RADBOUD UNIVERSITY

ARTIFICIAL INTELLIGENCE BACHELOR THESIS

The Detection of Facial Expressions for Action Coordination

Supervisor:
Dr. F.A. GROOTJEN

Author:
T.C. BEINEMA

Second reader:
Dr. B.E.R. DE RUYTER

SOW-BKI300 AI Bachelor Thesis
Artificial Intelligence
Faculty of Social Sciences
Radboud University Nijmegen
October 15, 2014

Abstract

The research described in this thesis aims to investigate whether, and if so which, facial expressions can be found that are used for action coordination between subjects. This is done by having subjects play a negotiation game known as Battle of the Sexes with no further contact other than a webcam stream of the other player's face. The collected data consisted of timestamps for events in the game and recordings of the subjects' faces, which were analyzed using FaceReader. Signs of interaction were found, but there was no evidence for specific facial expressions.

Contents

List of Figures

List of Tables

1 Preface

This thesis reports on an exploratory study that was carried out and which to investigate the use of facial expressions to signal action coordination. The study also explored the different techniques that might be used for this objective. In the next chapter I first introduce and elaborate on the research question and the hypotheses connected with it. The chapter that follows it describes the experimental set-up, which includes the experimental design, the implementation and information about how the data were collected and processed. Chapter 4 contains the results that were obtained while chapter 5 is devoted to an analysis and a discussion of these results. In the final chapter I present the conclusions to be drawn from this research as well as my suggestions for future research.

2 Introduction

In our day-to-day life we use many forms of communication. Communication is a two way interaction. The first part consists of verbal behavior, for example the intonation of our speech and the words we choose. The second part is non-verbal and can consist of the making of gestures, the direction in which we look, or our posture. Another form of non-verbal communication are facial expressions, which are used to convey the emotional state of an individual to an observer.

In the 1970s Ekman and Friesen [6] presented six presumed universal facial expressions of emotion. These six emotions were anger, disgust, fear, happiness, sadness and surprise. They were the emotions that were most consistently found in previous research on emotions across cultures. A seventh facial expression, contempt, was added in their 1986 paper [7]. The first six universal facial expressions are the expressions that are used in many studies as a standard. This is also the reason that they, along with the 'neutral' facial expression, are the facial expressions recognized by the FaceReader program[26], which will be used in the analysis of the data.

2.1 Research question

The central research question that is addressed in this thesis concerns the identification of facial expressions indicating or signaling action coordination. This question involves two aspects, namely

1. are there facial expressions that signal action coordination, and
2. if so, which facial expressions typically occur?

In order to find the answers to these questions an experiment was conducted using a coordination game[3]. For my study I decided on a game known as the Battle of the Sexes. The main reason for deciding to use this type of game was that it requires participants to interact during the experiment. Moreover, because of the experimental set-up, they should only be able to do so non-verbally. The set-up of a coordination game and its workings and why the Battle of the Sexes was chosen are described in more detail in the section below (Section 2.2).

Previous research on the effect of verbal communication in the Battle of the Sexes in order to coordinate actions can be found for example in work by Cooper et al.[4]. They show that there is an effect of communication on the process of the game in the form of an increased number of hits. Hits, in this case, are choice combinations that generate points. If the possibility for verbal communication does not exist, non-verbal communication could still provide a means for action coordination. Therefore my hypothesis for the first part of the research question is:

1. If there is non-verbal communication through facial expressions there should be an effect on the progress of the game in the form of an increased amount of hits.

To form a hypothesis for the second part of the question, a hypothesis of which facial expressions can be expected is needed. The expressions to be expected are not easily decided. One of the main reasons is that facial expressions can have many functions. An example of multiple uses of facial expressions can be the felt, false and miserable smiles[5]. The differences between these three types of smiles is that felt smiles were more symmetrical on both sides of the face, but the timing between the various muscle movements is also a very important differentiator. This might mean that if facial expressions are found, their use in action coordination could have multiple applications.

In the present study, I assume that facial expressions are indeed linked to the way the players experience the game, and can either be a reflection of emotions felt by the player about losing or winning a round, such as happiness or sadness, a reflection of emotions about the other player, such as feeling betrayed/angry or happy/cooperated with, or even a reflection of the player himself, such as being happy or sad about the outcome of a cooperation attempt, or being happy or sad about the outcome of a deception attempt. Facial expressions can also have a different meaning depending on the moment they occur. If a facial expression/emotion occurs before an action it might have a different meaning than when the expression is used following an action. The second hypothesis therefore is:

2. There are some of the basic emotions that can be found as action coordinating facial expressions. These can be used prior to an event or following an event. Prior to an event facial expressions are used to gain an opponent's trust or mislead the opponent. Following an event facial expressions are used to convey feelings about the outcome - such as: I like this outcome, I feel like you betrayed me, I did not expect this, etc - to the other player and in this manner they influence their following actions.

For this exploratory study, the scope will be on action coordinating facial expressions occurring as an initial reaction after an event. The reason for this is that these initial reactions are presented in a limited amount of time after the event. The prior to an event expressions are spread over a much larger period of time which makes them very difficult to analyse.

2.2 Strategy/Coordination Games

In the following paragraphs I will provide background information on Nash Equilibria and strategies. Subsequently three games, the Prisoner's Dilemma, the Stag Hunt and the Battle of the Sexes, will be discussed and a motivation as to why the latter was chosen for the experiment will be given. The three games are all strategy games, but only the second and the third are coordination games[9]. This is because they have more than one equilibrium, whilst the Prisoner's Dilemma only has one. Multiple equilibria require more coordination between players because they will be less inclined to settle for one equilibrium.

Equilibria and Strategies

In his 1950 paper[16], John Nash defined equilibria for an n-person game and proved that every finite game has at least one equilibrium. An equilibrium is the situation in which both players cannot improve their score if they can only change their own strategy. A strategy is a set of choices a player makes during a game.[21] A player can have a set of multiple pure strategies, called the strategy set, in which a pure strategy is a set with the player's ideal moves for every situation that may occur in the game. For two players a pure strategy equilibrium can occur when both play a pure strategy and end up in an equilibrium. A game can have multiple pure strategy equilibria since players can have multiple pure strategies. A player can also have an infinite set of mixed strategies, which are probability distributions over their pure strategies. An equilibrium in which at least one player is playing a mixed strategy is called a mixed-strategy equilibrium.

The Prisoner's Dilemma

The Prisoner's Dilemma, named so by Tucker in a memo to the UMAP journal around 1950 [24] [19] is a strategy game in which two men have a dilemma. A crime has happened and they are held by the police, who question them to find out who was the perpetrator. They can both choose to lie or speak the truth. If they both lie they get to go free. If they both speak the truth they both get a small sentence. If one of them lies and the other tells the truth, the one telling the truth will get a small reward and the one who lies will be sentenced. The score distribution is represented in table 1.

As Tucker stated as well, and as was mentioned before, the game has only one pure strategy equilibrium, namely (confess,confess). The situation in which they both keep silent and go free has a high risk for both of them, because either of them could improve their situation by changing their choice to confess. This means that players both prefer the same situation, unless the trust in each other is large enough.

	Confess	Not confess
Confess	$(-1,-1)$	$(1,-2)$
Not confess	$(-2,1)$	$(0,0)$

Table 1: The score distribution for the Prisoner's Dilemma. The first number in the tuple is the score for player A, the second number is the score for player B.

