2.4600	-0.0198	-0.0514	0.0014	-0.9047
33	1	-0.0394	0.0004	-6.4859	0.0013	-0.0200	-0.1579	-3.8500	0.0126	-0.1738	0.0047	1.2303
34	1	0.0161	-0.0016	22.7395	-0.0045	-0.1500	0.2182	6.4800	-0.0599	0.0836	-0.0319	-0.9455
36	1	0.1498	0.0024	-0.3340	0.0140	0.1000	1.4498	-3.5000	0.1221	1.0029	0.0964	1.2775
37	1	-0.0404	0.0011	-0.3193	0.0075	0.0200	-1.9444	15.0100	0.0125	2.1494	0.0099	-0.5833
38	1	0.0005	-0.0004	-19.2879	-0.0038	-0.0500	-0.2436	-1.8900	-0.0372	0.0927	-0.0030	-0.4871
39	1	-0.0766	0.0008	2.0144	0.0009	0.2000	-0.6985	6.1700	0.0310	-1.1321	0.0411	-0.1508
40	1	-0.0035	-0.0015	-54.6584	-0.0065	0.1000	-0.8190	31.4100	-0.0206	0.0124	-0.0002	0.2429
1	2	-0.0115	0.0011	-55.3037	-0.0092	0.0500	-2.6944	-20.1500	0.0647	4.5076	0.0593	-0.3056
2	2	-0.0130	0.0006	11.3456	0.0031	-0.0300	0.5000	8.9100	0.0472	0.2160	0.0391	0.0000
3	2	0.0344	-0.0015	-12.4291	-0.0340	-0.1100	1.0833	1.7200	-0.0501	-1.8400	-0.0261	0.7976
4	2	0.0104	0.0008	-2.6975	0.0089	0.0500	-0.4391	-10.7900	0.0707	0.0142	0.0013	-0.0160
6	2	-0.0069	0.0011	-0.9326	-0.0024	0.0600	-0.3720	-11.7500	0.0521	1.8473	0.0499	0.0105
8	2	-0.0183	-0.0001	2.3475	0.0121	0.1400	1.5714	8.4300	-0.0220	0.4655	0.0124	-0.3143
9	2	0.0236	-0.0005	-13.7053	-0.0014	0.0000	0.0256	9.0300	-0.0441	-0.3911	-0.0125	-0.2393
11	2	-0.1159	-0.0003	-22.4812	0.0254	-0.0400	0.4545	9.8700	-0.0133	1.3262	0.0457	-0.0909
12	2	0.0201	0.0008	4.0364	0.0077	0.0000	0.1273	2.5600	-0.0126	-0.5803	0.0191	-0.0182
13	2	0.0205	0.0022	6.5806	0.0364	0.0600	-0.3891	-14.5200	0.0410	0.4088	0.0243	0.2398
14	2	-0.0333	0.0006	-2.0463	0.0025	0.0400	-1.5203	-9.2700	0.0176	-0.0415	0.0092	-0.3032
16	2	-0.0102	-0.0009	14.6422	-0.0028	-0.0300	0.1389	-72.6600	-0.0190	-0.5119	-0.0131	0.0834
17	2	0.2069	-0.0001	-70.5504	0.0025	-0.1400	-1.0000	1.3000	-0.0018	-0.4153	-0.0050	-0.3333
18	2	0.0430	-0.0018	5.5807	-0.0030	0.1100	3.0364	-3.2800	-0.0639	-2.0865	-0.0422	0.2818
19	2	0.0150	0.0000	-2.1923	0.0087	0.0400	0.5491	-2.7000	-0.0210	0.1857	-0.0180	0.1830
19	2	0.0305	-0.0005	16.7450	-0.0092	-0.0400	0.1111	-4.6400	-0.0013	0.4176	0.0163	0.0000
20	2	0.1323	0.0008	18.3484	0.0095	-0.0400	-0.4469	12.6900	0.0309	5.1912	0.0672	-0.8031
22	2	-0.0220	0.0032	-13.9368	0.0056	0.0400	-0.6742	-9.0600	0.1226	1.7881	0.0645	0.0407
23	2	-0.0160	0.0004	-1.3926	0.0064	0.0700	-1.1333	-4.8800	0.0071	1.4113	0.0102	-0.4167
24	2	0.0043	0.0008	5.7527	-0.0029	-0.0100	-0.1357	-3.3800	0.0426	2.3259	0.0531	0.0452
25	2	0.0515	0.0018	-3.3180	0.0103	0.0400	-1.5000	1.4600	0.0794	3.4221	0.0224	0.2364
26	2	-0.0092	0.0015	3.2445	0.0029	0.0200	-0.4657	-15.2700	0.0637	-1.0050	0.0342	-0.1226
27	2	0.0046	0.0001	-16.8669	-0.0016	0.0000	0.0412	-7.8900	-0.0129	1.2730	0.0151	-0.2235
29	2	0.0165	0.0005	-1.5779	0.0069	-0.0400	1.0378	-1.5800	0.0139	-0.9116	-0.0181	0.2727
30	2	0.0286	-0.0005	-25.4795	0.0050	-0.0400	-0.8077	-54.8100	-0.0057	1.4665	-0.0015	0.0605
31	2	-0.0802	-0.0005	23.5301	-0.0047	0.0100	-0.2020	1.3900	-0.0221	-0.2076	-0.0342	-0.7878
32	2	-0.0057	0.0018	9.7714	-0.0156	0.0500	1.1349	-4.3700	0.0197	-0.9856	0.0307	0.6825
33	2	-0.0313	0.0006	26.4541	0.0116	-0.0400	-0.7000	20.5500	0.0470	0.6817	0.0217	-1.3250
34	2	0.0149	0.0001	4.9315	-0.0001	0.1200	-0.0057	1.8400	0.0285	0.0097	0.0004	0.7955
36	2	-0.1594	-0.0017	28.8816	-0.0021	0.0700	-0.0404	3.7600	-0.0872	-2.5387	-0.0845	-0.1313
37	2	0.0756	-0.0002	0.3345	-0.0029	-0.0300	-0.8056	-9.4100	0.0278	0.3481	0.0504	0.0833
38	2	-0.0233	0.0022	-1.6732	0.0540	-0.0400	-0.3889	-9.7900	0.0788	-0.8455	0.0284	-0.2223
40	2	0.0196	0.0010	44.5618	0.0079	0.0200	0.4732	1.2600	0.0418	0.0592	0.0046	-0.2054

Table B.5: Experiment Data by Reflexive Valence.

B.7 Experiment Data Manipulated by Reflexive Anger

The following table (B.6) shows the experiment data sorted and cleaned, grouped by the anger (anger vs. contentedness) change compared to before the film.

NO	VA2	ΔME	ΔMD	ΔOL	ΔMA	ΔCN	ΔMB	ΔCD	ΔMU	ΔMT	ΔMS	ΔON
1	1	0.0151	-0.0022	-10.9346	0.0028	-0.0300	0.8864	8.1400	-0.1031	-2.4176	-0.0615	0.3712
5	1	-0.0128	0.0001	20.3145	0.0072	0.1200	-1.0095	-3.9500	0.0088	0.9293	0.0015	-0.8000
9	1	-0.0252	0.0009	8.5938	0.0033	-0.0200	0.6667	-19.2900	0.0482	0.8528	0.0296	-0.0347
11	1	0.1224	0.0017	4.5009	0.0015	0.1000	-1.6242	-1.4700	0.0611	0.7464	0.0199	-0.5697
14	1	-0.0035	0.0021	7.7846	0.0037	0.0000	-0.2385	-3.1100	0.0561	0.7748	0.0545	0.1385
15	1	0.0351	0.0082	9.8306	0.0526	0.1600	1.0758	-3.5700	0.1768	3.3413	0.1172	0.1667
17	1	-0.0112	0.0007	95.2683	-0.0009	0.1200	-0.5000	-4.6500	0.0302	1.6099	0.0229	-0.3553
22	1	-0.0289	-0.0029	-10.0400	0.0005	-0.0100	-0.6923	-0.5600	-0.0862	-1.5915	-0.0448	-0.2308
25	1	0.0029	0.0003	-40.8523	0.0016	0.0200	1.0714	-18.5500	-0.0082	-0.4057	-0.0050	-0.0286
26	1	0.0118	0.0004	27.0060	0.0145	-0.0300	0.5833	-4.4300	-0.0125	2.4121	-0.0072	0.3258
27	1	0.0080	0.0002	2.5646	0.0005	0.0700	-0.3500	-3.7700	0.0080	0.9345	0.0020	0.0667
28	1	0.0379	-0.0002	-15.5506	0.0013	0.0000	-3.1985	-38.4000	0.0148	2.2540	-0.0029	-0.2222
32	1	0.0328	-0.0013	-12.2636	0.0005	-0.0200	-3.6904	-2.4600	-0.0198	-0.0514	0.0014	-0.9047
33	1	-0.0394	0.0004	-6.4859	0.0013	-0.0200	-0.1579	-3.8500	0.0126	-0.1738	0.0047	1.2303
35	1	-0.0198	0.0004	26.3025	0.0310	0.0600	1.2759	-14.2300	0.0324	-0.0831	0.0278	0.7759
36	1	0.1498	0.0024	-0.3340	0.0140	0.1000	1.4498	-3.5000	0.1221	1.0029	0.0964	1.2775
37	1	-0.0404	0.0011	-0.3193	0.0075	0.0200	-1.9444	15.0100	0.0125	2.1494	0.0099	-0.5833
38	1	0.0005	-0.0004	-19.2879	-0.0038	-0.0500	-0.2436	-1.8900	-0.0372	0.0927	-0.0030	-0.4871
40	1	-0.0035	-0.0015	-54.6584	-0.0065	0.1000	-0.8190	31.4100	-0.0206	0.0124	-0.0002	0.2429
2	2	0.3197	-0.0001	-7.9654	0.0070	0.0000	-0.9167	-3.1600	-0.0008	0.8881	-0.0242	-0.2500
2	2	-0.0130	0.0006	11.3456	0.0031	-0.0300	0.5000	8.9100	0.0472	0.2160	0.0391	0.0000
3	2	0.0344	-0.0015	-12.4291	-0.0340	-0.1100	1.0833	1.7200	-0.0501	-1.8400	-0.0261	0.7976
4	2	0.0104	0.0008	-2.6975	0.0089	0.0500	-0.4391	-10.7900	0.0707	0.0142	0.0013	-0.0160
6	2	-0.0069	0.0011	-0.9326	-0.0024	0.0600	-0.3720	-11.7500	0.0521	1.8473	0.0499	0.0105
8	2	-0.0183	-0.0001	2.3475	0.0121	0.1400	1.5714	8.4300	-0.0220	0.4655	0.0124	-0.3143
9	2	0.0236	-0.0005	-13.7053	-0.0014	0.0000	0.0256	9.0300	-0.0441	-0.3911	-0.0125	-0.2393
11	2	-0.1159	-0.0003	-22.4812	0.0254	-0.0400	0.4545	9.8700	-0.0133	1.3262	0.0457	-0.0909
12	2	0.0201	0.0008	4.0364	0.0077	0.0000	0.1273	2.5600	-0.0126	-0.5803	0.0191	-0.0182
13	2	0.0205	0.0022	6.5806	0.0364	0.0600	-0.3891	-14.5200	0.0410	0.4088	0.0243	0.2398
14	2	-0.0333	0.0006	-2.0463	0.0025	0.0400	-1.5203	-9.2700	0.0176	-0.0415	0.0092	-0.3032
17	2	0.2069	-0.0001	-70.5504	0.0025	-0.1400	-1.0000	1.3000	-0.0018	-0.4153	-0.0050	-0.3333
18	2	0.0430	-0.0018	5.5807	-0.0030	0.1100	3.0364	-3.2800	-0.0639	-2.0865	-0.0422	0.2818
19	2	0.0150	0.0000	-2.1923	0.0087	0.0400	0.5491	-2.7000	-0.0210	0.1857	-0.0180	0.1830
19	2	0.0305	-0.0005	16.7450	-0.0092	-0.0400	0.1111	-4.6400	-0.0013	0.4176	0.0163	0.0000
20	2	0.1323	0.0008	18.3484	0.0095	-0.0400	-0.4469	12.6900	0.0309	5.1912	0.0672	-0.8031
22	2	-0.0220	0.0032	-13.9368	0.0056	0.0400	-0.6742	-9.0600	0.1226	1.7881	0.0645	0.0407
24	2	0.0043	0.0008	5.7527	-0.0029	-0.0100	-0.1357	-3.3800	0.0426	2.3259	0.0531	0.0452
25	2	0.0515	0.0018	-3.3180	0.0103	0.0400	-1.5000	1.4600	0.0794	3.4221	0.0224	0.2364
26	2	-0.0092	0.0015	3.2445	0.0029	0.0200	-0.4657	-15.2700	0.0637	-1.0050	0.0342	-0.1226
27	2	0.0046	0.0001	-16.8669	-0.0016	0.0000	0.0412	-7.8900	-0.0129	1.2730	0.0151	-0.2235
28	2	-0.0595	-0.0002	-7.5337	-0.0006	0.0300	1.6465	-6.8100	0.0088	-0.6008	0.0152	0.5858
29	2	0.0165	0.0005	-1.5779	0.0069	-0.0400	1.0378	-1.5800	0.0139	-0.9116	-0.0181	0.2727
30	2	0.0286	-0.0005	-25.4795	0.0050	-0.0400	-0.8077	-54.8100	-0.0057	1.4665	-0.0015	0.0605
31	2	-0.0802	-0.0005	23.5301	-0.0047	0.0100	-0.2020	1.3900	-0.0221	-0.2076	-0.0342	-0.7878
32	2	-0.0057	0.0018	9.7714	-0.0156	0.0500	1.1349	-4.3700	0.0197	-0.9856	0.0307	0.6825
33	2	-0.0313	0.0006	26.4541	0.0116	-0.0400	-0.7000	20.5500	0.0470	0.6817	0.0217	-1.3250
34	2	0.0149	0.0001	4.9315	-0.0001	0.1200	-0.0057	1.8400	0.0285	0.0097	0.0004	0.7955
36	2	-0.1594	-0.0017	28.8816	-0.0021	0.0700	-0.0404	3.7600	-0.0872	-2.5387	-0.0845	-0.1313
37	2	0.0756	-0.0002	0.3345	-0.0029	-0.0300	-0.8056	-9.4100	0.0278	0.3481	0.0504	0.0833
38	2	-0.0233	0.0022	-1.6732	0.0540	-0.0400	-0.3889	-9.7900	0.0788	-0.8455	0.0284	-0.2223

Table B.6: Experiment Data by Reflexive Anger.