The Stag Hunt

The Stag Hunt is a coordination game originally mentioned by Jean-Jacques Rousseau in his "Discourse on the Origin of Inequality":

> *"If a deer was to be taken, every one saw that, in order to succeed, he must abide faithfully by his post: but if a hare happened to come within the reach of any one of them, it is not to be doubted that he pursued it without scruple, and, having seized his prey, cared very little, if by so doing he caused his companions to miss theirs." [20]*

This statement can be translated for two players, or hunters, to the score distribution that is represented in table 2. The most preferred outcome would be for both hunters to wait for the stag. If either one of them decides to leave his post to catch a rabbit, he gets to eat, but the other hunter does not, which means waiting for the stag is a huge risk for both of them. The situation in which both go for a rabbit has a lower score, but it also has a much lower risk for both[23]. The game therefore has two pure strategy equilibria $(2,2)$ and $(1,1)$ and a mixed strategy equilibrium between those two. The players both prefer the same equilibrium though, and that is why I chose the next game over this one.

	Stag	Rabbit
Stag	$(2,2)$	$(0,1)$
Rabbit	$(1,0)$	$(1,1)$

Table 2: The score distribution for the Stag Hunt. Again, the first number in the tuple is the score for player A, the second number is the score for player B.

The Battle of the Sexes

The Battle of the Sexes [13] represents a situation in which a man and a woman have made an appointment to go and do something together, but both of them can not exactly remember if they

	Football	Opera
Football	$(3, 2)$	$(0, 0)$
Opera	$(0, 0)$	$(2, 3)$

Table 3: The score distribution for the Battle of the Sexes. Again, the first number in the tuple is the score for player A, the second number is the score for player B.

had decided on a football game or the opera. The score distribution for this game is represented in table 3.

The man prefers the football game, but the woman prefers the opera. Going to the other persons preference is no problem, but they definitely do not want to end up alone. The two situations in which they are at the same venue, $(3, 2)$ and $(2, 3)$, are therefore the two pure strategy equilibria that the game has. It also has one mixed strategy equilibrium between those two situations.

The Battle of the Sexes will be the game that is used in the experiment for this research. Out of the three, the most interaction between the two players can be expected in this game. The reason for that is that there are two Nash Equilibria, but other than in the Stag Hunt, players prefer different equilibria. This means that the players will not settle on choosing the other players favorite option as much because it is a disadvantage for them. This would imply that in order to score as many points as you can as an individual player you must interact and maybe even cooperate with the other player. You might even have to pick the other player's preferred option to give him some points in order to make them pick your preferred option in return, because the $(0, 0)$ outcomes will help neither of you. Because there are eight possible patterns in which a round can proceed. These eight patterns are listed in table 4. Different reactions for each of the eight patterns after the scores of the round are displayed can be expected. For instance, the player that chooses first might be happy if they get points, but the player that was the second to make a choice might have done a concession, which makes him less happy. If a player chooses first and the other player chooses the option that gets neither of them points he might feel cheated, but the other player might feel somewhat happy that at least the first player did not get points.

First	**Second**	**Choice player 1**	**Choice player 2**	**Score player 1**	**Score player 2**
Player 1	Player 2	A	A	3	2
Player 1	Player 2	A	B	0	0
Player 1	Player 2	B	A	0	0
Player 1	Player 2	B	B	2	3
Player 2	Player 1	A	A	2	3
Player 2	Player 1	A	B	0	0
Player 2	Player 1	B	A	0	0
Player 2	Player 1	B	B	3	2

Table 4: Possible choice-score patterns for a single round of Battle of the Sexes.

2.3 Related Research

The study described in this thesis relates to various other fields of study, although there are no studies that research action coordination through facial expressions. I will describe three of these related field and give some examples of the research involved.

The first related field is that of (non-verbal) action coordination between humans. Knoblich at al.[12] studied the coordination of actions between humans by means of shared action representations. They found that their subjects were not as good at the team tasks as they were individually, but with feedback and some practice they quickly improved. Meulenbroek et al. [15] performed an experiment in which fourteen pairs of subjects were asked to reposition a cylinder without using dialogue and they proved the independency between the cognitive and the sensorimotor processing of action-related information.

A second field is that of affective computing. This includes the use of emotional expressions to tell the computer or robot what you want, the computer communicates to the user using emotions, or the computer influences emotions. Picard [18] describes two ways of making it possible for a user to communicate their frustration to the computer. The first is a mouse that can sense when the buttons are pushed harder out of frustration. The second are glasses that can detect muscle movement that happens when a user is, for example, frowning. Another application in affective computing is that of a robotic 'Tigger' stuffed animal that is used by Kirsch[11] for research with autistic children. This Tigger is able to recognize emotions, but he is also able to react to the way the children play with him by expressing emotions, thus giving them feedback on what is acceptable behavior. A light pull on its tail for instance is accepted, but poking its eyes is not. A more recent overview of the possibilities of combining affective computing techniques and autism research is given in the 2006 paper by el Kaliouby et al. [8].

The last is the field of emotion research, which includes the research of Ekman et al. mentioned before. Another example is the research by Bradley et al.[2], who studied emotional reaction to pictures. Lopes et al.[14] studied the effect between emotion regulation abilities and the quality of social interactions, and Rydell et al. [22] studied emotionality, emotion regulation and adaptation amongst 5-8 year olds.

3 Methods

3.1 Subjects

24 subjects took part in the experiment, all of whom were recruited amongst students. They were 16 men and 8 women with an average age of 22. The oldest subject was 28, the youngest 19. The subjects performed the experiment in pairs and those who formed a pair had met before. After the first three pairs an adjustment was made to the experiment of such a nature that the previously gathered data could not be used. The remaining 18 subjects were 13 men and 5 women with an average age of 22. The oldest subject was 26, the youngest 19.

3.2 Environmental/Technical Set-Up

There were several main requirements for the environment in which the experiment would take place. The most essential one was that subjects would not be able to communicate directly. It was therefore decided that the experiment was to take place in two adjacent rooms (see Figure 1). Another requirement was that there were not to many noises or other distractions and, because of the video recordings, plain white walls were also preferred for a uniform background. Since the timing of the events and the camera frames had to be precize, the choice for running it on a single computer was made. The self-written software for the experiment ran on a laptop with a build in webcam, that had an extra keyboard, screen and webcam connected to it. The choice for a laptop was made because the external webcams available were both of the same brand. These could not be distinguished by the OpenCV library[10] that was used for to display the webcam images. Between the rooms were two USB and one VGA connection that connected the screen, keyboard and webcam in one room to the laptop in the other room. The game and the webcam feeds were programmed using the Java language.[1]

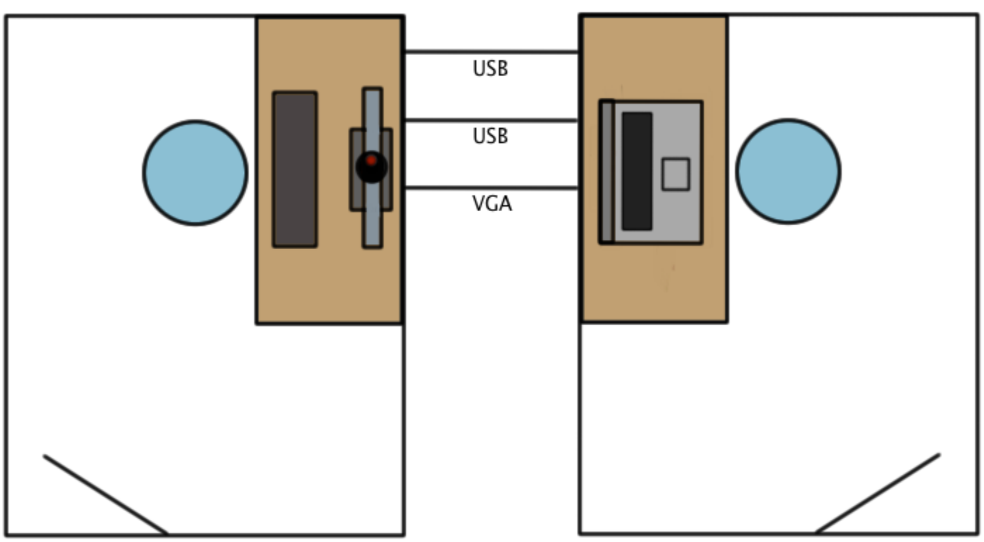


Figure 1: The set-up for the rooms.