B.8 Experiment Data Grouped by Arousal

The following table (B.7) shows the experiment data sorted and cleaned, grouped by the absolute arousal.

no	aro	me	md	ol	ma	cn	mb	cd	mu	mt	ms	on
2	1	1.1228	0.0043	1.2649	0.0074	1.0700	2.0000	99.8400	0.1448	3.3874	0.1229	0.5000
2	1	1.4295	0.0048	4.6451	0.0175	1.0400	1.5833	105.5900	0.1912	4.4915	0.1378	0.2500
3	1	1.1637	0.0073	41.2074	0.0453	1.1500	3.0000	124.4200	0.2453	6.0336	0.1857	0.7857
4	1	1.0830	0.0073	20.7004	0.0305	1.2100	1.7692	84.0000	0.3239	3.2981	0.2073	0.6923
5	1	1.1057	0.0035	3.9897	0.0047	1.0200	2.8095	142.8300	0.1430	2.6403	0.1109	1.0000
8	1	1.1236	0.0057	8.1056	0.0221	1.2100	3.5714	141.8500	0.2491	6.5171	0.1735	0.2857
8	1	1.3875	0.0058	20.8765	0.0113	1.0000	3.1333	126.2000	0.2719	6.0390	0.1625	1.3333
9	1	1.1202	0.0034	6.7887	0.0060	1.0000	2.6923	99.2100	0.1429	3.0658	0.1099	0.5385
9	1	1.1218	0.0030	11.9002	0.0041	1.0200	2.0000	109.4700	0.1388	2.6041	0.0928	0.8125
11	1	1.0973	0.0043	28.0612	0.0064	1.0500	3.5333	116.5300	0.1953	3.3681	0.1171	0.9333
11	1	1.1038	0.0057	10.0809	0.0333	1.1100	2.3636	124.9300	0.2431	5.4407	0.1827	0.2727
13	1	1.1253	0.0031	8.9782	0.0046	1.0500	3.2353	183.3300	0.1495	3.2230	0.1111	0.5294
13	1	1.1458	0.0053	15.5588	0.0410	1.1100	2.8462	168.8100	0.1905	3.6318	0.1354	0.7692
14	1	1.1057	0.0061	21.1031	0.0131	1.0400	1.3000	91.8900	0.2290	4.0840	0.1601	0.6000
14	1	1.1425	0.0034	15.3648	0.0069	1.0000	3.0588	104.2700	0.1553	3.3507	0.0964	0.7647
15	1	1.1968	0.0064	9.4995	0.0083	1.1700	1.8333	147.5400	0.2398	9.5810	0.2163	0.8333
16	1	1.0911	0.0062	4.9978	0.0108	1.0700	2.1111	209.0200	0.2487	3.8730	0.1641	0.8333
17	1	1.0915	0.0037	21.2479	0.0088	1.0200	3.0000	91.8100	0.1555	3.4357	0.1373	1.1053
17	1	1.2872	0.0043	45.9658	0.0104	1.0000	1.5000	88.4600	0.1839	4.6303	0.1552	0.4167
18	1	1.1960	0.0061	32.4603	0.0080	1.1100	6.6364	102.8300	0.1942	4.6305	0.1887	1.1818
18	1	1.2601	0.0052	22.1278	0.0076	1.0500	4.8750	115.5000	0.1806	4.0583	0.1526	1.9375
19	1	1.1494	0.0047	29.2471	0.0072	1.0000	2.7778	210.1500	0.1837	4.9068	0.1395	0.8889
20	1	1.3340	0.0071	32.0881	0.0210	1.2000	2.5882	130.5700	0.3159	14.9974	0.2440	1.0588
21	1	1.1305	0.0033	6.8945	0.0084	1.0200	3.2105	160.7400	0.1306	2.8011	0.1049	1.2632
22	1	1.1131	0.0082	21.6903	0.0133	1.1400	2.3846	127.5900	0.3108	6.0481	0.2092	0.9231
22	1	1.1351	0.0050	35.6271	0.0077	1.1000	3.0588	136.6500	0.1882	4.2600	0.1447	0.8824
23	1	1.1356	0.0040	14.7310	0.0067	1.0700	3.0667	102.0200	0.1547	2.8730	0.1133	0.6000
25	1	1.0904	0.0039	50.5508	0.0053	1.0500	1.4286	162.9300	0.1891	3.6397	0.1200	0.4286
25	1	1.1448	0.0060	6.3805	0.0172	1.1100	1.0000	145.8400	0.2603	6.6561	0.1374	0.6364
26	1	1.1041	0.0075	12.2170	0.0117	1.0700	1.4167	107.1400	0.3338	4.5654	0.1809	0.5833
26	1	1.1133	0.0060	8.9725	0.0088	1.0500	1.8824	122.4100	0.2701	5.5704	0.1467	0.7059
27	1	1.1077	0.0031	19.4585	0.0057	1.0000	2.0588	116.6300	0.1702	3.0877	0.0954	0.8235
28	1	1.1043	0.0046	30.5823	0.0067	1.0000	4.6429	191.8600	0.1909	4.3819	0.1546	1.0000
29	1	1.1434	0.0044	20.2000	0.0074	1.0200	2.0526	94.6700	0.1763	3.8852	0.1346	0.3158
30	1	1.2762	0.0038	8.9962	0.0080	1.1700	3.3889	205.6900	0.1758	4.9242	0.1413	0.9444
31	1	1.1200	0.0060	41.0467	0.0091	1.0700	3.8889	116.6000	0.2122	2.9084	0.1510	0.6667
31	1	1.1344	0.0053	21.6520	0.0088	1.1400	5.6471	134.3800	0.1673	2.7623	0.1371	1.3529
31	1	1.2002	0.0065	17.5166	0.0138	1.0600	4.0909	115.2100	0.2343	3.1160	0.1852	1.4545
32	1	1.1726	0.0070	10.7359	0.0314	1.1600	5.2222	132.1400	0.2449	5.2766	0.2019	0.8889
33	1	1.1866	0.0039	12.1218	0.0085	1.1700	4.1579	139.3700	0.1464	2.5823	0.1098	0.8947
34	1	1.0843	0.0060	7.7825	0.0125	1.0700	2.1875	104.8200	0.2114	3.0976	0.1551	0.7500
35	1	1.1090	0.0058	11.3788	0.0104	1.1400	2.7241	179.8400	0.2187	6.0650	0.1588	0.7241
36	1	1.0855	0.0074	47.8797	0.0210	1.2900	3.7778	114.6100	0.2719	3.6164	0.1918	1.7778
37	1	1.1684	0.0038	18.7782	0.0061	1.0500	4.5000	137.6900	0.1526	3.5612	0.1442	1.2500
37	1	1.2036	0.0047	18.7934	0.0107	1.0400	1.7500	143.2900	0.1929	6.0587	0.2045	0.7500
39	1	1.0912	0.0045	10.3795	0.0062	1.2900	0.9444	143.6100	0.2036	6.3488	0.1715	0.2778
39	1	1.1678	0.0037	8.3651	0.0053	1.0900	1.6429	137.4400	0.1726	7.4809	0.1304	0.4286
40	1	1.0847	0.0056	24.8059	0.0082	1.0500	1.8125	105.4500	0.2261	3.9834	0.1361	0.5625
2	2	1.1098	0.0049	12.6105	0.0105	1.0400	2.5000	108.7500	0.1920	3.6034	0.1620	0.5000
3	2	1.1495	0.0045	10.5802	0.0080	1.0200	3.5263	127.0200	0.1635	3.8452	0.1338	1.0526
3	2	1.1981	0.0058	28.7783	0.0113	1.0400	4.0833	126.1400	0.1952	4.1936	0.1596	1.5833
9	2	1.0966	0.0039	20.4940	0.0074	1.0000	2.6667	90.1800	0.1870	3.4569	0.1224	0.7778
11	2	1.2197	0.0060	32.5621	0.0079	1.1500	1.9091	115.0600	0.2564	4.1145	0.1370	0.3636
14	2	1.1092	0.0040	13.3185	0.0094	1.0400	1.5385	95.0000	0.1729	3.3092	0.1056	0.4615
16	2	1.1002	0.0062	4.2170	0.0222	1.1700	1.1538	133.8900	0.2708	5.3767	0.1438	0.4615
19	2	1.1039	0.0052	14.6944	0.0077	1.0000	2.1176	217.4900	0.2060	4.3035	0.1412	0.7059
19	2	1.1189	0.0052	12.5021	0.0164	1.0400	2.6667	214.7900	0.1850	4.4892	0.1232	0.8889
20	2	1.4092	0.0078	44.2034	0.0210	1.0700	2.6364	136.6900	0.3299	16.5669	0.3041	1.3636
21	2	1.2716	0.0034	4.5012	0.0073	1.0000	3.4167	150.7000	0.1377	3.3390	0.1159	0.5000
22	2	1.0842	0.0053	11.6503	0.0138	1.1300	1.6923	127.0300	0.2246	4.4566	0.1644	0.6923
23	2	1.1214	0.0054	19.4755	0.0175	1.1100	1.6667	104.5000	0.2177	5.5942	0.1599	0.5833
27	2	1.1123	0.0032	2.5916	0.0041	1.0000	2.1000	108.7400	0.1573	4.3607	0.1105	0.6000
29	2	1.1135	0.0049	10.3121	0.0083	1.0400	2.5455	81.8300	0.2097	4.6694	0.1550	0.7273
30	2	1.1691	0.0038	12.5887	0.0111	1.0700	2.6923	136.2500	0.1817	5.7935	0.1525	0.8462
32	2	1.1997	0.0075	8.2437	0.0163	1.1900	2.6667	125.3100	0.2448	4.2396	0.2340	0.6667
36	2	1.2449	0.0091	18.9981	0.0231	1.2200	3.8182	110.8500	0.3591	6.1551	0.2763	1.9091
37	2	1.1280	0.0049	18.4589	0.0136	1.0700	2.5556	152.7000	0.1651	5.7106	0.1541	0.6667
38	2	1.1108	0.0057	9.6525	0.0619	1.0000	2.4444	137.1100	0.2160	2.5459	0.1376	0.4444
38	2	1.1341	0.0035	11.3257	0.0079	1.0400	2.8333	146.9000	0.1372	3.3914	0.1092	0.6667
40	2	1.1008	0.0051	14.7093	0.0096	1.1700	1.4667	138.1200	0.2473	4.0550	0.1405	0.6000
40	2	1.1043	0.0066	69.3677	0.0161	1.0700	2.2857	106.7100	0.2679	4.0426	0.1407	0.3571

Table B.7: Experiment Data by Absolute Arousal.

B.9 Experiment Data Grouped by Disgust

The following table (B.8) shows the experiment data sorted and cleaned, grouped by the absolute disgust.

no	disgust	me	md	ol	ma	cn	mb	cd	mu	mt	ms	on
2	1	1.1098	0.0049	12.6105	0.0105	1.0400	2.5000	108.7500	0.1920	3.6034	0.1620	0.5000
2	1	1.4295	0.0048	4.6451	0.0175	1.0400	1.5833	105.5900	0.1912	4.4915	0.1378	0.2500
3	1	1.1495	0.0045	10.5802	0.0080	1.0200	3.5263	127.0200	0.1635	3.8452	0.1338	1.0526
3	1	1.1981	0.0058	28.7783	0.0113	1.0400	4.0833	126.1400	0.1952	4.1936	0.1596	1.5833
4	1	1.0830	0.0073	20.7004	0.0305	1.2100	1.7692	84.0000	0.3239	3.2981	0.2073	0.6923
8	1	1.3875	0.0058	20.8765	0.0113	1.0000	3.1333	126.2000	0.2719	6.0390	0.1625	1.3333
8	1	1.1236	0.0057	8.1056	0.0221	1.2100	3.5714	141.8500	0.2491	6.5171	0.1735	0.2857
9	1	1.1202	0.0034	6.7887	0.0060	1.0000	2.6923	99.2100	0.1429	3.0658	0.1099	0.5385
9	1	1.1218	0.0030	11.9002	0.0041	1.0200	2.0000	109.4700	0.1388	2.6041	0.0928	0.8125
11	1	1.0973	0.0043	28.0612	0.0064	1.0500	3.5333	116.5300	0.1953	3.3681	0.1171	0.9333
11	1	1.1038	0.0057	10.0809	0.0333	1.1100	2.3636	124.9300	0.2431	5.4407	0.1827	0.2727
12	1	1.1540	0.0034	26.5768	0.0136	1.0000	5.2105	183.1200	0.1506	3.2748	0.1112	0.9474
12	1	1.1218	0.0038	13.4356	0.0138	1.0000	2.4000	193.8100	0.1541	4.0897	0.1427	0.8000
13	1	1.1458	0.0053	15.5588	0.0410	1.1100	2.8462	168.8100	0.1905	3.6318	0.1354	0.7692
13	1	1.1253	0.0031	8.9782	0.0046	1.0500	3.2353	183.3300	0.1495	3.2230	0.1111	0.5294
14	1	1.1425	0.0034	15.3648	0.0069	1.0000	3.0588	104.2700	0.1553	3.3507	0.0964	0.7647
14	1	1.1092	0.0040	13.3185	0.0094	1.0400	1.5385	95.0000	0.1729	3.3092	0.1056	0.4615
16	1	1.0911	0.0062	4.9978	0.0108	1.0700	2.1111	209.0200	0.2487	3.8730	0.1641	0.8333
17	1	1.0915	0.0037	21.2479	0.0088	1.0200	3.0000	91.8100	0.1555	3.4357	0.1373	1.1053
17	1	1.2872	0.0043	45.9658	0.0104	1.0000	1.5000	88.4600	0.1839	4.6303	0.1552	0.4167
18	1	1.1960	0.0061	32.4603	0.0080	1.1100	6.6364	102.8300	0.1942	4.6305	0.1887	1.1818
18	1	1.2601	0.0052	22.1278	0.0076	1.0500	4.8750	115.5000	0.1806	4.0583	0.1526	1.9375
19	1	1.1494	0.0047	29.2471	0.0072	1.0000	2.7778	210.1500	0.1837	4.9068	0.1395	0.8889
19	1	1.1189	0.0052	12.5021	0.0164	1.0400	2.6667	214.7900	0.1850	4.4892	0.1232	0.8889
20	1	1.3340	0.0071	32.0881	0.0210	1.2000	2.5882	130.5700	0.3159	14.9974	0.2440	1.0588
20	1	1.4092	0.0078	44.2034	0.0210	1.0700	2.6364	136.6900	0.3299	16.5669	0.3041	1.3636
21	1	1.1305	0.0033	6.8945	0.0084	1.0200	3.2105	160.7400	0.1306	2.8011	0.1049	1.2632
21	1	1.2716	0.0034	4.5012	0.0073	1.0000	3.4167	150.7000	0.1377	3.3390	0.1159	0.5000
22	1	1.1351	0.0050	35.6271	0.0077	1.1000	3.0588	136.6500	0.1882	4.2600	0.1447	0.8824
22	1	1.1131	0.0082	21.6903	0.0133	1.1400	2.3846	127.5900	0.3108	6.0481	0.2092	0.9231
23	1	1.1356	0.0040	14.7310	0.0067	1.0700	3.0667	102.0200	0.1547	2.8730	0.1133	0.6000
23	1	1.1214	0.0054	19.4755	0.0175	1.1100	1.6667	104.5000	0.2177	5.5942	0.1599	0.5833
26	1	1.1041	0.0075	12.2170	0.0117	1.0700	1.4167	107.1400	0.3338	4.5654	0.1809	0.5833
26	1	1.1159	0.0079	39.2230	0.0262	1.0400	2.0000	102.7100	0.3213	6.9775	0.1737	0.9091
27	1	1.1077	0.0031	19.4585	0.0057	1.0000	2.0588	116.6300	0.1702	3.0877	0.0954	0.8235
27	1	1.1123	0.0032	2.5916	0.0041	1.0000	2.1000	108.7400	0.1573	4.3607	0.1105	0.6000
28	1	1.1043	0.0046	30.5823	0.0067	1.0000	4.6429	191.8600	0.1909	4.3819	0.1546	1.0000
28	1	1.0827	0.0042	7.4980	0.0074	1.0300	3.0909	146.6500	0.2145	6.0351	0.1669	1.3636
29	1	1.1434	0.0044	20.2000	0.0074	1.0200	2.0526	94.6700	0.1763	3.8852	0.1346	0.3158
29	1	1.1300	0.0054	8.7342	0.0152	1.0000	3.5833	80.2500	0.2236	3.7578	0.1369	1.0000
30	1	1.2762	0.0038	8.9962	0.0080	1.1700	3.3889	205.6900	0.1758	4.9242	0.1413	0.9444
31	1	1.1344	0.0053	21.6520	0.0088	1.1400	5.6471	134.3800	0.1673	2.7623	0.1371	1.3529
31	1	1.1200	0.0060	41.0467	0.0091	1.0700	3.8889	116.6000	0.2122	2.9084	0.1510	0.6667
32	1	1.1726	0.0070	10.7359	0.0314	1.1600	5.2222	132.1400	0.2449	5.2766	0.2019	0.8889
33	1	1.1159	0.0049	32.0900	0.0214	1.1100	3.3000	156.0700	0.2060	3.0902	0.1362	0.8000
33	1	1.1866	0.0039	12.1218	0.0085	1.1700	4.1579	139.3700	0.1464	2.5823	0.1098	0.8947
34	1	1.0843	0.0060	7.7825	0.0125	1.0700	2.1875	104.8200	0.2114	3.0976	0.1551	0.7500
34	1	1.0992	0.0061	12.7140	0.0124	1.1900	2.1818	106.6600	0.2399	3.1073	0.1555	1.5455
35	1	1.1090	0.0058	11.3788	0.0104	1.1400	2.7241	179.8400	0.2187	6.0650	0.1588	0.7241
36	1	1.0855	0.0074	47.8797	0.0210	1.2900	3.7778	114.6100	0.2719	3.6164	0.1918	1.7778
36	1	1.0951	0.0067	19.3321	0.0091	1.1200	2.3684	114.3500	0.2370	5.1522	0.1799	0.6316
37	1	1.1684	0.0038	18.7782	0.0061	1.0500	4.5000	137.6900	0.1526	3.5612	0.1442	1.2500
37	1	1.2036	0.0047	18.7934	0.0107	1.0400	1.7500	143.2900	0.1929	6.0587	0.2045	0.7500
38	1	1.1108	0.0057	9.6525	0.0619	1.0000	2.4444	137.1100	0.2160	2.5459	0.1376	0.4444
39	1	1.1678	0.0037	8.3651	0.0053	1.0900	1.6429	137.4400	0.1726	7.4809	0.1304	0.4286
40	1	1.0847	0.0056	24.8059	0.0082	1.0500	1.8125	105.4500	0.2261	3.9834	0.1361	0.5625
40	1	1.1043	0.0066	69.3677	0.0161	1.0700	2.2857	106.7100	0.2679	4.0426	0.1407	0.3571
2	2	1.1228	0.0043	1.2649	0.0074	1.0700	2.0000	99.8400	0.1448	3.3874	0.1229	0.5000
5	2	1.1057	0.0035	3.9897	0.0047	1.0200	2.8095	142.8300	0.1430	2.6403	0.1109	1.0000
6	2	1.0983	0.0054	16.9971	0.0082	1.1100	3.4545	112.1300	0.2196	4.4749	0.1736	0.7273
9	2	1.0966	0.0039	20.4940	0.0074	1.0000	2.6667	90.1800	0.1870	3.4569	0.1224	0.7778
11	2	1.2197	0.0060	32.5621	0.0079	1.1500	1.9091	115.0600	0.2564	4.1145	0.1370	0.3636
14	2	1.1057	0.0061	21.1031	0.0131	1.0400	1.3000	91.8900	0.2290	4.0840	0.1601	0.6000
15	2	1.2319	0.0146	19.3301	0.0609	1.3300	2.9091	143.9700	0.4166	12.9223	0.3335	1.0000
16	2	1.0809	0.0053	19.6400	0.0080	1.0400	2.2500	136.3600	0.2297	3.3611	0.1510	0.9167
16	2	1.1002	0.0062	4.2170	0.0222	1.1700	1.1538	133.8900	0.2708	5.3767	0.1438	0.4615
17	2	1.0803	0.0044	116.5162	0.0079	1.1400	2.5000	87.1600	0.1857	5.0456	0.1602	0.7500
19	2	1.1039	0.0052	14.6944	0.0077	1.0000	2.1176	217.4900	0.2060	4.3035	0.1412	0.7059
20	2	1.2769	0.0070	25.8550	0.0115	1.1100	3.0833	124.0000	0.2990	11.3757	0.2369	2.1667
22	2	1.0842	0.0053	11.6503	0.0138	1.1300	1.6923	127.0300	0.2246	4.4566	0.1644	0.6923
25	2	1.0904	0.0039	50.5508	0.0053	1.0500	1.4286	162.9300	0.1891	3.6397	0.1200	0.4286
27	2	1.1203	0.0034	5.1562	0.0046	1.0700	1.7500	104.9700	0.1653	5.2952	0.1125	0.6667
29	2	1.1135	0.0049	10.3121	0.0083	1.0400	2.5455	81.8300	0.2097	4.6694	0.1550	0.7273
32	2	1.1997	0.0075	8.2437	0.0163	1.1900	2.6667	125.3100	0.2448	4.2396	0.2340	0.6667
36	2	1.2449	0.0091	18.9981	0.0231	1.2200	3.8182	110.8500	0.3591	6.1551	0.2763	1.9091
37	2	1.1280	0.0049	18.4589	0.0136	1.0700	2.5556	152.7000	0.1651	5.7106	0.1541	0.6667
38	2	1.1341	0.0035	11.3257	0.0079	1.0400	2.8333	146.9000	0.1372	3.3914	0.1092	0.6667
39	2	1.0912	0.0045	10.3795	0.0062	1.2900	0.9444	143.6100	0.2036	6.3488	0.1715	0.2778
40	2	1.1008	0.0051	14.7093	0.0096	1.1700	1.4667	138.1200	0.2473	4.0550	0.1405	0.6000

Table B.8: Experiment Data by Absolute Disgust.

B.10 Experiment Data Grouped by Valence

The following table (B.9) shows the experiment data sorted and cleaned, grouped by the absolute valence.

no	val1	me	md	ol	ma	cn	mb	cd	mu	mt	ms	on
1	1	1.1520	0.0082	20.3774	0.0190	1.0400	2.6364	141.8300	0.3190	10.3792	0.2706	1.4545
2	1	1.4295	0.0048	4.6451	0.0175	1.0400	1.5833	105.5900	0.1912	4.4915	0.1378	0.2500
6	1	1.0983	0.0054	16.9971	0.0082	1.1100	3.4545	112.1300	0.2196	4.4749	0.1736	0.7273
9	1	1.0966	0.0039	20.4940	0.0074	1.0000	2.6667	90.1800	0.1870	3.4569	0.1224	0.7778
11	1	1.2197	0.0060	32.5621	0.0079	1.1500	1.9091	115.0600	0.2564	4.1145	0.1370	0.3636
12	1	1.1017	0.0030	9.3992	0.0061	1.0000	2.2727	191.2500	0.1667	4.6700	0.1236	0.8182
14	1	1.1057	0.0061	21.1031	0.0131	1.0400	1.3000	91.8900	0.2290	4.0840	0.1601	0.6000
15	1	1.2319	0.0146	19.3301	0.0609	1.3300	2.9091	143.9700	0.4166	12.9223	0.3335	1.0000
16	1	1.1002	0.0062	4.2170	0.0222	1.1700	1.1538	133.8900	0.2708	5.3767	0.1438	0.4615
17	1	1.0803	0.0044	116.5162	0.0079	1.1400	2.5000	87.1600	0.1857	5.0456	0.1602	0.7500
20	1	1.2769	0.0070	25.8550	0.0115	1.1100	3.0833	124.0000	0.2990	11.3757	0.2369	2.1667
21	1	1.0867	0.0039	40.0207	0.0282	1.0400	3.0769	139.1700	0.1745	4.1530	0.1625	0.8462
21	1	1.1305	0.0033	6.8945	0.0084	1.0200	3.2105	160.7400	0.1306	2.8011	0.1049	1.2632
21	1	1.2716	0.0034	4.5012	0.0073	1.0000	3.4167	150.7000	0.1377	3.3390	0.1159	0.5000
22	1	1.0842	0.0053	11.6503	0.0138	1.1300	1.6923	127.0300	0.2246	4.4566	0.1644	0.6923
25	1	1.0933	0.0042	9.6985	0.0069	1.0700	2.5000	144.3800	0.1809	3.2340	0.1150	0.4000
26	1	1.1159	0.0079	39.2230	0.0262	1.0400	2.0000	102.7100	0.3213	6.9775	0.1737	0.9091
27	1	1.1203	0.0034	5.1562	0.0046	1.0700	1.7500	104.9700	0.1653	5.2952	0.1125	0.6667
28	1	1.0827	0.0042	7.4980	0.0074	1.0300	3.0909	146.6500	0.2145	6.0351	0.1669	1.3636
28	1	1.1422	0.0044	15.0317	0.0080	1.0000	1.4444	153.4600	0.2057	6.6359	0.1517	0.7778
29	1	1.1135	0.0049	10.3121	0.0083	1.0400	2.5455	81.8300	0.2097	4.6694	0.1550	0.7273
30	1	1.1405	0.0043	38.0682	0.0061	1.1100	3.5000	191.0600	0.1874	4.3270	0.1540	0.7857
31	1	1.1344	0.0053	21.6520	0.0088	1.1400	5.6471	134.3800	0.1673	2.7623	0.1371	1.3529
31	1	1.2002	0.0065	17.5166	0.0138	1.0600	4.0909	115.2100	0.2343	3.1160	0.1852	1.4545
32	1	1.1997	0.0075	8.2437	0.0163	1.1900	2.6667	125.3100	0.2448	4.2396	0.2340	0.6667
33	1	1.1472	0.0043	5.6359	0.0098	1.1500	4.0000	135.5200	0.1590	2.4085	0.1145	2.1250
34	1	1.1153	0.0045	35.4535	0.0079	1.0400	2.4000	113.1400	0.1800	3.1909	0.1236	0.6000
36	1	1.0951	0.0067	19.3321	0.0091	1.1200	2.3684	114.3500	0.2370	5.1522	0.1799	0.6316
36	1	1.2449	0.0091	18.9981	0.0231	1.2200	3.8182	110.8500	0.3591	6.1551	0.2763	1.9091
37	1	1.1280	0.0049	18.4589	0.0136	1.0700	2.5556	152.7000	0.1651	5.7106	0.1541	0.6667
38	1	1.1336	0.0039	30.6136	0.0117	1.0900	3.0769	148.7900	0.1744	3.2987	0.1122	1.1538
38	1	1.1341	0.0035	11.3257	0.0079	1.0400	2.8333	146.9000	0.1372	3.3914	0.1092	0.6667
39	1	1.0912	0.0045	10.3795	0.0062	1.2900	0.9444	143.6100	0.2036	6.3488	0.1715	0.2778
40	1	1.1008	0.0051	14.7093	0.0096	1.1700	1.4667	138.1200	0.2473	4.0550	0.1405	0.6000
1	2	1.1369	0.0104	31.3120	0.0162	1.0700	1.7500	133.6900	0.4221	12.7968	0.3321	1.0833
2	2	1.1098	0.0049	12.6105	0.0105	1.0400	2.5000	108.7500	0.1920	3.6034	0.1620	0.5000
2	2	1.1228	0.0043	1.2649	0.0074	1.0700	2.0000	99.8400	0.1448	3.3874	0.1229	0.5000
3	2	1.1495	0.0045	10.5802	0.0080	1.0200	3.5263	127.0200	0.1635	3.8452	0.1338	1.0526
3	2	1.1981	0.0058	28.7783	0.0113	1.0400	4.0833	126.1400	0.1952	4.1936	0.1596	1.5833
4	2	1.0726	0.0065	23.3979	0.0216	1.1600	2.2083	94.7900	0.2532	3.2839	0.2060	0.7083
4	2	1.0830	0.0073	20.7004	0.0305	1.2100	1.7692	84.0000	0.3239	3.2981	0.2073	0.6923
5	2	1.1057	0.0035	3.9897	0.0047	1.0200	2.8095	142.8300	0.1430	2.6403	0.1109	1.0000
6	2	1.1315	0.0061	30.5419	0.0102	1.1500	2.7333	116.9000	0.2515	5.5048	0.1873	0.8000
8	2	1.1236	0.0057	8.1056	0.0221	1.2100	3.5714	141.8500	0.2491	6.5171	0.1735	0.2857
8	2	1.3875	0.0058	20.8765	0.0113	1.0000	3.1333	126.2000	0.2719	6.0390	0.1625	1.3333
9	2	1.1202	0.0034	6.7887	0.0060	1.0000	2.6923	99.2100	0.1429	3.0658	0.1099	0.5385
9	2	1.1218	0.0030	11.9002	0.0041	1.0200	2.0000	109.4700	0.1388	2.6041	0.0928	0.8125
11	2	1.0973	0.0043	28.0612	0.0064	1.0500	3.5333	116.5300	0.1953	3.3681	0.1171	0.9333
11	2	1.1038	0.0057	10.0809	0.0333	1.1100	2.3636	124.9300	0.2431	5.4407	0.1827	0.2727
12	2	1.1218	0.0038	13.4356	0.0138	1.0000	2.4000	193.8100	0.1541	4.0897	0.1427	0.8000
12	2	1.1540	0.0034	26.5768	0.0136	1.0000	5.2105	183.1200	0.1506	3.2748	0.1112	0.9474
13	2	1.1253	0.0031	8.9782	0.0046	1.0500	3.2353	183.3300	0.1495	3.2230	0.1111	0.5294
13	2	1.1458	0.0053	15.5588	0.0410	1.1100	2.8462	168.8100	0.1905	3.6318	0.1354	0.7692
14	2	1.1092	0.0040	13.3185	0.0094	1.0400	1.5385	95.0000	0.1729	3.3092	0.1056	0.4615
14	2	1.1425	0.0034	15.3648	0.0069	1.0000	3.0588	104.2700	0.1553	3.3507	0.0964	0.7647
16	2	1.0809	0.0053	19.6400	0.0080	1.0400	2.2500	136.3600	0.2297	3.3611	0.1510	0.9167
16	2	1.0911	0.0062	4.9978	0.0108	1.0700	2.1111	209.0200	0.2487	3.8730	0.1641	0.8333
17	2	1.0915	0.0037	21.2479	0.0088	1.0200	3.0000	91.8100	0.1555	3.4357	0.1373	1.1053
17	2	1.2872	0.0043	45.9658	0.0104	1.0000	1.5000	88.4600	0.1839	4.6303	0.1552	0.4167
18	2	1.1960	0.0061	32.4603	0.0080	1.1100	6.6364	102.8300	0.1942	4.6305	0.1887	1.1818
18	2	1.2601	0.0052	22.1278	0.0076	1.0500	4.8750	115.5000	0.1806	4.0583	0.1526	1.9375
19	2	1.1189	0.0052	12.5021	0.0164	1.0400	2.6667	214.7900	0.1850	4.4892	0.1232	0.8889
19	2	1.1494	0.0047	29.2471	0.0072	1.0000	2.7778	210.1500	0.1837	4.9068	0.1395	0.8889
20	2	1.3340	0.0071	32.0881	0.0210	1.2000	2.5882	130.5700	0.3159	14.9974	0.2440	1.0588
20	2	1.4092	0.0078	44.2034	0.0210	1.0700	2.6364	136.6900	0.3299	16.5669	0.3041	1.3636
22	2	1.1131	0.0082	21.6903	0.0133	1.1400	2.3846	127.5900	0.3108	6.0481	0.2092	0.9231
22	2	1.1351	0.0050	35.6271	0.0077	1.1000	3.0588	136.6500	0.1882	4.2600	0.1447	0.8824
23	2	1.1214	0.0054	19.4755	0.0175	1.1100	1.6667	104.5000	0.2177	5.5942	0.1599	0.5833
23	2	1.1356	0.0040	14.7310	0.0067	1.0700	3.0667	102.0200	0.1547	2.8730	0.1133	0.6000
24	2	1.1148	0.0066	25.0718	0.0170	1.0400	1.9231	117.7100	0.2908	8.8441	0.2430	0.6923
25	2	1.0904	0.0039	50.5508	0.0053	1.0500	1.4286	162.9300	0.1891	3.6397	0.1200	0.4286
25	2	1.1448	0.0060	6.3805	0.0172	1.1100	1.0000	145.8400	0.2603	6.6561	0.1374	0.6364
26	2	1.1041	0.0075	12.2170	0.0117	1.0700	1.4167	107.1400	0.3338	4.5654	0.1809	0.5833
26	2	1.1133	0.0060	8.9725	0.0088	1.0500	1.8824	122.4100	0.2701	5.5704	0.1467	0.7059
27	2	1.1077	0.0031	19.4585	0.0057	1.0000	2.0588	116.6300	0.1702	3.0877	0.0954	0.8235
27	2	1.1123	0.0032	2.5916	0.0041	1.0000	2.1000	108.7400	0.1573	4.3607	0.1105	0.6000
28	2	1.1043	0.0046	30.5823	0.0067	1.0000	4.6429	191.8600	0.1909	4.3819	0.1546	1.0000
29	2	1.1300	0.0054	8.7342	0.0152	1.0000	3.5833	80.2500	0.2236	3.7578	0.1369	1.0000
29	2	1.1434	0.0044	20.2000	0.0074	1.0200	2.0526	94.6700	0.1763	3.8852	0.1346	0.3158
30	2	1.1691	0.0038	12.5887	0.0111	1.0700	2.6923	136.2500	0.1817	5.7935	0.1525	0.8462
30	2	1.2762	0.0038	8.9962	0.0080	1.1700	3.3889	205.6900	0.1758	4.9242	0.1413	0.9444
31	2	1.1200	0.0060	41.0467	0.0091	1.0700	3.8889	116.6000	0.2122	2.9084	0.1510	0.6667
32	2	1.1669	0.0088	20.5073	0.0158	1.2100	6.3571	127.7700	0.2646	4.2910	0.2326	1.5714
32	2	1.1726	0.0070	10.7359	0.0314	1.1600	5.2222	132.1400	0.2449	5.2766	0.2019	0.8889
33	2	1.1159	0.0049	32.0900	0.0214	1.1100	3.3000	156.0700	0.2060	3.0902	0.1362	0.8000
33	2	1.1866	0.0039	12.1218	0.0085	1.1700	4.1579	139.3700	0.1464	2.5823	0.1098	0.8947
34	2	1.0843	0.0060	7.7825	0.0125	1.0700	2.1875	104.8200	0.2114	3.0976	0.1551	0.7500
34	2	1.0992	0.0061	12.7140	0.0124	1.1900	2.1818	106.6600	0.2399	3.1073	0.1555	1.5455
35	2	1.1090	0.0058	11.3788	0.0104	1.1400	2.7241	179.8400	0.2187	6.0650	0.1588	0.7241
36	2	1.0855	0.0074	47.8797	0.0210	1.2900	3.7778	114.6100	0.2719	3.6164	0.1918	1.7778
37	2	1.1684	0.0038	18.7782	0.0061	1.0500	4.5000	137.6900	0.1526	3.5612	0.1442	1.2500
37	2	1.2036	0.0047	18.7934	0.0107	1.0400	1.7500	143.2900	0.1929	6.0587	0.2045	0.7500
38	2	1.1108	0.0057	9.6525	0.0619	1.0000	2.4444	137.1100	0.2160	2.5459	0.1376	0.4444
39	2	1.1678	0.0037	8.3651	0.0053	1.0900	1.6429	137.4400	0.1726	7.4809	0.1304	0.4286
40	2	1.1043	0.0066	69.3677	0.0161	1.0700	2.2857	106.7100	0.2679	4.0426	0.1407	0.3571

Table B.9: Experiment Data by Absolute Valence.