[1] To obtain the source code for the game and the incorporated webcam displays contact the author.

3.3 Experimental Paradigm

During the experiment subjects play the Battle of the Sexes game for - in the final version - 97 rounds. A round of the game consists of making a choice for either the 'A' option or the 'B' option. The score distribution is the same as described in the introduction, but the names of the venues are changed in order to be more neutral. While, playing, the subjects see a video frame and an information frame on their screen. The video frame contains a camera feed from the webcam of the other subject (640x480 pixels). The information frame contains information about the game such as the round and the subject's choice and score for the previous round. It also displays which buttons they should use for making a choice, the scores table and their and their opponents current total score. One subject can see that he is the 'green' player whilst the other is the 'red' player. The color labeling of the players was done, in combination with the colored circles in the scores table, to make the scores table easier to read. The information frames for both players can be seen in Figure 2.

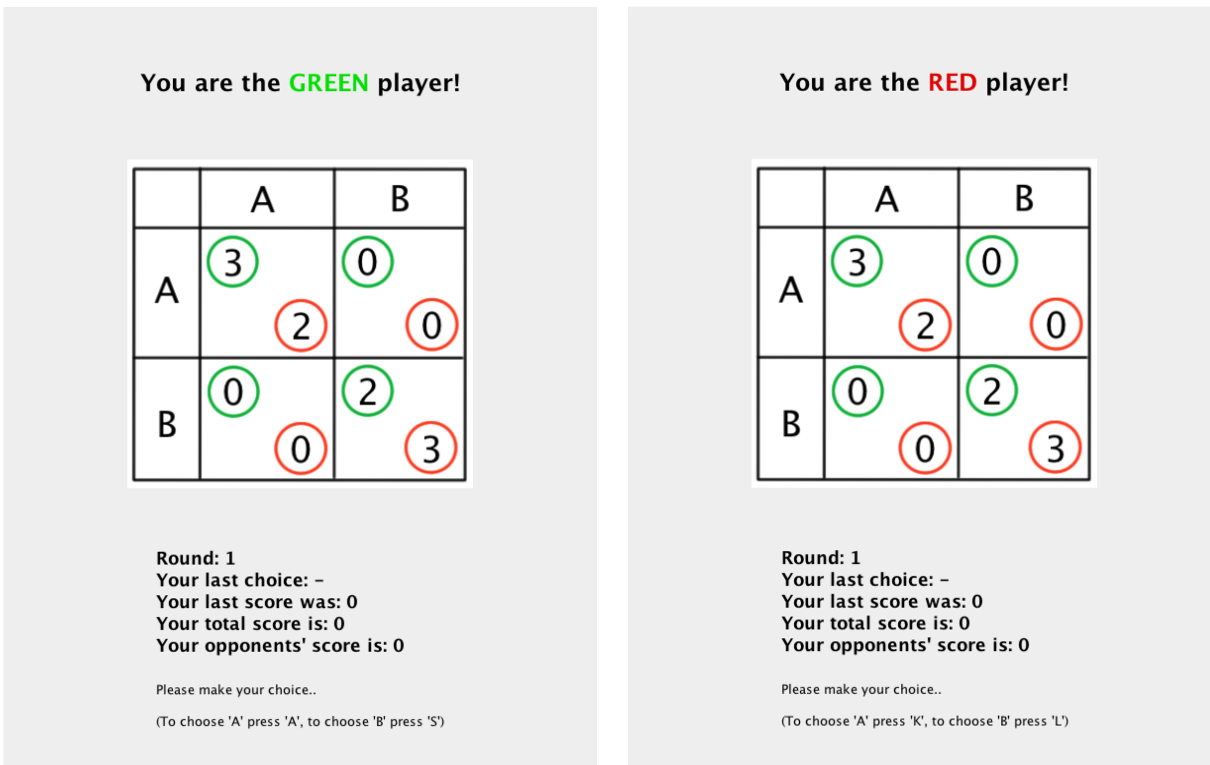


Figure 2: The information frames for player 1 and player 2, respectively the green and the red player.

The objective for the game was for subjects to score as many points as possible for themselves. This meant that subjects had to work together to reach that goal, because in order to get points you had to make the same choice as your opponent. What made this difficult was that you did not want to give your opponent their prefered, three point score to often, because that might let them obtain a higher total score than your own score. You had to give them some points though, in order to seduce them to chose your three point option. Through the video frames the subjects were able to see each other and interact, but they were told not to mime words or make gestures to communicate. The information sheet the subjects got beforehand can be found in Appendix A on page 24.

3.4 Testing and Discarded Sessions

A pilot study was performed with two male students (not included in the total number of subjects) and they were asked to play the game for thirty minutes. The maximum number of rounds was set to infinite. The purpose of the pilot was to see what kind of behavior would emerge and to see if there were still adjustments to be made in, for example, the number of rounds. A few conclusions could be drawn from it, both on resulting behavior and the design of the game. The behavioral conclusions from that pilot were the following:

- Subjects did not like the unknown maximum for the rounds. This might have its causes in the impossibility of planning and using a strategy that fits the amount of rounds.
- They also got bored quickly, which resulted in pressing the buttons very quickly. It was an unwanted development, because the aim was to have them think about what was happening and communicate non-verbally. The main cause for the boredom was the length of time they had to play the game. Combined with an unknown amount of rounds to go this made staying focussed very difficult.
- After playing for a while the subjects had to laugh. This was near the end of the button pressing. After the game was finished, when asked, they explained that the smiles were because of a 'What are we doing?' feeling they had gotten. When the laughing stopped, they also continued to play the game seriously again.

For the design there was one major adjustment that had to be made. The total score so far for the subject's opponent would also have to be displayed on a subject's information frame. The presence of that score would give them more motivation to try and get a higher score because of a directly visible 'target score' that they had to compete with. It would also allow them to decide whether or not to give their opponent points.

Taking these findings into account, the experiment was started with a maximum of 25 rounds and with this maximum displayed for the subjects to see during the game. After three pairs of subjects the number of rounds was changed and the maximum was removed. This was done because the presence of a maximum influenced the strategies of the subjects towards the end, which caused a decrease of interaction in the final rounds. This change rendered the data collected from these three pairs unusable, because for the final 18 subjects the number of rounds was changed to 97 and no maximum was shown. The amount of rounds was based on an observed average of 10 rounds per minute and the aim was to get 10 minutes of video footage. It was assumed that 100 rounds would be a number subjects expected and therefore the maximum was adjusted to 97.