B.11 Experiment Data Grouped by Happiness

The data sorted and cleaned, grouped by happiness (happy vs. sad).

no	overall	me	md	ol	ma	cn	mb	cd	mu	mt	ms	on
1	1	1.1520	0.0082	20.3774	0.0190	1.0400	2.6364	141.8300	0.3190	10.3792	0.2706	1.4545
1	1	1.1484	0.0093	86.6157	0.0254	1.0200	4.4444	153.8400	0.3574	8.2892	0.2728	1.3889
1	1	1.1369	0.0104	31.3120	0.0162	1.0700	1.7500	133.6900	0.4221	12.7968	0.3321	1.0833
2	1	1.1098	0.0049	12.6105	0.0105	1.0400	2.5000	108.7500	0.1920	3.6034	0.1620	0.5000
3	1	1.1637	0.0073	41.2074	0.0453	1.1500	3.0000	124.4200	0.2453	6.0336	0.1857	0.7857
3	1	1.1981	0.0058	28.7783	0.0113	1.0400	4.0833	126.1400	0.1952	4.1936	0.1596	1.5833
3	1	1.1495	0.0045	10.5802	0.0080	1.0200	3.5263	127.0200	0.1635	3.8452	0.1338	1.0526
4	1	1.0830	0.0073	20.7004	0.0305	1.2100	1.7692	84.0000	0.3239	3.2981	0.2073	0.6923
4	1	1.1044	0.0103	20.9857	0.0554	1.2000	1.7778	90.6100	0.3831	4.0335	0.2564	0.4444
4	1	1.0726	0.0065	23.3979	0.0216	1.1600	2.2083	94.7900	0.2532	3.2839	0.2060	0.7083
7	1	1.1024	0.0035	4.7708	0.0051	1.0700	1.3636	115.0700	0.1707	3.1096	0.1195	0.7273
8	1	1.1236	0.0057	8.1056	0.0221	1.2100	3.5714	141.8500	0.2491	6.5171	0.1735	0.2857
8	1	1.3875	0.0058	20.8765	0.0113	1.0000	3.1333	126.2000	0.2719	6.0390	0.1625	1.3333
9	1	1.1202	0.0034	6.7887	0.0060	1.0000	2.6923	99.2100	0.1429	3.0658	0.1099	0.5385
9	1	1.1218	0.0030	11.9002	0.0041	1.0200	2.0000	109.4700	0.1388	2.6041	0.0928	0.8125
9	1	1.0966	0.0039	20.4940	0.0074	1.0000	2.6667	90.1800	0.1870	3.4569	0.1224	0.7778
11	1	1.0973	0.0043	28.0612	0.0064	1.0500	3.5333	116.5300	0.1953	3.3681	0.1171	0.9333
11	1	1.1038	0.0057	10.0809	0.0333	1.1100	2.3636	124.9300	0.2431	5.4407	0.1827	0.2727
12	1	1.1540	0.0034	26.5768	0.0136	1.0000	5.2105	183.1200	0.1506	3.2748	0.1112	0.9474
12	1	1.1218	0.0038	13.4356	0.0138	1.0000	2.4000	193.8100	0.1541	4.0897	0.1427	0.8000
12	1	1.1017	0.0030	9.3992	0.0061	1.0000	2.2727	191.2500	0.1667	4.6700	0.1236	0.8182
13	1	1.1458	0.0053	15.5588	0.0410	1.1100	2.8462	168.8100	0.1905	3.6318	0.1354	0.7692
13	1	1.1253	0.0031	8.9782	0.0046	1.0500	3.2353	183.3300	0.1495	3.2230	0.1111	0.5294
13	1	1.1676	0.0045	9.9890	0.0133	1.1100	2.2500	178.2600	0.1928	4.5814	0.1684	0.8333
14	1	1.1425	0.0034	15.3648	0.0069	1.0000	3.0588	104.2700	0.1553	3.3507	0.0964	0.7647
14	1	1.1092	0.0040	13.3185	0.0094	1.0400	1.5385	95.0000	0.1729	3.3092	0.1056	0.4615
15	1	1.1968	0.0064	9.4995	0.0083	1.1700	1.8333	147.5400	0.2398	9.5810	0.2163	0.8333
15	1	1.3704	0.0091	31.9821	0.0132	1.4100	1.9231	143.8400	0.2977	16.0828	0.3378	0.6154
16	1	1.0911	0.0062	4.9978	0.0108	1.0700	2.1111	209.0200	0.2487	3.8730	0.1641	0.8333
17	1	1.0915	0.0037	21.2479	0.0088	1.0200	3.0000	91.8100	0.1555	3.4357	0.1373	1.1053
17	1	1.2872	0.0043	45.9658	0.0104	1.0000	1.5000	88.4600	0.1839	4.6303	0.1552	0.4167
17	1	1.0803	0.0044	116.5162	0.0079	1.1400	2.5000	87.1600	0.1857	5.0456	0.1602	0.7500
18	1	1.1960	0.0061	32.4603	0.0080	1.1100	6.6364	102.8300	0.1942	4.6305	0.1887	1.1818
18	1	1.2601	0.0052	22.1278	0.0076	1.0500	4.8750	115.5000	0.1806	4.0583	0.1526	1.9375
19	1	1.1039	0.0052	14.6944	0.0077	1.0000	2.1176	217.4900	0.2060	4.3035	0.1412	0.7059
19	1	1.1189	0.0052	12.5021	0.0164	1.0400	2.6667	214.7900	0.1850	4.4892	0.1232	0.8889
20	1	1.4092	0.0078	44.2034	0.0210	1.0700	2.6364	136.6900	0.3299	16.5669	0.3041	1.3636
21	1	1.2716	0.0034	4.5012	0.0073	1.0000	3.4167	150.7000	0.1377	3.3390	0.1159	0.5000
22	1	1.1351	0.0050	35.6271	0.0077	1.1000	3.0588	136.6500	0.1882	4.2600	0.1447	0.8824
22	1	1.1131	0.0082	21.6903	0.0133	1.1400	2.3846	127.5900	0.3108	6.0481	0.2092	0.9231
23	1	1.1356	0.0040	14.7310	0.0067	1.0700	3.0667	102.0200	0.1547	2.8730	0.1133	0.6000
24	1	1.1105	0.0058	19.3191	0.0199	1.0500	2.0588	121.0900	0.2482	6.5182	0.1899	0.6471
24	1	1.1711	0.0098	17.2899	0.0399	1.0300	2.5385	115.0700	0.2932	8.0260	0.2786	0.8462
24	1	1.1148	0.0066	25.0718	0.0170	1.0400	1.9231	117.7100	0.2908	8.8441	0.2430	0.6923
25	1	1.1448	0.0060	6.3805	0.0172	1.1100	1.0000	145.8400	0.2603	6.6561	0.1374	0.6364
25	1	1.0904	0.0039	50.5508	0.0053	1.0500	1.4286	162.9300	0.1891	3.6397	0.1200	0.4286
26	1	1.1041	0.0075	12.2170	0.0117	1.0700	1.4167	107.1400	0.3338	4.5654	0.1809	0.5833
26	1	1.1133	0.0060	8.9725	0.0088	1.0500	1.8824	122.4100	0.2701	5.5704	0.1467	0.7059
27	1	1.1077	0.0031	19.4585	0.0057	1.0000	2.0588	116.6300	0.1702	3.0877	0.0954	0.8235
27	1	1.1123	0.0032	2.5916	0.0041	1.0000	2.1000	108.7400	0.1573	4.3607	0.1105	0.6000
28	1	1.1043	0.0046	30.5823	0.0067	1.0000	4.6429	191.8600	0.1909	4.3819	0.1546	1.0000
28	1	1.0827	0.0042	7.4980	0.0074	1.0300	3.0909	146.6500	0.2145	6.0351	0.1669	1.3636
29	1	1.1434	0.0044	20.2000	0.0074	1.0200	2.0526	94.6700	0.1763	3.8852	0.1346	0.3158
29	1	1.1300	0.0054	8.7342	0.0152	1.0000	3.5833	80.2500	0.2236	3.7578	0.1369	1.0000
29	1	1.1135	0.0049	10.3121	0.0083	1.0400	2.5455	81.8300	0.2097	4.6694	0.1550	0.7273
30	1	1.2762	0.0038	8.9962	0.0080	1.1700	3.3889	205.6900	0.1758	4.9242	0.1413	0.9444
30	1	1.1405	0.0043	38.0682	0.0061	1.1100	3.5000	191.0600	0.1874	4.3270	0.1540	0.7857
30	1	1.1691	0.0038	12.5887	0.0111	1.0700	2.6923	136.2500	0.1817	5.7935	0.1525	0.8462
31	1	1.1200	0.0060	41.0467	0.0091	1.0700	3.8889	116.6000	0.2122	2.9084	0.1510	0.6667
32	1	1.1726	0.0070	10.7359	0.0314	1.1600	5.2222	132.1400	0.2449	5.2766	0.2019	0.8889
33	1	1.1866	0.0039	12.1218	0.0085	1.1700	4.1579	139.3700	0.1464	2.5823	0.1098	0.8947
33	1	1.1159	0.0049	32.0900	0.0214	1.1100	3.3000	156.0700	0.2060	3.0902	0.1362	0.8000
33	1	1.1472	0.0043	5.6359	0.0098	1.1500	4.0000	135.5200	0.1590	2.4085	0.1145	2.1250
34	1	1.0843	0.0060	7.7825	0.0125	1.0700	2.1875	104.8200	0.2114	3.0976	0.1551	0.7500
34	1	1.0992	0.0061	12.7140	0.0124	1.1900	2.1818	106.6600	0.2399	3.1073	0.1555	1.5455
34	1	1.1153	0.0045	35.4535	0.0079	1.0400	2.4000	113.1400	0.1800	3.1909	0.1236	0.6000
36	1	1.0855	0.0074	47.8797	0.0210	1.2900	3.7778	114.6100	0.2719	3.6164	0.1918	1.7778
36	1	1.0951	0.0067	19.3321	0.0091	1.1200	2.3684	114.3500	0.2370	5.1522	0.1799	0.6316
37	1	1.1684	0.0038	18.7782	0.0061	1.0500	4.5000	137.6900	0.1526	3.5612	0.1442	1.2500
37	1	1.2036	0.0047	18.7934	0.0107	1.0400	1.7500	143.2900	0.1929	6.0587	0.2045	0.7500
38	1	1.1336	0.0039	30.6136	0.0117	1.0900	3.0769	148.7900	0.1744	3.2987	0.1122	1.1538
38	1	1.1108	0.0057	9.6525	0.0619	1.0000	2.4444	137.1100	0.2160	2.5459	0.1376	0.4444
39	1	1.1678	0.0037	8.3651	0.0053	1.0900	1.6429	137.4400	0.1726	7.4809	0.1304	0.4286
39	1	1.0912	0.0045	10.3795	0.0062	1.2900	0.9444	143.6100	0.2036	6.3488	0.1715	0.2778
39	1	1.1297	0.0050	30.3425	0.0082	1.2900	1.7857	121.4200	0.2115	4.2020	0.1711	0.4286
40	1	1.1043	0.0066	69.3677	0.0161	1.0700	2.2857	106.7100	0.2679	4.0426	0.1407	0.3571
5	2	1.1057	0.0035	3.9897	0.0047	1.0200	2.8095	142.8300	0.1430	2.6403	0.1109	1.0000
11	2	1.2197	0.0060	32.5621	0.0079	1.1500	1.9091	115.0600	0.2564	4.1145	0.1370	0.3636
15	2	1.2319	0.0146	19.3301	0.0609	1.3300	2.9091	143.9700	0.4166	12.9223	0.3335	1.0000
16	2	1.1002	0.0062	4.2170	0.0222	1.1700	1.1538	133.8900	0.2708	5.3767	0.1438	0.4615
20	2	1.3340	0.0071	32.0881	0.0210	1.2000	2.5882	130.5700	0.3159	14.9974	0.2440	1.0588
20	2	1.2769	0.0070	25.8550	0.0115	1.1100	3.0833	124.0000	0.2990	11.3757	0.2369	2.1667
21	2	1.0867	0.0039	40.0207	0.0282	1.0400	3.0769	139.1700	0.1745	4.1530	0.1625	0.8462
22	2	1.0842	0.0053	11.6503	0.0138	1.1300	1.6923	127.0300	0.2246	4.4566	0.1644	0.6923
25	2	1.0933	0.0042	9.6985	0.0069	1.0700	2.5000	144.3800	0.1809	3.2340	0.1150	0.4000
26	2	1.1159	0.0079	39.2230	0.0262	1.0400	2.0000	102.7100	0.3213	6.9775	0.1737	0.9091
27	2	1.1203	0.0034	5.1562	0.0046	1.0700	1.7500	104.9700	0.1653	5.2952	0.1125	0.6667
28	2	1.1422	0.0044	15.0317	0.0080	1.0000	1.4444	153.4600	0.2057	6.6359	0.1517	0.7778
31	2	1.2002	0.0065	17.5166	0.0138	1.0600	4.0909	115.2100	0.2343	3.1160	0.1852	1.4545
32	2	1.1997	0.0075	8.2437	0.0163	1.1900	2.6667	125.3100	0.2448	4.2396	0.2340	0.6667
35	2	1.1090	0.0058	11.3788	0.0104	1.1400	2.7241	179.8400	0.2187	6.0650	0.1588	0.7241
35	2	1.0892	0.0062	37.6813	0.0414	1.2000	4.0000	165.6100	0.2511	5.9819	0.1866	1.5000
35	2	1.2115	0.0066	27.9802	0.0079	1.2300	2.8000	246.8800	0.2671	9.3072	0.1877	1.2000
36	2	1.2449	0.0091	18.9981	0.0231	1.2200	3.8182	110.8500	0.3591	6.1551	0.2763	1.9091
37	2	1.1280	0.0049	18.4589	0.0136	1.0700	2.5556	152.7000	0.1651	5.7106	0.1541	0.6667
40	2	1.0847	0.0056	24.8059	0.0082	1.0500	1.8125	105.4500	0.2261	3.9834	0.1361	0.5625

Table B.10: Experiment Data by Absolute Happiness.

B.12 Experiment Data Grouped by Anger

The following table (B.11) shows the experiment data sorted and cleaned, grouped by the absolute anger (anger vs. contentedness).

no	valaro	me	md	ol	ma	cn	mb	cd	mu	mt	ms	on
1	1	1.1520	0.0082	20.3774	0.0190	1.0400	2.6364	141.8300	0.3190	10.3792	0.2706	1.4545
5	1	1.0929	0.0036	24.3042	0.0119	1.1400	1.8000	138.8800	0.1518	3.5696	0.1124	0.2000
9	1	1.0966	0.0039	20.4940	0.0074	1.0000	2.6667	90.1800	0.1870	3.4569	0.1224	0.7778
11	1	1.2197	0.0060	32.5621	0.0079	1.1500	1.9091	115.0600	0.2564	4.1145	0.1370	0.3636
14	1	1.1057	0.0061	21.1031	0.0131	1.0400	1.3000	91.8900	0.2290	4.0840	0.1601	0.6000
15	1	1.2319	0.0146	19.3301	0.0609	1.3300	2.9091	143.9700	0.4166	12.9223	0.3335	1.0000
17	1	1.0803	0.0044	116.5162	0.0079	1.1400	2.5000	87.1600	0.1857	5.0456	0.1602	0.7500
22	1	1.0842	0.0053	11.6503	0.0138	1.1300	1.6923	127.0300	0.2246	4.4566	0.1644	0.6923
25	1	1.0933	0.0042	9.6985	0.0069	1.0700	2.5000	144.3800	0.1809	3.2340	0.1150	0.4000
26	1	1.1159	0.0079	39.2230	0.0262	1.0400	2.0000	102.7100	0.3213	6.9775	0.1737	0.9091
27	1	1.1203	0.0034	5.1562	0.0046	1.0700	1.7500	104.9700	0.1653	5.2952	0.1125	0.6667
28	1	1.1422	0.0044	15.0317	0.0080	1.0000	1.4444	153.4600	0.2057	6.6359	0.1517	0.7778
32	1	1.1997	0.0075	8.2437	0.0163	1.1900	2.6667	125.3100	0.2448	4.2396	0.2340	0.6667
33	1	1.1472	0.0043	5.6359	0.0098	1.1500	4.0000	135.5200	0.1590	2.4085	0.1145	2.1250
35	1	1.0892	0.0062	37.6813	0.0414	1.2000	4.0000	165.6100	0.2511	5.9819	0.1866	1.5000
36	1	1.2449	0.0091	18.9981	0.0231	1.2200	3.8182	110.8500	0.3591	6.1551	0.2763	1.9091
36	1	1.0951	0.0067	19.3321	0.0091	1.1200	2.3684	114.3500	0.2370	5.1522	0.1799	0.6316
37	1	1.1280	0.0049	18.4589	0.0136	1.0700	2.5556	152.7000	0.1651	5.7106	0.1541	0.6667
38	1	1.1341	0.0035	11.3257	0.0079	1.0400	2.8333	146.9000	0.1372	3.3914	0.1092	0.6667
40	1	1.1008	0.0051	14.7093	0.0096	1.1700	1.4667	138.1200	0.2473	4.0550	0.1405	0.6000
2	2	1.1228	0.0043	1.2649	0.0074	1.0700	2.0000	99.8400	0.1448	3.3874	0.1229	0.5000
2	2	1.1098	0.0049	12.6105	0.0105	1.0400	2.5000	108.7500	0.1920	3.6034	0.1620	0.5000
2	2	1.4295	0.0048	4.6451	0.0175	1.0400	1.5833	105.5900	0.1912	4.4915	0.1378	0.2500
3	2	1.1981	0.0058	28.7783	0.0113	1.0400	4.0833	126.1400	0.1952	4.1936	0.1596	1.5833
3	2	1.1495	0.0045	10.5802	0.0080	1.0200	3.5263	127.0200	0.1635	3.8452	0.1338	1.0526
4	2	1.0830	0.0073	20.7004	0.0305	1.2100	1.7692	84.0000	0.3239	3.2981	0.2073	0.6923
5	2	1.1057	0.0035	3.9897	0.0047	1.0200	2.8095	142.8300	0.1430	2.6403	0.1109	1.0000
6	2	1.1315	0.0061	30.5419	0.0102	1.1500	2.7333	116.9000	0.2515	5.5048	0.1873	0.8000
8	2	1.3875	0.0058	20.8765	0.0113	1.0000	3.1333	126.2000	0.2719	6.0390	0.1625	1.3333
8	2	1.1236	0.0057	8.1056	0.0221	1.2100	3.5714	141.8500	0.2491	6.5171	0.1735	0.2857
9	2	1.1218	0.0030	11.9002	0.0041	1.0200	2.0000	109.4700	0.1388	2.6041	0.0928	0.8125
9	2	1.1202	0.0034	6.7887	0.0060	1.0000	2.6923	99.2100	0.1429	3.0658	0.1099	0.5385
11	2	1.0973	0.0043	28.0612	0.0064	1.0500	3.5333	116.5300	0.1953	3.3681	0.1171	0.9333
11	2	1.1038	0.0057	10.0809	0.0333	1.1100	2.3636	124.9300	0.2431	5.4407	0.1827	0.2727
12	2	1.1540	0.0034	26.5768	0.0136	1.0000	5.2105	183.1200	0.1506	3.2748	0.1112	0.9474
12	2	1.1218	0.0038	13.4356	0.0138	1.0000	2.4000	193.8100	0.1541	4.0897	0.1427	0.8000
13	2	1.1253	0.0031	8.9782	0.0046	1.0500	3.2353	183.3300	0.1495	3.2230	0.1111	0.5294
13	2	1.1458	0.0053	15.5588	0.0410	1.1100	2.8462	168.8100	0.1905	3.6318	0.1354	0.7692
14	2	1.1425	0.0034	15.3648	0.0069	1.0000	3.0588	104.2700	0.1553	3.3507	0.0964	0.7647
14	2	1.1092	0.0040	13.3185	0.0094	1.0400	1.5385	95.0000	0.1729	3.3092	0.1056	0.4615
16	2	1.0911	0.0062	4.9978	0.0108	1.0700	2.1111	209.0200	0.2487	3.8730	0.1641	0.8333
17	2	1.0915	0.0037	21.2479	0.0088	1.0200	3.0000	91.8100	0.1555	3.4357	0.1373	1.1053
17	2	1.2872	0.0043	45.9658	0.0104	1.0000	1.5000	88.4600	0.1839	4.6303	0.1552	0.4167
18	2	1.2601	0.0052	22.1278	0.0076	1.0500	4.8750	115.5000	0.1806	4.0583	0.1526	1.9375
18	2	1.1960	0.0061	32.4603	0.0080	1.1100	6.6364	102.8300	0.1942	4.6305	0.1887	1.1818
19	2	1.1494	0.0047	29.2471	0.0072	1.0000	2.7778	210.1500	0.1837	4.9068	0.1395	0.8889
19	2	1.1189	0.0052	12.5021	0.0164	1.0400	2.6667	214.7900	0.1850	4.4892	0.1232	0.8889
20	2	1.3340	0.0071	32.0881	0.0210	1.2000	2.5882	130.5700	0.3159	14.9974	0.2440	1.0588
20	2	1.4092	0.0078	44.2034	0.0210	1.0700	2.6364	136.6900	0.3299	16.5669	0.3041	1.3636
22	2	1.1351	0.0050	35.6271	0.0077	1.1000	3.0588	136.6500	0.1882	4.2600	0.1447	0.8824
22	2	1.1131	0.0082	21.6903	0.0133	1.1400	2.3846	127.5900	0.3108	6.0481	0.2092	0.9231
23	2	1.1356	0.0040	14.7310	0.0067	1.0700	3.0667	102.0200	0.1547	2.8730	0.1133	0.6000
24	2	1.1148	0.0066	25.0718	0.0170	1.0400	1.9231	117.7100	0.2908	8.8441	0.2430	0.6923
25	2	1.0904	0.0039	50.5508	0.0053	1.0500	1.4286	162.9300	0.1891	3.6397	0.1200	0.4286
25	2	1.1448	0.0060	6.3805	0.0172	1.1100	1.0000	145.8400	0.2603	6.6561	0.1374	0.6364
26	2	1.1133	0.0060	8.9725	0.0088	1.0500	1.8824	122.4100	0.2701	5.5704	0.1467	0.7059
26	2	1.1041	0.0075	12.2170	0.0117	1.0700	1.4167	107.1400	0.3338	4.5654	0.1809	0.5833
27	2	1.1123	0.0032	2.5916	0.0041	1.0000	2.1000	108.7400	0.1573	4.3607	0.1105	0.6000
27	2	1.1077	0.0031	19.4585	0.0057	1.0000	2.0588	116.6300	0.1702	3.0877	0.0954	0.8235
28	2	1.0827	0.0042	7.4980	0.0074	1.0300	3.0909	146.6500	0.2145	6.0351	0.1669	1.3636
28	2	1.1043	0.0046	30.5823	0.0067	1.0000	4.6429	191.8600	0.1909	4.3819	0.1546	1.0000
29	2	1.1434	0.0044	20.2000	0.0074	1.0200	2.0526	94.6700	0.1763	3.8852	0.1346	0.3158
29	2	1.1300	0.0054	8.7342	0.0152	1.0000	3.5833	80.2500	0.2236	3.7578	0.1369	1.0000
30	2	1.1691	0.0038	12.5887	0.0111	1.0700	2.6923	136.2500	0.1817	5.7935	0.1525	0.8462
31	2	1.1200	0.0060	41.0467	0.0091	1.0700	3.8889	116.6000	0.2122	2.9084	0.1510	0.6667
32	2	1.1726	0.0070	10.7359	0.0314	1.1600	5.2222	132.1400	0.2449	5.2766	0.2019	0.8889
32	2	1.1669	0.0088	20.5073	0.0158	1.2100	6.3571	127.7700	0.2646	4.2910	0.2326	1.5714
33	2	1.1866	0.0039	12.1218	0.0085	1.1700	4.1579	139.3700	0.1464	2.5823	0.1098	0.8947
33	2	1.1159	0.0049	32.0900	0.0214	1.1100	3.3000	156.0700	0.2060	3.0902	0.1362	0.8000
34	2	1.0843	0.0060	7.7825	0.0125	1.0700	2.1875	104.8200	0.2114	3.0976	0.1551	0.7500
34	2	1.0992	0.0061	12.7140	0.0124	1.1900	2.1818	106.6600	0.2399	3.1073	0.1555	1.5455
35	2	1.1090	0.0058	11.3788	0.0104	1.1400	2.7241	179.8400	0.2187	6.0650	0.1588	0.7241
36	2	1.0855	0.0074	47.8797	0.0210	1.2900	3.7778	114.6100	0.2719	3.6164	0.1918	1.7778
37	2	1.1684	0.0038	18.7782	0.0061	1.0500	4.5000	137.6900	0.1526	3.5612	0.1442	1.2500
37	2	1.2036	0.0047	18.7934	0.0107	1.0400	1.7500	143.2900	0.1929	6.0587	0.2045	0.7500
38	2	1.1108	0.0057	9.6525	0.0619	1.0000	2.4444	137.1100	0.2160	2.5459	0.1376	0.4444
39	2	1.1678	0.0037	8.3651	0.0053	1.0900	1.6429	137.4400	0.1726	7.4809	0.1304	0.4286
40	2	1.0847	0.0056	24.8059	0.0082	1.0500	1.8125	105.4500	0.2261	3.9834	0.1361	0.5625

Table B.11: Experiment Data by Absolute Anger.

B.13 Mouse Movement Differences Grouped by Film

Mouse Movement Differences Grouped by Film pt.1: Low Arousal, Neutral Film

NO	dME	dMD	dOL	dMA	dCN	dMB	dCD	dMU	dMT	dMS	dON
1	-0.0115	0.0011	-55.3037	-0.0092	0.0500	-2.6944	-20.1500	0.0647	4.5076	0.0593	-0.3056
2	-0.0130	0.0006	11.3456	0.0031	-0.0300	0.5000	8.9100	0.0472	0.2160	0.0391	0.0000
3	0.0486	0.0013	18.1981	0.0033	0.0200	0.5570	-0.8800	0.0317	0.3484	0.0258	0.5307
4	0.0104	0.0008	-2.6975	0.0089	0.0500	-0.4391	-10.7900	0.0707	0.0142	0.0013	-0.0160
5	-0.0389	0.0010	34.3369	0.0063	0.1900	-1.5238	-3.2700	0.0595	1.8953	0.0481	-0.5714
6	-0.0069	0.0011	-0.9326	-0.0024	0.0600	-0.3720	-11.7500	0.0521	1.8473	0.0499	0.0105
7	-0.0544	0.0002	-4.7732	0.0002	-0.0500	-1.3667	-4.5900	0.0432	1.1062	0.0018	-0.0167
8	-0.2456	0.0000	-15.1184	-0.0013	0.0700	-1.1333	7.2200	-0.0008	0.0126	-0.0014	-0.7333
9	-0.0016	0.0004	-5.1115	0.0019	-0.0200	0.6923	-10.2600	0.0041	0.4617	0.0171	-0.2740
12	0.0065	0.0014	-17.9803	0.0269	0.0600	-1.1697	8.4000	0.0478	2.0726	0.0656	-0.6606
12	-0.0322	0.0004	-13.1412	0.0002	0.0000	-2.8105	10.6900	0.0035	0.8149	0.0315	-0.1474
12	0.0205	0.0022	6.5806	0.0364	0.0600	-0.3891	-14.5200	0.0410	0.4088	0.0243	0.2398
12	-0.0333	0.0006	-2.0463	0.0025	0.0400	-1.5203	-9.2700	0.0176	-0.0415	0.0092	-0.3032
12	0.1736	0.0027	22.4826	0.0049	0.2400	0.0898	-3.7000	0.0579	6.5018	0.1215	-0.2179
12	-0.0102	-0.0009	14.6422	-0.0028	-0.0300	0.1389	-72.6600	-0.0190	-0.5119	-0.0131	0.0834
12	0.1957	0.0006	24.7179	0.0016	-0.0200	-1.5000	-3.3500	0.0284	1.1946	0.0179	-0.6886
12	-0.0641	0.0009	10.3325	0.0004	0.0600	1.7614	-12.6700	0.0136	0.5722	0.0361	-0.7557
12	0.0455	-0.0005	14.5527	-0.0005	0.0000	0.6602	-7.3400	-0.0223	0.6033	-0.0017	0.1830
22	0.0752	0.0007	12.1153	0.0000	-0.1300	0.0482	6.1200	0.0140	1.5695	0.0601	0.3048
22	0.1411	0.0001	-2.3933	-0.0011	-0.0200	0.2062	-10.0400	0.0071	0.5379	0.0110	-0.7632
22	-0.0220	0.0032	-13.9368	0.0056	0.0400	-0.6742	-9.0600	0.1226	1.7881	0.0645	0.0407
22	-0.0142	0.0014	4.7445	0.0108	0.0400	-1.4000	2.4800	0.0630	2.7212	0.0466	-0.0167
22	0.0043	0.0008	5.7527	-0.0029	-0.0100	-0.1357	-3.3800	0.0426	2.3259	0.0531	0.0452
22	0.0544	0.0021	-44.1703	0.0119	0.0600	-0.4286	-17.0900	0.0712	3.0164	0.0174	0.2078
22	-0.0092	0.0015	3.2445	0.0029	0.0200	-0.4657	-15.2700	0.0637	-1.0050	0.0342	-0.1226
22	0.0046	0.0001	-16.8669	-0.0016	0.0000	0.0412	-7.8900	-0.0129	1.2730	0.0151	-0.2235
22	-0.0216	-0.0004	-23.0843	0.0007	0.0300	-1.5520	-45.2100	0.0236	1.6532	0.0123	0.3636
22	-0.0134	0.0010	-11.4658	0.0078	-0.0200	1.5307	-14.4200	0.0473	-0.1274	0.0023	0.6842
32	-0.1071	0.0000	3.5925	0.0031	-0.1000	-0.6966	-69.4400	0.0059	0.8693	0.0112	-0.0982
32	-0.0144	0.0007	19.3947	0.0003	-0.0700	-1.7582	-17.7800	0.0449	0.1461	0.0139	-0.6862
32	-0.0057	0.0018	9.7714	-0.0156	0.0500	1.1349	-4.3700	0.0197	-0.9856	0.0307	0.6825
32	-0.0707	0.0010	19.9682	0.0129	-0.0600	-0.8579	16.7000	0.0596	0.5079	0.0264	-0.0947
32	0.0149	0.0001	4.9315	-0.0001	0.1200	-0.0057	1.8400	0.0285	0.0097	0.0004	0.7955
32	0.1025	0.0008	16.6014	-0.0025	0.0900	0.0759	67.0400	0.0484	3.2422	0.0289	0.4759
32	-0.0096	0.0007	28.5476	0.0119	0.1700	1.4094	0.2600	0.0349	-1.5358	0.0119	1.1462
32	0.0352	0.0009	0.0152	0.0046	-0.0100	-2.7500	5.6000	0.0403	2.4975	0.0603	-0.5000
32	-0.0228	0.0018	-20.9611	0.0502	-0.0900	-0.6325	-11.6800	0.0416	-0.7528	0.0254	-0.7094
32	-0.0381	0.0013	21.9774	0.0029	0.2000	0.1428	-16.0200	0.0389	-3.2789	0.0407	0.0000
42	0.0196	0.0010	44.5618	0.0079	0.0200	0.4732	1.2600	0.0418	0.0592	0.0046	-0.2054