3.5 Measurements

Two types of data were gathered for each pair of subject during the experiment. The first was a log file, which contained the timestamps for each 'event', which was either a key press or the display of a new round and updated scores. The events were saved in a `.txt` file, and information about the game state was saved with them. When a key press event was saved the following game state information was saved with it: the timestamp, player number of the player that pressed the key, and that player's choice. When a display event was saved the information saved with it was as follows: the timestamp, player number of the player that got to see the new information, that player's last choice, the round number, the score for the last round, and the total score so far in the game for the player. What this looked like can be seen in the following example:

```
16:42:34:1405608154832 KEYPRESSED PLAYER2 Choice: B
16:42:35:1405608155814 KEYPRESSED PLAYER1 Choice: A
16:42:45:1405608165259 DISPLAY PLAYER1 Choice: A Round: 16 Roundscore: 3 Totalscore: 20
16:42:45:1405608165259 DISPLAY PLAYER2 Choice: A Round: 16 Roundscore: 2 Totalscore: 20
16:42:45:1405608165264 KEYPRESSED PLAYER2 Choice: A
16:42:46:1405608166248 KEYPRESSED PLAYER1 Choice: A
16:42:48:1405608168338 DISPLAY PLAYER1 Choice: A Round: 17 Roundscore: 0 Totalscore: 20
16:42:48:1405608168338 DISPLAY PLAYER2 Choice: B Round: 17 Roundscore: 0 Totalscore: 20
```

The other type of data that was saved were frames from both of the cameras. Each frame was saved as a 640x480 pixels bitmap file with its creation timestamp as its filename. The frames were not resized in the code, but directly grabbed from the webcams in the 640x480 pixels format. For each pair of subjects two folders of camera images and one log file were saved.

3.6 Data Pre-Processing

As previously mentioned the webcam images that were saved in the experiment were saved per frame as a `.bmp` file. Due to the manner in which they were saved some pre-processing was needed. The original plan was to use IntraFace[25] and then Aligned Cluster Analysis[27] to analyse the camera data, but since Aligned Cluster Analysis needed a `.asf` file that described a skeleton, and at least one `.amc` file with motion capture data. This was a setback, since the data had already been analysed with IntraFace, but a final choice was made to use FaceReader[26]. FaceReader provided a means of analysing the video data and obtaning the amount of prescence of each emotion for each frame as an output. Before the data could be processed by either FaceReader or IntraFace, it had to be transformed from frames into videos. This was done in three steps:

1. **Check framerate**
   Before the frames were converted to video the frame rate per second was calculated to check for extreme high or low rates. This was needed to ensure that there were no large gaps in the video data, as to make sure that, when the videos were created, there would be a fluent motion in the facial expressions of the subjects. Using the `find . >> output.txt` command the filenames of the bitmap frames were listed in a `.txt` file. This file was then imported into Matlab and the frames per second were calculated and plotted using the code in Appendix B. The resulting plots can be seen in figures 5 - 13 in Appendix C on pages 26 - 30.

2. **Select frames of interest**
   Only the frames between the first choice that was made and the last display of scores were of interest. The frames recorded before and after these events were recorded during set up and after the game was finished, which meant they were not of interest for analysis and therefore excluded from the video. During the selection of frames the folders with frames were copied and the excluded frames were removed from the copies.

3. **Converting frames to video**
   The last pre-processing step was to convert each folder of frames that were collected for a subject to a `.m4v` video file. This was done using Time Lapse Assembler [17]. Time Lapse Assembler requires `.jpg` files as its input. Therefore, using Automator [1] on OS X 10.9, the frames were converted from `.bmp` to `.jpg`. After this conversion each folder of frames was assembled into a video. The frame rate that was used for all folders was 20 frames per second. This frame rate was chosen as a constant to make it easier during data analysis to combine the frames and the events. With a constant frame rate the original frame number would be easier to calculate and that frame number could then be linked to the original bitmapfile and

file name. Since this filename contained the timestamp of the moment at which the frame was created, the 20 frames per second constant was an essential step in retracing that timestamp.

3.7 Facial Expression Analysis

After the frames were converted from bitmap to a video an analysis of the facial expressions that occurred in each frame could be performed. This analysis was done using the FaceReader program[26]. The program delivered an output file for the video of each subject. This file contained a classification score, for each frame in the video, for the neutral, happy, sad, scared, surprised, angry and disgusted emotions on a scale of 0-1 (1 meant that the emotional expression was present and 0 meant that it was absent). These are the same seven universal emotional expressions that were mentioned before. It also gave a valence score (on a scale of -1 to 1) for each frame. This was a measure for how negative/positive the emotional expression was (-1 being negative and 1 being positive).

3.8 Selecting the Frames of Interest

The frames of interest for the emotion/valence classification scores were the frames from the moments that the scores were displayed (t), and the frames on those moments t + 200 milliseconds, t + 400 milliseconds, and t + 600 milliseconds. These timesteps were chosen because this would allow a first subconscious reaction, but did not give much opportunity for subjects to have corrected their initial expression consciously. The frame at the time of the display of the event was to function as an uninfluenced measurement, while the emotion and valence measurements of the others could be used to compare with those of that frame. The exact frame numbers were calculated using the matlab code in Appendix D on page 31.

3.9 Pattern Analysis

Since I wanted to see if there was an effect of the occuring pattern in the game on the emotional expressions/valence, the patterns that occured for each round had to be analysed. The values 1-8 were given to each round depending on the occuring pattern (numbering was done in the same order as the order in table 4). This was done twice, once from the point of view of each subject.