NO	dME	dMD	dOL	dMA	dCN	dMB	dCD	dMU	dMT	dMS	dON
1	0.9900	1.1183	0.3615	0.6378	1.0490	0.3938	0.8690	1.1810	1.5438	1.2174	0.7800
2	0.9884	1.1395	9.9696	1.4189	0.9720	1.2500	1.0892	1.3260	1.0638	1.3181	1.0000
3	1.0423	1.2889	2.7200	1.4125	1.0196	1.1580	0.9931	1.1939	1.0906	1.1928	1.5042
4	1.0097	1.1231	0.8847	1.4120	1.0431	0.8012	0.8862	1.2792	1.0043	1.0063	0.9774
5	0.9648	1.2857	9.6064	2.3404	1.1863	0.4576	0.9771	1.4161	1.7178	1.4337	0.4286
6	0.9939	1.2200	0.9704	0.8095	1.0550	0.8802	0.9087	1.2613	1.5051	1.3632	1.0133
7	0.9527	1.0455	0.8111	1.0247	0.9554	0.6039	0.9660	1.2538	1.3872	1.0131	0.9523
8	0.8230	1.0000	0.2758	0.8850	1.0700	0.6383	1.0572	0.9971	1.0021	0.9914	0.4500
9	0.9986	1.1333	0.5705	1.4634	0.9804	1.3462	0.9063	1.0295	1.1773	1.1843	0.6628
11	1.0059	1.3256	0.3592	5.2031	1.0571	0.6689	1.0721	1.2448	1.6154	1.5602	0.2922
12	0.9721	1.1176	0.5055	1.0147	1.0000	0.4606	1.0584	1.0232	1.2488	1.2833	0.8444
13	1.0182	1.7097	1.7330	8.9130	1.0571	0.8797	0.9208	1.2742	1.1268	1.2187	1.4530
14	0.9709	1.1765	0.8668	1.3623	1.0400	0.5030	0.9111	1.1133	0.9876	1.0954	0.6035
15	1.1451	1.4219	3.3667	1.5904	1.2051	1.0490	0.9749	1.2415	1.6786	1.5617	0.7385
16	0.9907	0.8548	3.9297	0.7407	0.9720	1.0658	0.6524	0.9236	0.8678	0.9202	1.1001
17	1.1793	1.1622	2.1633	1.1818	0.9804	0.5000	0.9635	1.1826	1.3477	1.1304	0.3770
18	0.9491	1.1731	1.4669	1.0526	1.0571	1.3613	0.8903	1.0753	1.1410	1.2366	0.6100
19	1.0412	0.9038	1.9904	0.9351	1.0000	1.3118	0.9663	0.8917	1.1402	0.9880	1.2592
20	1.0564	1.0986	1.3776	1.0000	0.8917	1.0186	1.0469	1.0443	1.1047	1.2463	1.2879
21	1.1248	1.0303	0.6529	0.8690	0.9804	1.0642	0.9375	1.0544	1.1920	1.1049	0.3958
22	0.9806	1.6400	0.6088	1.7273	1.0364	0.7796	0.9337	1.6514	1.4197	1.4457	1.0461
23	0.9875	1.3500	1.3221	2.6119	1.0374	0.5435	1.0243	1.4072	1.9472	1.4113	0.9722
24	1.0039	1.1379	1.2978	0.8543	0.9905	0.9341	0.9721	1.1716	1.3568	1.2796	1.0699
25	1.0499	1.5385	0.1262	3.2453	1.0571	0.7000	0.8951	1.3765	1.8287	1.1450	1.4848
26	0.9917	1.2500	1.3616	1.3295	1.0190	0.7526	0.8753	1.2358	0.8196	1.2331	0.8263
27	1.0042	1.0323	0.1332	0.7193	1.0000	1.0200	0.9324	0.9242	1.4123	1.1583	0.7286
28	0.9804	0.9130	0.2452	1.1045	1.0300	0.6657	0.7644	1.1236	1.3773	1.0796	1.3636
29	0.9883	1.2273	0.4324	2.0541	0.9804	1.7457	0.8477	1.2683	0.9672	1.0171	3.1666
30	0.9161	1.0000	1.3993	1.3875	0.9145	0.7944	0.6624	1.0336	1.1765	1.0793	0.8960
31	0.9873	1.1321	1.8957	1.0341	0.9386	0.6887	0.8677	1.2684	1.0529	1.1014	0.4928
32	0.9951	1.2571	1.9102	0.5032	1.0431	1.2173	0.9669	1.0804	0.8132	1.1521	1.7678
33	0.9404	1.2564	2.6473	2.5176	0.9487	0.7937	1.1198	1.4071	1.1967	1.2404	0.8942
34	1.0137	1.0167	1.6337	0.9920	1.1121	0.9974	1.0176	1.1348	1.0031	1.0026	2.0607
35	1.0924	1.1379	2.4590	0.7596	1.0789	1.0279	1.3728	1.2213	1.5346	1.1820	1.6572
36	0.9912	1.1045	2.4767	2.3077	1.1518	1.5951	1.0023	1.1473	0.7019	1.0661	2.8148
37	1.0301	1.2368	1.0008	1.7541	0.9905	0.3889	1.0407	1.2641	1.7013	1.4182	0.6000
38	0.9799	1.4615	0.3153	5.2906	0.9174	0.7944	0.9215	1.2385	0.7718	1.2264	0.3852
39	0.9674	1.3514	3.6273	1.5472	1.1835	1.0869	0.8834	1.2254	0.5617	1.3121	1.0000
40	1.0181	1.1786	2.7964	1.9634	1.0190	1.2611	1.0119	1.1849	1.0149	1.0338	0.6348

Table B.12: Mouse Movement Differences Grouped by Film pt.1: Low Arousal, Neutral Film:

Note. d stands for the difference calculated by subtraction. f stands for the factor calculated by division.

Mouse Movement Differences Grouped by Film pt.2: High Arousal, Negative Film

NO	dME	dMD	dOL	dMA	dCN	dMB	dCD	dMU	dMT	dMS	dON
1	-0.0151	0.0022	10.9346	-0.0028	0.0300	-0.8864	-8.1400	0.1031	2.4176	0.0615	-0.3712
2	-0.3197	0.0001	7.9654	-0.0070	0.0000	0.9167	3.1600	0.0008	-0.8881	0.0242	0.2500
3	0.0344	-0.0015	-12.4291	-0.0340	-0.1100	1.0833	1.7200	-0.0501	-1.8400	-0.0261	0.7976
4	-0.0214	-0.0030	-0.2853	-0.0249	0.0100	-0.0086	-6.6100	-0.0592	-0.7354	-0.0491	0.2479
5	-0.0261	0.0009	14.0224	-0.0009	0.0700	-0.5143	0.6800	0.0507	0.9660	0.0466	0.2286
6	0.0332	0.0007	13.5448	0.0020	0.0400	-0.7212	4.7700	0.0319	1.0299	0.0137	0.0727
7	-0.0072	0.0011	15.7255	0.0032	0.0000	0.7197	15.3000	0.0427	0.8533	0.0197	-0.3940
8	0.0183	0.0001	-2.3475	-0.0121	-0.1400	-1.5714	-8.4300	0.0220	-0.4655	-0.0124	0.3143
9	0.0236	-0.0005	-13.7053	-0.0014	0.0000	0.0256	9.0300	-0.0441	-0.3911	-0.0125	-0.2393
11	-0.1159	-0.0003	-22.4812	0.0254	-0.0400	0.4545	9.8700	-0.0133	1.3262	0.0457	-0.0909
11	0.0201	0.0008	4.0364	0.0077	0.0000	0.1273	2.5600	-0.0126	-0.5803	0.0191	-0.0182
11	-0.0218	0.0008	5.5698	0.0277	0.0000	0.5962	-9.4500	-0.0023	-0.9496	-0.0330	-0.0641
11	0.0035	-0.0021	-7.7846	-0.0037	0.0000	0.2385	3.1100	-0.0561	-0.7748	-0.0545	-0.1385
11	0.1385	-0.0055	12.6520	-0.0477	0.0800	-0.9860	-0.1300	-0.1189	3.1605	0.0043	-0.3846
11	-0.0193	-0.0009	15.4230	-0.0142	-0.1300	1.0962	2.4700	-0.0411	-2.0156	0.0072	0.4552
11	0.2069	-0.0001	-70.5504	0.0025	-0.1400	-1.0000	1.3000	-0.0018	-0.4153	-0.0050	-0.3333
11	0.0430	-0.0018	5.5807	-0.0030	0.1100	3.0364	-3.2800	-0.0639	-2.0865	-0.0422	0.2818
11	0.0305	-0.0005	16.7450	-0.0092	-0.0400	0.1111	-4.6400	-0.0013	0.4176	0.0163	0.0000
21	0.1323	0.0008	18.3484	0.0095	-0.0400	-0.4469	12.6900	0.0309	5.1912	0.0672	-0.8031
21	0.1849	-0.0005	-35.5195	-0.0209	-0.0400	0.3398	11.5300	-0.0368	-0.8140	-0.0466	-0.3462
21	0.0289	0.0029	10.0400	-0.0005	0.0100	0.6923	0.5600	0.0862	1.5915	0.0448	0.2308
21	-0.0160	0.0004	-1.3926	0.0064	0.0700	-1.1333	-4.8800	0.0071	1.4113	0.0102	-0.4167
21	-0.0563	-0.0032	7.7819	-0.0229	0.0100	-0.6154	2.6400	-0.0024	0.8181	-0.0356	-0.1539
21	0.0515	0.0018	-3.3180	0.0103	0.0400	-1.5000	1.4600	0.0794	3.4221	0.0224	0.2364
21	-0.0118	-0.0004	-27.0060	-0.0145	0.0300	-0.5833	4.4300	0.0125	-2.4121	0.0072	-0.3258
21	-0.0080	-0.0002	-2.5646	-0.0005	-0.0700	0.3500	3.7700	-0.0080	-0.9345	-0.0020	-0.0667
21	-0.0595	-0.0002	-7.5337	-0.0006	0.0300	1.6465	-6.8100	0.0088	-0.6008	0.0152	0.5858
21	0.0165	0.0005	-1.5779	0.0069	-0.0400	1.0378	-1.5800	0.0139	-0.9116	-0.0181	0.2727
31	0.0286	-0.0005	-25.4795	0.0050	-0.0400	-0.8077	-54.8100	-0.0057	1.4665	-0.0015	0.0605
31	-0.0802	-0.0005	23.5301	-0.0047	0.0100	-0.2020	1.3900	-0.0221	-0.2076	-0.0342	-0.7878
31	-0.0328	0.0013	12.2636	-0.0005	0.0200	3.6904	2.4600	0.0198	0.0514	-0.0014	0.9047
31	-0.0313	0.0006	26.4541	0.0116	-0.0400	-0.7000	20.5500	0.0470	0.6817	0.0217	-1.3250
31	-0.0161	0.0016	-22.7395	0.0045	0.1500	-0.2182	-6.4800	0.0599	-0.0836	0.0319	0.9455
31	0.1223	0.0004	-9.7011	-0.0335	0.0300	-1.2000	81.2700	0.0160	3.3253	0.0011	-0.3000
31	-0.1594	-0.0017	28.8816	-0.0021	0.0700	-0.0404	3.7600	-0.0872	-2.5387	-0.0845	-0.1313
31	0.0756	-0.0002	0.3345	-0.0029	-0.0300	-0.8056	-9.4100	0.0278	0.3481	0.0504	0.0833
31	-0.0233	0.0022	-1.6732	0.0540	-0.0400	-0.3889	-9.7900	0.0788	-0.8455	0.0284	-0.2223
31	0.0385	0.0005	19.9630	0.0020	0.0000	0.8413	-22.1900	0.0079	-2.1468	-0.0004	0.1508
41	0.0035	0.0015	54.6584	0.0065	-0.1000	0.8190	-31.4100	0.0206	-0.0124	0.0002	-0.2429

NO	dME	dMD	dOL	dMA	dCN	dMB	dCD	dMU	dMT	dMS	dON
1	0.9869	1.2683	1.5366	0.8526	1.0288	0.6638	0.9426	1.3232	1.2329	1.2273	0.7448
2	0.7764	1.0208	2.7148	0.6000	1.0000	1.5790	1.0299	1.0042	0.8023	1.1756	2.0000
3	1.0296	0.7945	0.6984	0.2494	0.9043	1.3611	1.0138	0.7958	0.6950	0.8595	2.0151
4	0.9806	0.7087	0.9864	0.5505	1.0083	0.9952	0.9270	0.8455	0.8177	0.8085	1.5578
5	0.9761	1.2500	1.5770	0.9244	1.0614	0.7143	1.0049	1.3340	1.2706	1.4146	2.1430
6	1.0302	1.1296	1.7969	1.2439	1.0360	0.7912	1.0425	1.1453	1.2302	1.0789	1.1000
7	0.9935	1.3143	4.2962	1.6275	1.0000	1.5278	1.1330	1.2501	1.2744	1.1649	0.4583
8	1.0163	1.0175	0.7104	0.4525	0.8843	0.5600	0.9406	1.0883	0.9286	0.9285	2.1001
9	1.0215	0.8718	0.3313	0.8108	1.0000	1.0096	1.1001	0.7642	0.8869	0.8979	0.6923
11	0.9050	0.9500	0.3096	4.2152	0.9652	1.2381	1.0858	0.9481	1.3223	1.3336	0.7500
12	1.0182	1.2667	1.4294	2.2623	1.0000	1.0560	1.0134	0.9244	0.8757	1.1545	0.9778
13	0.9813	1.1778	1.5576	3.0827	1.0000	1.2650	0.9470	0.9881	0.7927	0.8040	0.9231
14	1.0032	0.6557	0.6311	0.7176	1.0000	1.1835	1.0338	0.7550	0.8103	0.6596	0.7692
15	1.1124	0.6233	1.6545	0.2167	1.0602	0.6611	0.9991	0.7146	1.2446	1.0129	0.6154
16	0.9825	0.8548	4.6573	0.3604	0.8889	1.9501	1.0184	0.8482	0.6251	1.0501	1.9863
17	1.1915	0.9773	0.3945	1.3165	0.8772	0.6000	1.0149	0.9903	0.9177	0.9688	0.5556
18	1.0373	0.7722	1.2076	0.7273	1.1100	1.8434	0.9691	0.7524	0.6894	0.8172	1.3131
19	1.0273	0.9038	2.3394	0.4390	0.9615	1.0417	0.9784	0.9930	1.0930	1.1323	1.0000
20	1.1036	1.1143	1.7097	1.8261	0.9640	0.8551	1.1023	1.1033	1.4563	1.2837	0.6293
21	1.1701	0.8718	0.1125	0.2589	0.9615	1.1104	1.0828	0.7891	0.8040	0.7132	0.5909
22	1.0267	1.5472	1.8618	0.9638	1.0088	1.4091	1.0044	1.3838	1.3571	1.2725	1.3334
23	0.9859	1.0800	0.9333	1.5766	1.0673	0.5953	0.9554	1.0337	1.3374	1.0681	0.5833
24	0.9519	0.6735	1.4501	0.4261	1.0097	0.7576	1.0229	0.9918	1.1019	0.8722	0.8181
25	1.0471	1.4286	0.6579	2.4928	1.0374	0.4000	1.0101	1.4389	2.0582	1.1948	1.5910
26	0.9894	0.9494	0.3115	0.4466	1.0288	0.7084	1.0431	1.0389	0.6543	1.0415	0.6416
27	0.9929	0.9412	0.5026	0.8913	0.9346	1.2000	1.0359	0.9516	0.8235	0.9822	0.9000
28	0.9479	0.9545	0.4988	0.9250	1.0300	2.1399	0.9556	1.0428	0.9095	1.1002	1.7531
29	1.0148	1.1020	0.8470	1.8313	0.9615	1.4077	0.9807	1.0663	0.8048	0.8832	1.3749
30	1.0251	0.8837	0.3307	1.8197	0.9640	0.7692	0.7131	0.9696	1.3389	0.9903	1.0770
31	0.9332	0.9231	2.3433	0.6594	1.0094	0.9506	1.0121	0.9057	0.9334	0.8153	0.4584
32	0.9727	1.1733	2.4876	0.9693	1.0168	2.3839	1.0196	1.0809	1.0121	0.9940	2.3570
33	0.9727	1.1395	5.6939	2.1837	0.9652	0.8250	1.1516	1.2956	1.2830	1.1895	0.3765
34	0.9856	1.3556	0.3586	1.5696	1.1442	0.9091	0.9427	1.3328	0.9738	1.2581	2.5758
35	1.1123	1.0645	0.7425	0.1908	1.0250	0.7000	1.4907	1.0637	1.5559	1.0059	0.8000
36	0.8720	0.8132	2.5202	0.9091	1.0574	0.9894	1.0339	0.7572	0.5875	0.6942	0.9312
37	1.0670	0.9592	1.0181	0.7868	0.9720	0.6848	0.9384	1.1684	1.0610	1.3271	1.1249
38	0.9795	1.6286	0.8523	7.8354	0.9615	0.8627	0.9334	1.5743	0.7507	1.2601	0.6666
39	1.0353	1.1111	2.9233	1.3226	1.0000	1.8908	0.8455	1.0388	0.6619	0.9977	1.5428
40	1.0032	1.2941	4.7159	1.6771	0.9145	1.5584	0.7726	1.0833	0.9969	1.0014	0.5952

Table B.13: Mouse Movement Differences Grouped by Film pt.2: High Arousal, Negative Film

Note. d stands for the difference calculated by subtraction. f stands for the factor calculated by division.