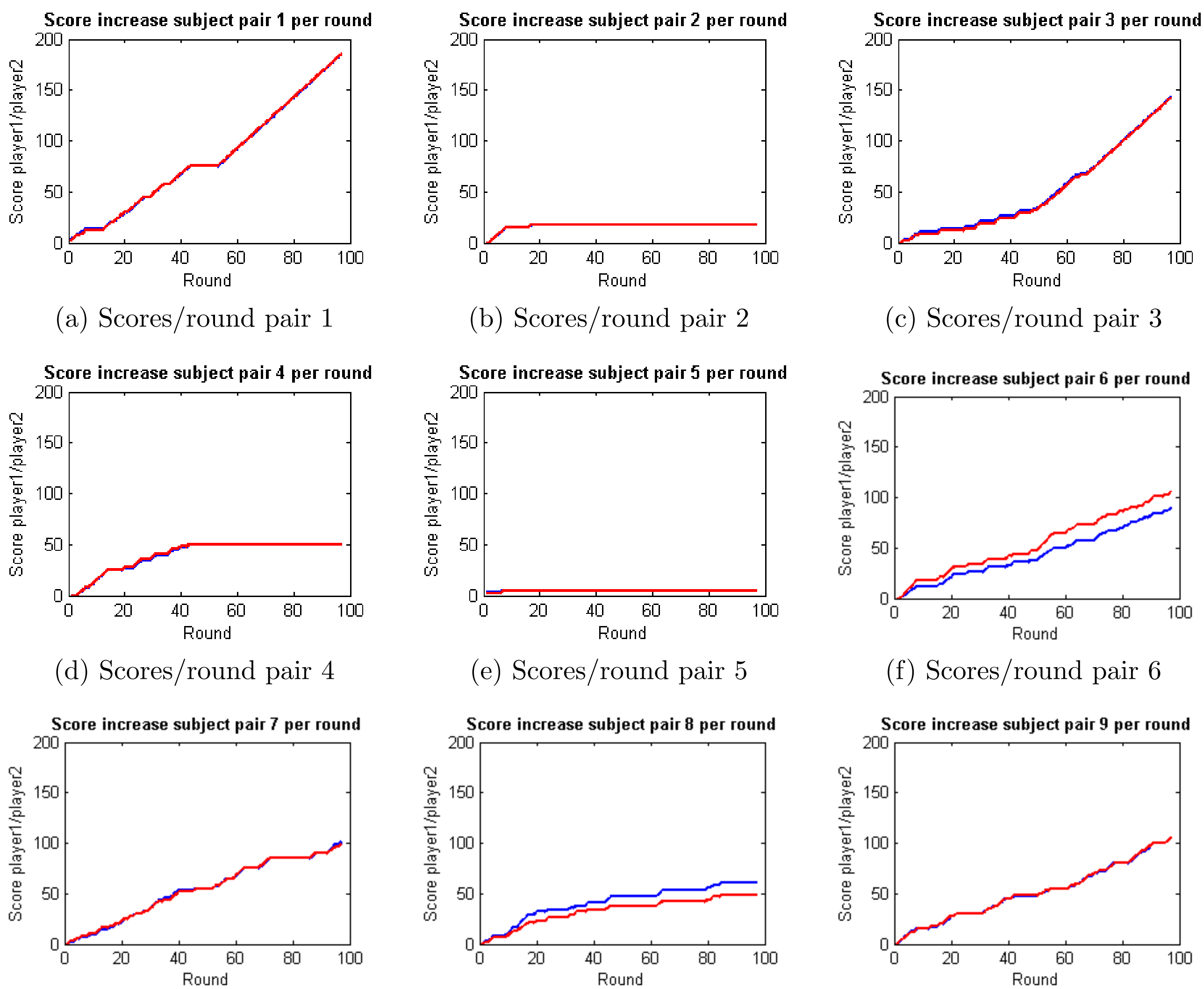
3.10 Status Analysis

The other independent variable that had to be encoded for statistical analysis was the game status for the subjects. This meant that each round also got a value that coded for whether the subject was, at that moment in the game, winning (1), tied (2), or losing (3).

4 Results

4.1 Interaction By Score

The first research question requires an answer as to whether there is interaction between the subjects. This interaction is analyzed by using the scores that the subjects got during the game. The plotted scores for the game can be found in figure 3. The steeper the line in this plot, the more hits there were for both subjects during the game. As can be seen, the subjects of most pairs gave each other points. They also did so quite effectively since the lines in, for example figures 1 and 3 have a steep ascend. The subjects in pair 2 and 5 stopped giving each other points, not to far from the start of the experiment, but whether this is because of a lack of communication or because of stubbornness (simply not wanting to choose the other player's favorite option) cannot be said. Still, indications are that there has been some form of communication between most of the paired subjects.



(a) Scores/round pair 1 (b) Scores/round pair 2 (c) Scores/round pair 3

(d) Scores/round pair 4 (e) Scores/round pair 5 (f) Scores/round pair 6

(g) Scores/round pair 7 (h) Scores/round pair 8 (i) Scores/round pair 9

Figure 3: Plots of the score increase per round for all nine subject pairs.

4.2 Emotional Expressions - Statistical Analysis

In order to see if the observed patterns and/or statuses had their effect on the emotional expressions a statistical analysis was performed. This was a doubly multivariate repeated measures ANOVA analysis and it was performed with the seven emotion scores and the valence score for a video frame as its dependent variables. The frames that were selected were the frames from the time of the 'display of scores'-event for each round, the frames for t + 200 milliseconds, t + 400 milliseconds, and t + 600 milliseconds. Therefore Time was the within-subject variable. These times were chosen because an initial reaction on the displaying of the scores should happen in this range. The between-subject variables were Pattern (order of choice and choice) and Status (winning/tied/losing). For the SPSS output of this analysis, see Appendix E on page 32.

Multivariate tests showed a main effect of Pattern (F(56, 7938) = 3.920 , $p < 0.001$, Wilk's Λ = 0.863, η^2 =0.021), a main effect of Status (F(16, 2946) = 9.620 , $p < 0.001$, Wilk's $\Lambda = 0.903$, η^2 = 0.050), and an interaction effect for Pattern * Status (F(112, 10341) = 3.072 , $p < 0.001$, Wilk's $\Lambda = 0.795$, $\eta^2 = 0.28$). This would suggest that both Pattern and Status weakly affect the emotional expression that is visible on a subjects face, and that the same is true when they are combined.

At least, the mentioned effects would be there if the sphericity assumption was intact. But Mauchly's test of sphericity showed a significant effect ($p < 0.001$) for all the dependent variables (the emotions and valence scores). This indicated that the F-values used in the multivariate tests might be elevated, which could cause a Type I error (claiming significant results while there are none). Since the effects found in the multivariate tests were all weakly significant, this was a risk that had to be taken into account. Therefore the corrected values of the Within-Subjects Effects table were consulted. These corrected results (using the Greenhouse-Geisser method) showed no significant main effect for Pattern and Status, as well as no significant interaction effect for Pattern and Status.

The most important conclusion that could be drawn is that there is no significant effect of Time. This essentially meant that the emotional expression of a subject did not change between the first frame during the newly displayed scores and the $t + 600$ milliseconds frame. The conclusion therefore had to be that the choices that are made (Pattern) and whether a subject was winning, tied, or losing (Status) have caused no initial reaction in facial expression.

5 Discussion

In the following subsections I will discuss the results of the performed study, as well as discuss its limitations. Possibly useful adjustments to improve the technical set-up and the quality of the collected data in future research will also be named.

5.1 Interaction

The interaction plots that were included in the results section showed signs of interaction between subjects. The subjects were placed in separate rooms for the experiment and therefore the interaction can only have been caused by two factors. The first would be the presence of communication through facial expressions. The second could be that the subjects fell into a pattern of making choices during the experiment. They could, for example, have landed on a 'This round we will both choose A and next round we will both choose B'-rhythm. According to comments the subjects made after the experiment the latter did occur occasionally. In the videos of the subjects there are subjects that start to laugh when the scores are displayed, this can be seen as action coordinating expressions. There are also subjects that start to smile as a reaction to the smiles of the person that they are paired with. Since the most occurring facial expressions during the experiment were Neutral and Happy, this could be a coincidence, but the timing of these smiles would strongly suggest that it is not. This would indicate that there was indeed communication between the subjects.

5.2 Facial Expressions

The statistical test that was performed on the emotional expressions and valence scores in the FaceReader output showed no significant effect from the patterns and the statuses that occurred during the game. This would suggest that the facial expressions did not change as an initial reaction to the display of the scores. This is something that can to checked in future research since there was a significance for sphericity, which suggests that they might have be repeated using better data. Various changes can be made to the experiment in order to guarantee a better quality of the data and a better distribution between the rounds and the patterns/statuses. The suggested changes are described in the section below. Another point of interest is the wide variety of uses for each facial expression and the difference in reaction between subjects this might cause. One subject might for example smile ironically when their opponent 'betrays' them, but another subjects might give their opponent a surprised look. This would indicate that the data gathered was too complex to analyze using the methods that were applied.

5.3 Suggestions for the Experiment

For the experiment, there are adjustments that could improve the quality of the data collected. I will list a few of them, the suggestions for the technical set-up section and the suggestions for the experimental procedure can be found below.

Technical Improvements

The technical set-up in the experiment for this study consisted of a laptop using an extra display, keyboard and webcam. This meant that the subjects might have realized that they had a different display, keyboard and webcam than the other player. In order to exclude any chance of subjects being influenced by this fact the screens, keyboards and webcams should be the same for both players. This might cause a problem with the webcams since the OpenCV library was not able to distinguish between two external webcams. The webcams were both of the same brand, although their models did differ, which caused me to assume that (at least part of) the problem was due to the drivers they used. Even when using one external webcam it could take a few times unplugging and re-inserting the webcam's USB connection before it was recognized by OpenCV. The resolution used to save the webcam images as bitmap files (640x480px) was high enough to use with FaceReader, even after the frames were converted to videos. A higher resolution would suggest more details, but when using the self-written code it could also be a cause for a lower frame rate because larger bitmap files would have to be saved.

Experimental Adjustments

The experiment itself could be improved as well, in order to improve the quality of the collected data. During the experiment subjects tended to touch their faces or looked on the instruction sheet next to them on the table, which were both causes for FaceReader to be unable to find a face in some frames. An option to prevent this might be to give subjects two buttons that they had to press with one hand each, and by this means keeping their hands busy. It would also be useful to prohibit their faces from looking anywhere but straight at the camera by removing the instruction sheet when the experiment started or displaying the instructions on the screens. These observations were all new for the experiment itself and had not been observed in the pilot run.

Another adjustment that can be made is to the number of rounds subjects had to play. Playing 97 rounds could cause subjects to get bored and this might be an explanation as to why some interaction graphs (see figure 3 in the Results), for example the graph for subject pair 4, start with a steep ascend, which levels after 40 rounds or so. A short break in ascend can, for example, also be seen for pairs 1, 7 and 9 at about the same round. This would suggest that subjects start to get bored somewhere near the 40th round. Therefore the number of rounds could be limited to 40. In order to improve concentration the scores in the scores table might also be changed between rounds to encourage subjects to think about their next choice.

A future adjustment that could be made would be a limited view of the other player through the webcam feed for each round. Cooper et al. used a limited communication time in their 1989 paper[4] and applying a limited viewing time to the webcam streams might solve the problem of unlimited amount of communication before the subjects' choices and therefore many frames to search. This adjustment would be mainly useful if one were to study the occurrence of facial expressions prior to the subjects making their choice.

A final adjustment would be to introduce a control group to exclude the possibility of interaction between subjects through a consensus in their choices. The subjects in this group would play the same game as the subjects in this study, but they would not have a webcam feed. This does come with some difficulties, since subjects should be informed about the video data that is collected during the experiment. Asking subjects if it is allowed to collect video data while there seems to be no use for video in the experiment might make them cautious, which could change their behavior.

6 Conclusion

This study had one research question which consisted of two parts. The first part concerned the question: "Are there facial expressions that signal action coordination?" The hypothesis for this part was that if there was non-verbal communication through facial expressions there should be an effect on the progress of the game in the form of an increased amount of hits. The results indicated that this was indeed the case for most of the subject pairs since the choices that the subjects made did not fit chance level. Observations did prove subjects to smile at the other player as a reaction to in-game events although the effect on the score might have (partially) come from an understanding in button pressing between two subjects in a pair.

The second part of the research question was: "If so, which facial expressions typically occur?" The hypothesis for this second part was that some of the universal emotions could be found as action coordinating facial expressions prior to or after a game event. Analysing the facial expressions that occurred before an event were outside the scope of this study. The reason for this was the expected difficulty of finding the significant facial expressions in the large amount of time that could precede an event. The timeslot for an initial reaction on a display event was easier to pinpoint. The smiles that subjects exchanged were signs that the universal emotions were indeed used as action coordination. In this study I have not been able to find any statistically significant results that point towards any specific emotion that is used in particular as a result of in-game situations.

6.1 Future Research

The study gave some interesting insights, but it also raised a number of new questions. For example:

1. Can action coordination through facial expressions be found prior to subjects making a choice?
2. Are there multiple uses for the 'Happy' facial expression in action coordination, and what are they?
3. Is there a difference in action coordinating facial expressions between males and females?
4. Is there a difference in action coordinating facial expressions between pairs of subjects that are familiar with one another, and pairs of subjects that have not met before?

Acknowledgements

I would like to thank Franc Grootjen for his supervision and the opportunity to do this project, as well as for the occasional motivational speech or kick-in-the-butt when they were needed. I would also like to thank Ron Dotsch for the idea and his advice on the experiment. Furthermore, I would like to thank Boris de Ruyter for his advice on and help with FaceReader, and I would like to thank Inge Rabeling for her statistical advice. Finally, I would like to thank all the participants in the experiment, including the two subjects that participated in the trial.

References

[1] Apple. Automator. `http://support.apple.com/kb/HT2488`, 2014. [Online; accessed 07-August-2014].

[2] M.M. Bradley, M. Codispoti, B.N. Cuthbert, and P.J. Lang. Emotion and motivation i: defensive and appetitive reactions in picture processing. *Emotion*, 1(3):276, 2001.

[3] R. Cooper. *Coordination games*. Cambridge University Press, pages viii-x, 1999. (ISBN: 9780521578967).

[4] R. Cooper, D. V. DeJong, R. Forsythe, and T. W. Ross. Communication in the battle of the sexes game: some experimental results. *The RAND Journal of Economics*, pages 568–587, 1989.

[5] P. Ekman and W. V. Friesen. Felt, false, and miserable smiles. *Journal of nonverbal behavior*, 6(4):238–252, 1982.

[6] P. Ekman and W.V. Friesen. Constants across cultures in the face and emotion. *Journal of personality and social psychology*, 17(2):124–9, February 1971.

[7] P. Ekman and W.V. Friesen. A new pan-cultural facial expression of emotion. *Motivation and emotion*, 10(2):159–168, 1986.

[8] R. el Kaliouby, R. Picard, and S. Baron-Cohen. Affective computing and autism. *Annals of the New York Academy of Sciences*, 1093(1):228–248, 2006.

[9] J. K. Goeree and C. A. Holt. Coordination games. *Encyclopedia of cognitive science*, 2:204–208, 2002.

[10] Itseez. Open Source Computer Vision Library. `http://opencv.org/`, 2014. [Online; accessed 04-Februari-2014].

[11] D. Kirsch. *The Affective Tigger: a study on the construction of an emotionally reactive toy*. PhD thesis, Massachusetts Institute of Technology, 1999.

[12] G. Knoblich and N. Sebanz. The social nature of perception and action. *Current Directions in Psychological Science*, 15(3):99–104, 2006.

[13] L.J. Kray, L. Thompson, and A. Galinsky. Battle of the sexes: Gender stereotype confirmation and reactance in negotiations. *Journal of personality and social psychology*, 80(6):942, 2001.

[14] P.N. Lopes, P. Salovey, S. Côté, M. Beers, and R.E. Petty. Emotion regulation abilities and the quality of social interaction. *Emotion*, 5(1):113, 2005.

[15] R.G.J. Meulenbroek, J. Bosga, M. Hulstijn, and S. Miedl. Joint-action coordination in transferring objects. *Experimental Brain Research*, 180(2):333–343, 2007.

[16] J. F. Nash Jr. Equilibrium points in n-person games. *Proceedings of the national academy of sciences*, 36(1):48–49, 1950.

[17] Day of the New Dan. Time Lapse Assembler. `http://www.dayofthenewdan.com/projects/time-lapse-assembler-1/`, 2014. [Online; accessed 07-August-2014].

[18] RW Picard. {Affective Computing for HCI}. *Human-Computer Interaction: Ergonomics and User Interfaces*, 1:829–833, 1999.

[19] A. Rapoport. *Prisoner's dilemma: A study in conflict and cooperation*, volume 165. University of Michigan Press, Page 13, Page 24, 1965.