Appendix C

Documentation

In this part, I will deliver the rudimentary documentation for the software created for this thesis. First, I will focus on MouseTraX, thereafter I will cover the software for the experiment and the scripts for the data manipulation and the statistical analysis.

C.1 MouseTraX

MouseTraX (Mouse Tracker for OS X) is a tool written in Objective-C for tracking mouse movements. The reason for Objective-C was first of all the available system, as my computer runs Mac OS X and no other machine was available. The second reason is the really nice API to the Operating System provided by Apple's Cocoa framework, containing nice and easy approachable mouse events. In its actual state, MouseTraX provides basic functionality, but is far from complete. It is open source and will be made publicly available when this work is published. Probably the project will be added to SourceForge; in any case the future information about this product can be found on http://www.njyo.net.

C.1.1 Requirements

The tools have been tested on both systems 10.3 "Panther" and 10.4 "Tiger". However, they have not been tested for 10.2 "Jaguar" and earlier versions, so they might work. Just give them a try.

general Mouse or similar input device

kernel Mac OS 10.3.x ”Panther” or higher - not tested for 10.2 and lower.

client:midi Mac OS 10.3.x ”Panther”.

C.1.2 Features

Following features are planned for the first full release of the software:

- Configurable logging interval (working).
- Configurable logging duration (working).
- Configurable logging format.
- Distinction of mouse buttons.
- Accessible API for plugging in evaluation algorithms.
- Extendable by different types of clients (working).
- Usable for any similar input device like graphic tablets (working partially).
- MouseTraX_kernel and MouseTraX_client:midi (working).
- Full support of OS 10.4 ”Tiger”.

For the second version of the MouseTraX bundle following features would be planned:

- Evaluation scripts integrated for basic mouse motion evaluation.
- Port of the core to Python with the help of PyObjC for more operation system independence.
- Accessible API for receiving events from outside.
- Environment for execution of scripts (e.g. AppleScript or Python code).
- Support of more types of input devices (e.g. eye-tracking).
- MouseTrax_client:mini and MouseTraX_client:maxi.
- Visualisation and browsing of the mouse tracks.
- Export of the mouse tracks as graphics.

C.1.3 User Documentation

The software can be obtained at the web address mentioned above. Installation consists of copying the wanted parts to the wanted location. Now they are ready to use.

MouseTraX_kernel

The kernel is used for logging the mouse movements. To run it, start the Terminal.app, change into the folder containing the MouseTraX_kernel and run it by typing:

```
./MouseTraX_10.x_kernel
```

Where the `x` stands for the system you use. This runs the kernel in its default configuration, which is unlimited logging on change, stop it by `Ctrl+C`. The result will be written into a `.trx` file in the same folder with the start timestamp as name. However, these default values can be changed by a couple of switches.

```
MouseTraX_kernel [-f filename] [-p network_port]\
    [-m mach_port] [-i logging_interval] [-d logging_duration]
```

switch	name	default value	description
-f	filename	`date_time.trx`	the file to log into
-p	network_port	`4711`	the port listening for clients
-m	mach_port	`MouseTraX`	the Mach port for clients
-i	logging_interval	0	i = 0 . . . logging on-event i > 0 . . . logging every i seconds
-d	logging_duration	0	d = 0 . . . unlimited logging d > 0 . . . logging for d seconds

Table C.1: MouseTraX_kernel Switches.

The switches for file name, network port and mach port are not exclusive, but setting one of these switches disables the automatic logging into the timestamped file. The switches without value set the default values. So for example setting `-f foo.trx -p` makes the kernel write the log into `foo.trx` and waiting on port `4711` for clients.

It is planned to enable kernel configuration while running, so that changes in logging interval could be made, or new log files could be added at runtime.

This is not working yet, so after starting the logging parameters cannot be changed.

MouseTraX_client:midi

The client application can be run by simply double clicking the application package. This starts the small window seen in Figure C.1. The display consists of three information fields (x- and y- coordinate and special action, see Table C.2), the connection indicator (the wheel spins when connected) and the "Connect" and "Quit" buttons. To connect to a kernel, click on "Connect"; per default the local host (127.0.0.1) is entered. Here, you can choose the wanted host by the format `ip_address:port`, if no port is submitted, the default port (`4711`) is used. When connected, the spinning-wheel should start spinning and the mouse coordinates should be visible. To connect to another host just repeat the connecting procedure.

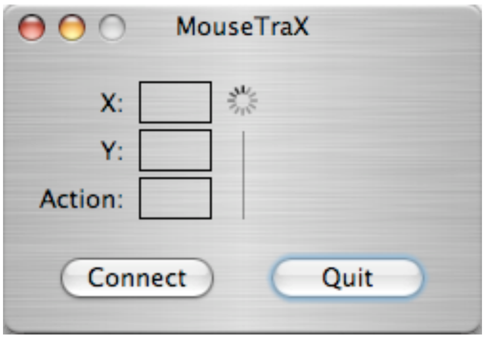


Figure C.1: MouseTraX_client GUI:
The right side shows what is going on right now (coordinates and mouse events), the spinning wheel in the middle shows if the client is connected and the right side is empty but might be filled with on-the-fly calculated mouse motion characteristics.

abbreviation	meaning
empty	no action, normal movement
LD	Mouse Down (one of the buttons)
LU	Mouse Up (one of the buttons)
MD	Mouse Dragged

Table C.2: MouseTraX_client:midi Actions.

C.1.4 Developer Documentation

Overview

The complete source code and class diagrams for both tools can be found on the included CD or at the web address mentioned above. Here, I will only emphasise some interesting issues of the tools.

Both applications were created in ObjC and had the intention to be modular and extensible. Following set of classes are used for the tools. The prefix MTX is for MouseTraX, the K stands for kernel, the U for utility, the prefix NNU is for "net.njyo.util" and represents general utility classes, that are not only for this project:

MTXKController The controller for the tracking program.

MTXKControllerMachListener A controller class listening on a Mach port.

MTXKEventDistributor A class for distributing events to messengers.

MTXKFileMessenger A class for writing events into a file.

MTXKMachMessenger A class for messaging events on a Mach port.

MTXKNetworkMessenger A class for messaging events over the network.

MTXKTracker The class tracking the mouse.

MTXUEventMessenger A messenger is an abstract class forwarding an event to a specific resource. This resource can be a file, a network stream, etc.

MTXUEventReceiver A MTXUEventReceiver recieves events and processes them (like a pipe).

MTXUNetworkReceiver A class for receiving strings via the network

NetSocket An Objective-C class to simplify asynchronous networking. It was created by and can be obtained at http://www.blackholemedia.com/code/.

This package does not run under OS 10.4 ”Tiger”, therefore the MouseTraX_client:midi does actually not work on 10.4.

NNUThreadOwner A class running in its own thread.

Architecture

In Figure C.2 we see the inheritance tree of the classes in MouseTraX.

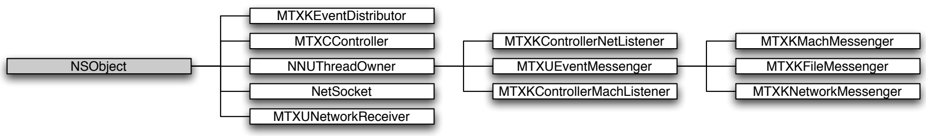


Figure C.2: MouseTraX Class Inheritance.

A data flow model of the software can be seen in Figure C.3. This model includes the most important methods, member variables and the knowledge about the data flow. There are two sources for data. The first source is the MTXKTracker, tracking the mouse. Form here the data is forwarded to the different drains. The second source (configuration data) is the MTXKMachListener. The initial configuration data enters here (the flags from the invocation). Later, when the kernel is running, reconfiguration can be done via the portHandle. The MTXController then forwards the configuration changes to the appropriate instances.

One major problem for an ObjC newbie like me, was the reference counting of ObjC. Unlike Java's garbage collection and C's manual de-allocation, ObjC implements the hybrid solution of reference counting. This means that each object can be destroyed as soon as the reference counter is zero. The programmer has to take care of the reference count by increasing and decreasing it. This, combined with the aim of sending messages via network protocols, gave me some headaches. In Figure C.4 we can see, how the network connection was implemented with the help of NetSockets.

Another major problem of this software, was to make it multithreaded. Data might be sent via the (congested) network, and the tracker must not slow down because of this. For this reason, various classes can run in their own thread. These classes are the listeners for configuration changes, the

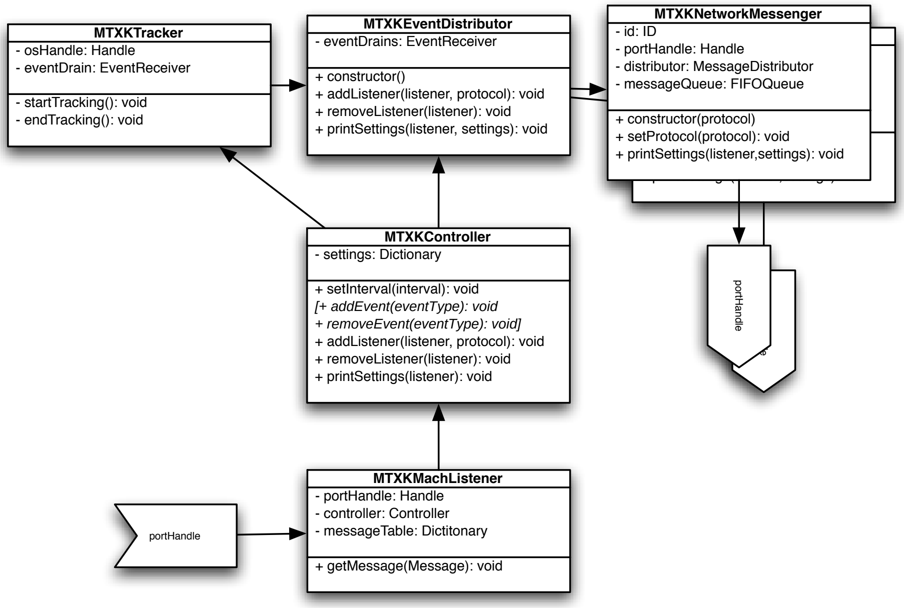


Figure C.3: MouseTraX Communication:
Here we can see the two data sources. The source for tracking data is the MTXK-Tracker, the source for configuration data is the MTXKMachListener.

`MTXKTracker`, and all the event messengers. This heavy multithreading of each class running in its own thread leads to an exhaustive use of buffers in the event procession chain. These buffers might not only slow down the real-time visualisation, but also require quite a bit of memory. The other - more programmatical - problem is that complicated locking and notification mechanisms had to be implemented. Especially for communication over the network, this produces a bit more than minimal traffic. However, by the use of a pipe scheme for the data propagation, the data flow is pretty easy to understand. One really important part here is the distributor class (`MTXKEventDistributor`), which can be used to multiplex the input from one source to multiple drains by the help of multiple buffers.

C.1.5 Known Issues

Here are some problems that have not been solved in the current state. Some of the problems should be resolved then with a possible version 1.0 of the

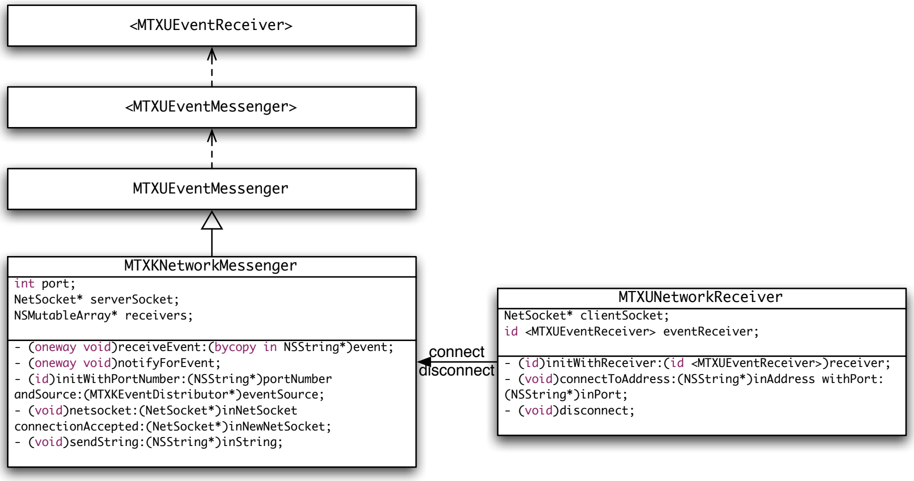


Figure C.4: MouseTraX Network.

tool. Other points are just things the user should be aware of.

Possible data loss Due to the insecurity of the network communication, data loss can occur, when the logging process is stopped by terminating the program. When terminated, some buffers still might contain unsent data. For this reason, at the end of a logging session one should keep some few seconds buffer time.

Logging format The format of the logging strings is very rudimentary and could be made nicer. Especially the possibility to modify it would be interesting. Right now it looks like this:
`[hour]:[min]:[sec].[msec];[x];[y];[action]`

Mouse buttons There is no distinction between the mouse buttons.

Better control The control of the kernel is pretty basic. This should be improved, so that re-configuration of the kernel while running is possible.

C.1.6 Feature Requests

Some advanced features would be nice for future use. These have been listed here.

Analysis methods Right now, only simple analysis methods are used and those are not even integrated into MouseTraX. Integrated analysis should be done in the next releases, but including advanced algorithms (clustering, Bayes algorithm, etc.) would be really nice. This could help creating clusters of emotions and then maybe moods could also be measured or users could be distinguished.

On-the-fly analysis The analysis of mouse movements on the fly should be available in a next release.

API An accessible API, that enables synchronisation and execution of scrips would make this a really powerful experiment tool.

C.2 Experiment

For the experiment, a web application for an online questionnaire based on Java/JSP was developed. The web application took control of the whole experiment and collected the subjects' answers. It was implemented by a standard Model-View-Controller pattern. The software plus its source code and JavaDoc can be found on the accompanying CD. The software can also be found on http://www.njyo.net, the videos and questions for the experiment can be found on the CD or can be received upon request (due to size reasons).

C.2.1 Requirements

The questionnaire webapp was used with Caucho Resin 3.0.13. Any comparable application server for Java Servlets and JSP is suitable (like Apache Tomcat). The (`.war`) archive is self-extracting, when dropped into the serving folder of the web server.

C.2.2 User Documentation

The use of the questionnaire is straight forward. Copy the `.war` archive into the serving folder of the web server. This extracts the package in its full extent. The file structure looks like following, shown in Table C.3.

When this software is run, the folder for the resulting data is created. This is intended to be used for the tracking and for the logging by the webapp. Therefore, does the webapp create a sub-folder named `browser`, where it saves all the clicking and answer data as raw text files. The contact information (for the remuneration) is stored in a separate contact file in the same folder.

C.2.3 Developer Documentation

Overview

The web application is based on the MVC (model-view-controller) pattern. The domain model can be seen in Figure C.5. In general, the whole system works as follows: The controller is the central instance. It receives and

```
contact.jsp
data/
browser/
contacts.txt
negativeFirst/
positiveFirst/
default.css
default.js
index.html
index.jsp
media/
    negative.mov
    neutral.mov
    positive.mov
question.jsp
thanks.jsp
video.jsp
WEB-INF/
    classes/
        net/
            njyo/
                mousetrax/
                    questionnaire/
                        Controller.java
                        Defaults.java
                        ExperimentManager.java
                        Persistence.java
                        domain/
                            AnswerGroup.java
                            ClickingLog.java
                            TestPerson.java
                            TestingScheme.java
                        exceptions/
                            NoOpenQuestionsException.java
                        support/
                            QuestionnaireSaxHandler.java
                util/
                    xml/
                        ASaxHandler.java
                        SaxXMLParser.java
    config/
        questions.xml
    web.xml
welcome.jsp
```

Table C.3: Directory Listing of MouseTraX Questionnaire.

handles the requests, fills the answers into the appropriate `TestPersons`, initiates the storing procedure and creates the `ExperimentManager`. This `ExperimentManager` is the second central class in the application. It is a singleton and steers the experimental flow, the distribution of the test subjects to different groups and the creation of the questions.

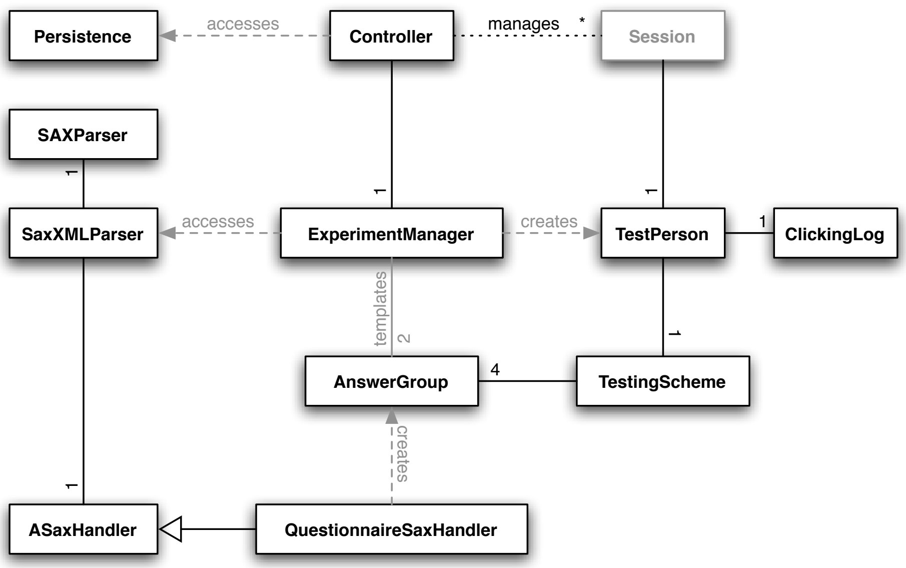


Figure C.5: MouseTraX Questionnaire Domain Model.

AnswerGroup A group of questions and the according answers.

ASaxHandler An abstract class for the use with `SaxXMLParser`.

ClickingLog Logging class holding the click records of the test subject.

Controller Webapp controller class. Controls the flow of the experiment. Accesses the sessions for the `TestPerson`, fills in answers and creates the `ExperimentManger`. Accesses the `Persistence` to store the `AnswerGroups` and the `ClickingLog` at the end of the experiment.

Defaults Central helper class holding all default values and constants (strings, integers). Singleton.

ExperimentManager The managing class for the whole experiment. The `ExperimentManager` initiates the parsing of the questions into template `AnswerGroups`. When it is ordered to create a new `TestPerson`, it clones the `AnswerGroups`, creates the `TestScheme` and decides, to which group a `TestPerson` belongs to. Singleton.

NoOpenQuestionsException Exception showing that all question were already answered.

Persistence A persistence class attempting to store the given values. Singleton.

QuestionnaireSaxHandler A class for parsing all questions from the definition file.

SaxXMLParser XML SAX parser for configuration files.

TestingScheme Defines the scheme for exactly one test subject. This scheme defines into which group one test person belongs. It also provides a type of iterator, so that a simple method call can be used to iterate over all questions in the appropriate order.

TestPerson Class representing one test subject. Holds all the answers and the specific data for a test subject.

Architecture

The architecture of the questionnaire is pretty simple, as we have seen in Figure C.5. The responsibility of each class is clear and the number of classes is few. Now special design patterns have been used, as the whole structure is simple. Some central classes have been implemented as Singletons, the `ExperimentManager` can be seen as a Factory for the `TestPerson`, as it equips the instances with all the initial data needed.

The class of `TestScheme` can be seen as a wider type of Iterator pattern. This class provides a simple way to iterate through all the questions of one test subject in the correct order. This is used when the questions are read and the answers are written.

C.2.4 Known Issues

There are two known issues, that should be improved, if this software should be used for more experiments. Except of these points this software is now working without any problems.

Synchronisation Right now, there is no simple way to tell, if a user moved the browser window in the experiment. This could result in problems when searching the mouse tracks for the position, where the video was shown. The moving of the browser window can only be found in the mouse tracks by searching for a dragging movement outside of the browser's contents window. If the clicking log saves the absolute and relative position of each click, it is easy to spot clicks in the video section. This should be added.

Video button Depending on the browser, it is possible to start video playback by clicking on a link instead of the control button of the media player. This is an issue, that can only be resolved by the use of a different browser, supporting this functionality.

Assignment of test subjects to groups This was an error found during the experiment. The algorithm of assigning the test subjects should balance the test groups, so that both groups contain the same amount of test subjects at the end. This issue has been resolved for this release version.

C.2.5 Feature Requests

No new features have been requested except of the two first points of the known issues. For another use of this program, the needed adaptations are limited to four points. First, the videos have to be replaced. Second, the questions in the `question.xml` have to be replaced. Third, the `ExperimentManager` has to be adapted to the wanted number of test subjects and different videos. Fourth, the `TestingScheme` has to be adapted to the wanted amount of videos.

From this point of view, the feature mainly needed would be easier configurability.

C.3 Data Manipulation

The manipulation of the experiment data is done by Python scripts. These scripts did parse the experiment data, calculate the movement operators and collect the raw data into one single table for statistical processing. The input for these scripts is the cropped experiment data. This means that the mouse tracks should only contain the real experiment log data. This cropping can be done by comparing the data with the webapp clicking logs. The scripts can be found on the CD or on http://www.njyo.net.

C.3.1 Requirements

The only requirement for the scripts is Python 2.3. As the scripts have not been tested for earlier or later Python releases, their full functionality cannot be guaranteed.

C.3.2 User Documentation

To use the script you have to extract the data manipulation archive. The resulting file structure will look like Table C.4. The manipulation scripts are named in their order to be applied. Right now, only `2_digdata.py` does work.

```
1_crop.py
2_digdata.py
domain/
    Gesture.py
    Person.py
    Sequence.py
    Testpart.py
    Utility.py
test.py
```

Table C.4: Directory Listing of Data Manipulation Tools.

The data digging script (`2_digdata.py`) takes the input from a folder and creates a single output file with all data collected in one file. The input folder has to contain all experiment data in the format `[no][dir].[type].txt` (e.g. `01p.trx.txt`). The meaning for the variables here can be seen in Table C.5.

variable	name	values
`[no]`	test subject number	0 - n
`[dir]`	test direction	`p` ... positive first
		`n` ... negative first
`[type]`	log data type	`ans` ... answers of the subject
		`cli` ... clicking log from the webapp
		`trx` ... mouse tracks

Table C.5: Data Manipulation Script Input File Parameters.

To run the calculation of the data type following into the Terminal:

```
python 2_digdata.py [infolder] [outfile];\
    echo "Om mani padme hum"
```

This will not just improve you karma, it will also create the file specified by `[outfile]` containing the analysed mouse data from the raw experiment data found in `[infolder]`.

C.3.3 Developer Documentation

Overview

The classes written in Python have been fully implemented and tested. The PyUnit scripts for these tests can be found in the appropriate files. These scripts assure that the right movement characteristics are calculated. When cleaning and reviewing the code, these should be moved out of those files into separate classes. To parse the input files properly, it is important to create a representative structure of the mouse motions. This structure can be seen in the Figure C.6. As we can see there, the mouse tracks are represented by a tree of different classes. The advantage of this tree representation is that calculations can be run recursively and can easily be delegated.

Gesture Represents a single gesture like for example a mouse movement or the event of "Mouse Down".

Person Represents the test subject.

Sequence Represents a sequence of movements from one click to the next.

Testpart Represents one part of the test, with one specific emotional state.

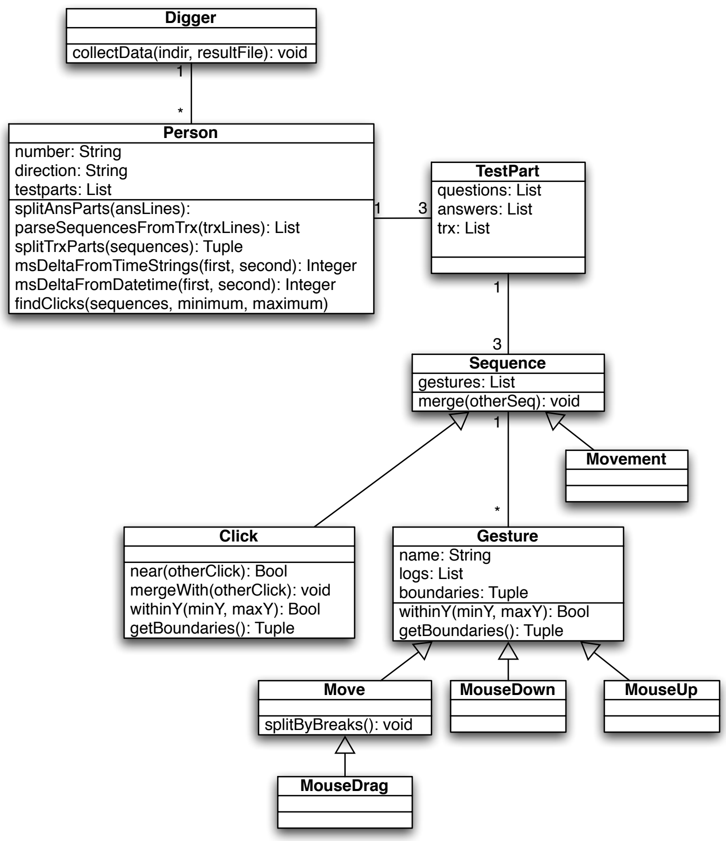


Figure C.6: Data Manipulation Script Domain Model.

Utility Class with different utility functions like calculation of the distance between a point and a line.

Architecture

The chosen architecture of a tree of classes enables nice recursive data processing. This minimises code by delegation and reuse. The inheritance mechanisms of Python support this advantage even further. The whole program flow of the script is therefore recursive, a schematised outline can be seen in Figure C.7.

The algorithms for the calculation of the mouse motion characteristics are distributed in the appropriate classes. This makes it hard to directly

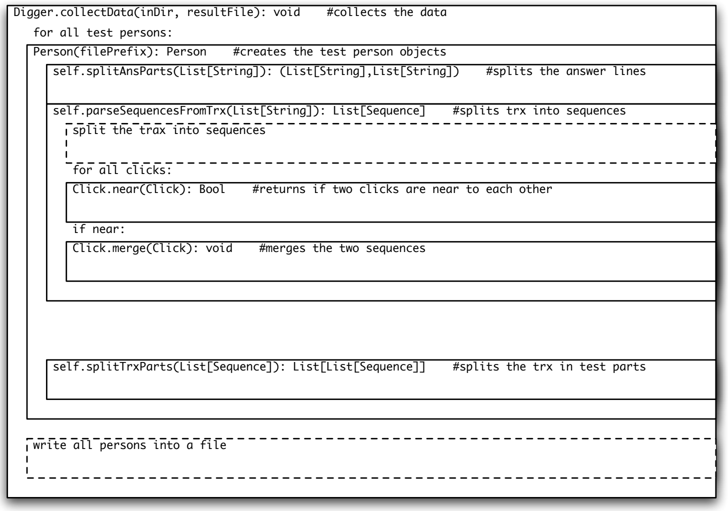


Figure C.7: Data Manipulation Recursion Schema.

integrate the algorithms into the tracking software; some refactoring might be needed here.

Known Issues and Feature Requests

Apart from the needed refactoring, there are no problems in the data digging script. However, the cropping script does not work. The cropping has now to be done by manually synchronising the mouse tracks with the clicking logs from the webapp. This could be automatised in case that a new experiment with the same set-up is done.

C.4 Statistical Analysis

The statistical analysis was done with the help of some basic Mathematica scripts. These scripts do not contain any special logic, they only automated some parts of the analysis. For this reason, I will not provide any documentation for them here. The scripts can be found on the adjoining CD or can be received upon request.

Glossary

Affective state The sum of all emotions, moods and temperament of a person at a specific point of time. This state can be classified by different models, e.g. the valence/arousal model.

ANOVA Analysis of Variance. Statistical analysis for finding significant differences in the mean values of more than two groups.

ARO Arousal. Measured on a scale from 1 (I feel relaxed) to 7 (I feel excited).

Arousal A measurement scale for the level of activation the emotion provokes. Contentedness has low arousal, joy has high arousal.

CD Click duration. The average time from pressing the mouse button (Mouse Down) to releasing it (Mouse Up). A measure for movement speed.

Click The process of pressing down and then releasing the mouse button, usually with the intention to make the computer respond. Moving the mouse inbetween is called dragging. In this work, click is used in its wider sense as the mental process of activating a specific item. This means that multiple real clicks can be aggregated to one, if they had the same intention but did not trigger any computer response.

CN Click number. The number of clicks performed to achieve the wanted action, usually higher on small, hard-to-hit targets. A measure for movement precision.

DIS Disgust. Measured on a scale from 1 (I feel delighted) to 7 (I feel disgusted).

Emotion An unconscious bias of our way to think and behave, provoked by an event.

Emotional state *see affective state.*

Flight-or-fight The unconscious decision when spotting danger (e.g. wild animals), if it is wiser to fight against the danger or if chances of survival are higher if we flee.

GUI Graphical user interface. The part of any kind of graphical interactive system, the user is confronted with.

HCI Human-computer interaction. The study of interaction between people (users) and computers.

HTML HyperText Markup Language. A format to write texts crossreferencing each other (hypertext). Commonly used for web sites and viewable by web browsers. Developed 1989 by Tim Berners-Lee.

Ideal movement The direct and therefore shortest connection from the start of a movement to the end of the movement.

KLM Keystroke Level Model. A cognitive model for calculation the time needed to complete a simple action.

MA Movement acceleration. The average acceleration of a mouse movement in all the movement intervals.

OS X Macintosh OS 10.3 Panther. A (FreeBSD) UNIX-based Operating System developed by Apple Macintosh. It is based on Darwin and Mach and provides a familiar UNIX environment with GCC, X11 and POSIX services with all the libraries, utilities for kernel, networking or command-line.

MB Movement breaks. The number of movement breaks in a movement. A measure for the movement smoothness.

MD Movement deceleration. The average deceleration of a mouse movement in all the movement intervals.

ME Movement efficiency. The ratio between the ideal movement and the real movement performed by the mouse.

Mouse event Mouse actions like Left Mouse Button Down, Left Mouse Button Up, Mouse Moved or Mouse Dragged are modelled as so-called mouse events. Internally, an event occurs, every time such an action is performed. This event then can be handled by the code.

Mouse motion The movement performed by the user when using a mouse (or similar input device) to control a machine. In this work it stands for the movement from one movement break to the next.

Mouse movement *see mouse motion.*

Mouse track A recorded mouse movement, stored as a pair of coordinates, a timestamp and a possible mouse event that occurred at this position. Multiple entries like this enable reconstruction of the mouse movements.

MouseTraX Mouse Tracker for OS X. The software written by me as part of this thesis project. This software records (tracks) the screen mouse position at any time. In a next step a movement profile could be calculated and interpreted.

Movement break Dividing events in a mouse movement, such as clicking, freezing for a specific amount of time or radically changing the direction. These events obviously break the movement into multiple different movements.

Movement interval The interval from one line in the mouse tracks to the next. The smallest interval of the recorded movements.

MS Movement speed. The average speed of one mouse movement from click to click.

MT Movement targeting. The standard deviation from the average (ideal) movement. A measure for precision.

MU Movement uniformity. The standard deviation of the speed in each movement interval.

ObjC Objective-C. An object oriented programming language implemented as an extension to C. In contrast to C++, it uses message passing and is more dynamic. It is the main language for programming on OS X, which provides a feature-rich and powerful library named Cocoa.

OL Overshot length. The maximum length of all target overshots in one movement. A measure for movement efficiency.

ON Overshot number. The number of times the mouse crossed the threshold-line from any side in one movement. A measure for movement precision.

Polling Continuously and periodically actively reading a value to see when and how it changes.

t-Test Statistical analysis for finding significant differences in the mean values of two groups.

Target overshot The event of moving the mouse too far over the target, which is measured by overstepping the threshold-line. This can for example not occur at edges of a screen.

Targeted movement A movement where the target was clear since the movement started and was not changed during movement. An example would be the movement to close an alert window by pressing its only button. Another is the movement to press the next button after marking the definite answer in a questionnaire.

Threshold-line A line going through the end point of a movement, perpendicular on the ideal connection of start and end of a mouse movement.

VA1 Valence-arousal combination. Measured on a scale from 1 (I feel great) to 7 (I feel bad).

VA2 Valence-arousal combination. Measured on a scale from 1 (I feel angry) to 7 (I feel pleased).

VAL Valence. Measured on a scale from 1 (I feel sad) to 7 (I feel happy).

Valence The measurement scale if we have positive or negative attitude towards a feeling. Anger has for example negative valence, happiness has positive valence.

Valence/arousal model A model to classify emotional states by the axes valence, arousal and control, where the axis for internal or external control is often left out.

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