[20] J-J. Rousseau and G.D.H. Cole (Trans.). *Discourse on the origin of inequality.* Hackett Publishing, page 31. 1992 (Original published 1754).

[21] S. Russel and P. Norvig. Decisions with Multiple Agents. In *Artificial Intelligence*, volume 83, chapter 17.5, pages 666–678. 2010.

[22] A-M. Rydell, L. Berlin, and G. Bohlin. Emotionality, emotion regulation, and adaptation among 5-to 8-year-old children. *Emotion*, 3(1):30, 2003.

[23] B. Skyrms. The Stag Hunt. *Proceedings and Addresses of the American Philosophical Association*, (3):31–41, 2001.

[24] A.W. Tucker. The mathematics of tucker: A sampler. *Two-Year College Mathematics Journal*, pages 228–232, 1983.

[25] X. Xuehan and F. De La Torre. Supervised descent method and its applications to face alignment. In *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2013.

[26] B. Zaman and T. Shrimpton-Smith. The FaceReader: Measuring instant fun of use. In *Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles*, pages 457–460. ACM, 2006.

[27] Feng Zhou, F Torre, and Jessica K Hodgins. Aligned cluster analysis for temporal segmentation of human motion. In *Automatic Face & Gesture Recognition, 2008. FG'08. 8th IEEE International Conference on*, pages 1–7. IEEE, 2008.

Appendices

A Information for Subjects

(In Dutch)

Deelnemersinformatie experiment

Algemeen:
Dit experiment vindt plaats in tweetallen. Bij dit experiment ben je via een camera feed zichtbaar voor de andere proefpersoon. Ook zullen de camerabeelden opgeslagen worden.

Uitvoering:
Tijdens het experiment zit je achter een computerscherm en een toetsenbord. Op het scherm zal je een cameraschermpje zien met beelden van de andere deelnemer. Ook zal je een infoscherm zien met daarin onder andere je score, welke ronde het is, wat je laatste keuze was, etc.
Je zal vervolgens een spel gaan spelen waarbij je per ronde steeds één keer 'A' of 'B' kunt kiezen. Je kunt je keuze niet wijzigen als je eenmaal gekozen hebt. Het experiment zal ongeveer 10 minuten duren, maar het totaal aantal ronden dat dit inhoudt is voor jou onbekend. Als je gemaakte keuze dezelfde is als die van je tegenstander krijg je punten, anders helaas niet. Als hoeveelheid punten die je krijgt als jullie allebei 'A' is niet hetzelfde als de hoeveelheid punten die je krijgt als jullie allebei 'B' kiezen, voor de een zal 'A' de voorkeur hebben en voor de ander 'B'. De precieze puntenverdeling zal straks in tabelvorm op het informatiescherm te zien zijn. Het uiteindelijke doel is om zelf zo veel mogelijk punten te verdienen.

Gelieve niet:

- Te gebaren naar de andere proefpersoon of te 'praten' via de camera.
- Snel op de knoppen te drukken om zo snel mogelijk klaar te zijn. Het zijn niet enorm veel ronden, dus probeer rustig een overdachte keuze te maken.

Figure 4: The information sheet the subjects were given before the experiment.

B Matlab Code: Calculate and Plot the Frame Rate

```
function createPlot(times, fromhere, tohere)
%CREATEPLOT Takes a list of timestamps (hh-mm-ss) and two timestamps
%(hh-mm-ss) and creates a frames/second plot. The frames/second of all times
%will be colored blue and the frames per second between the 'fromhere' and
%'tohere' will be highlighted in red.

times = sort(times);
times = cellstr(times);      %Sort and change type of array

tokens(1,1) = times(1,1);    %A list of unique times
count(1,1) = 1;              %The appearance of each time
index = 1;
for i = 2:size(times, 1)
    if (strcmp(tokens(index, 1), times(i,1)))
       count(index, 1) = count(index, 1)+1;
    else
       index = index + 1;
       tokens(index, 1) = times(i, 1);
       count(index, 1) = 1;
    end
end

%Find the indices that match 'fromhere' and 'tohere'
starthere = 1;
endhere = size(tokens, 1);
found = 0;
for i = 1:size(tokens, 1)
   if (found == 0 && strcmp(fromhere, tokens(i,1)))
       starthere = i;
       found = 1;
   end
end

for i = 1:size(tokens, 1)
    if (strcmp(tohere, tokens(i, 1)))
       endhere = i;
    end
end

%Set framerate of the frames outside 'fromhere'-'tohere' to 0
count2 = count;
for i = 1:starthere
   count2(i) = 0;
end

for i = endhere:size(tokens, 1)
   count2(i) = 0;
end

%Plot.
plot(count, 'b');
hold on;
plot(count2, 'r');
title('Frame rate for the recordings of subject pair 1', 'FontWeight', 'bold');
xlabel('Seconds');
ylabel('Frames/second');
end
```

C Frame Rate Plots

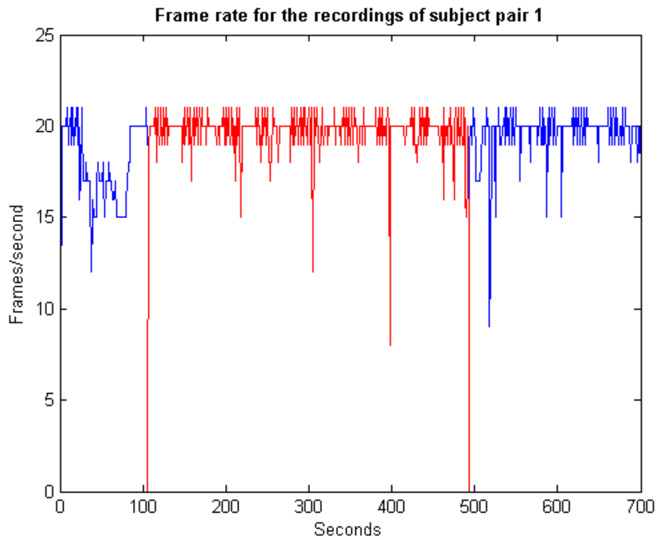


Figure 5: Frame rate per second for the saved frames of subject 1a and 1b

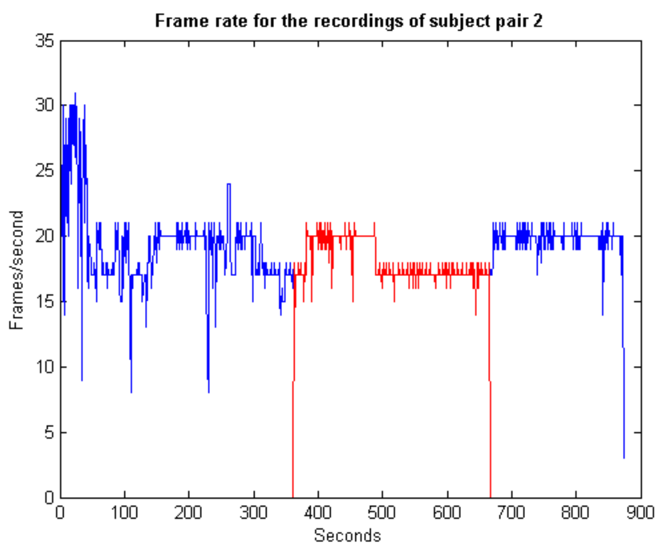


Figure 6: Frame rate per second for the saved frames of subject 2a and 2b

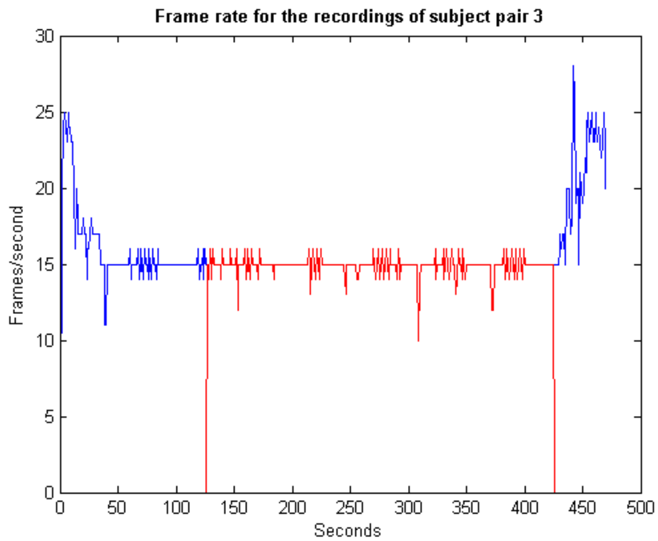


Figure 7: Frame rate per second for the saved frames of subject 3a and 3b

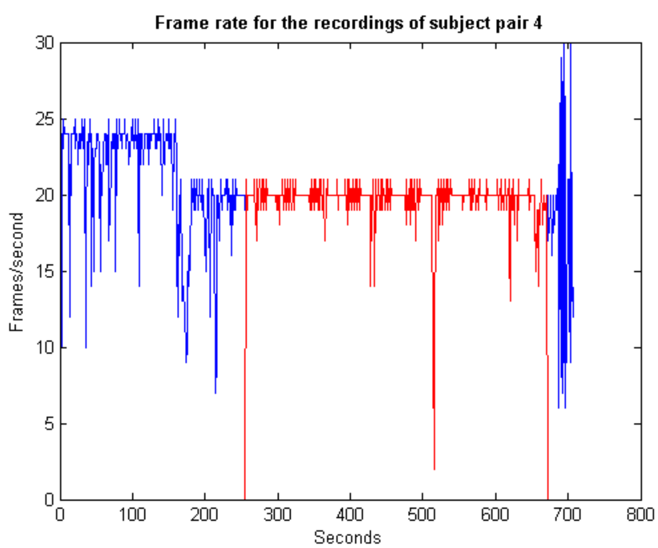


Figure 8: Frame rate per second for the saved frames of subject 4a and 4b

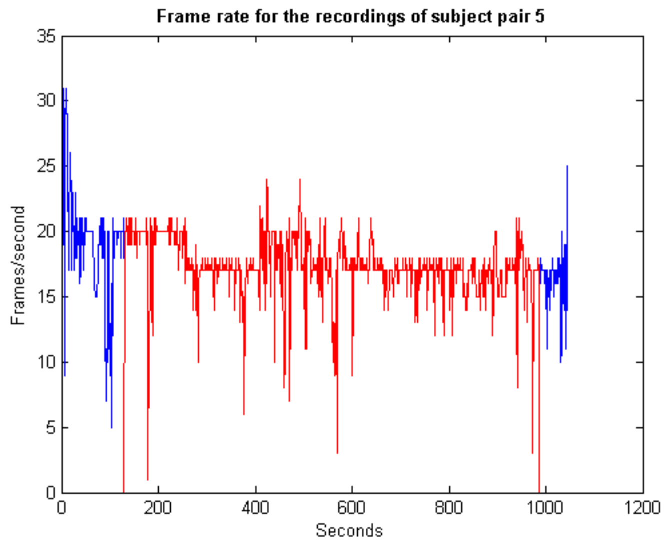


Figure 9: Frame rate per second for the saved frames of subject 5a and 5b

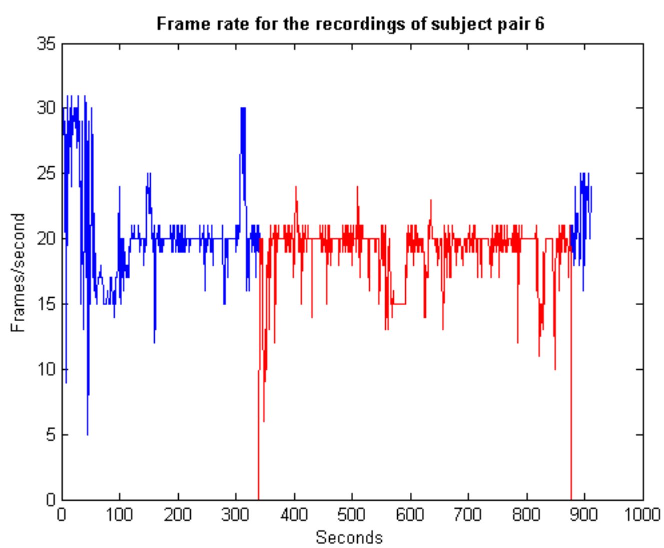


Figure 10: Frame rate per second for the saved frames of subject 6a and 6b

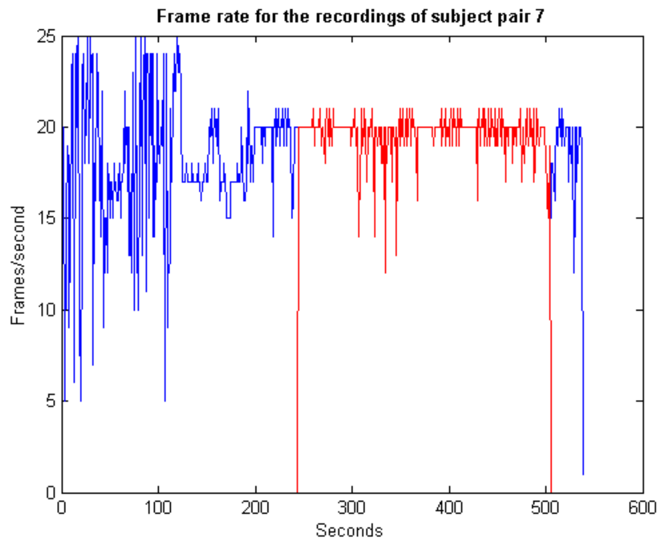


Figure 11: Frame rate per second for the saved frames of subject 7a and 7b

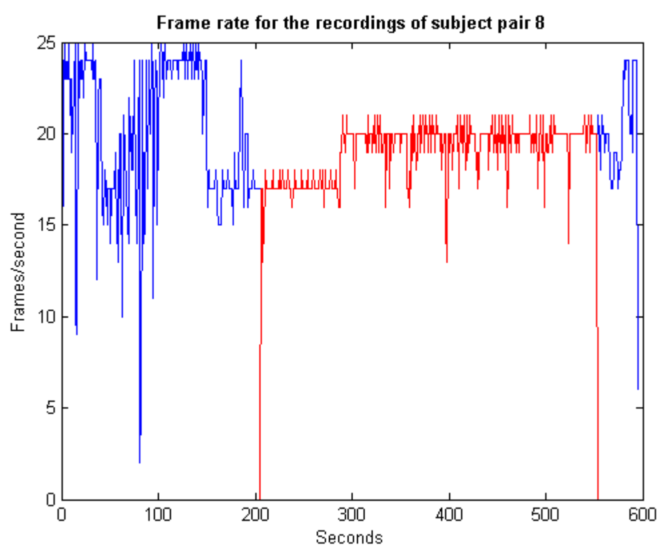


Figure 12: Frame rate per second for the saved frames of subject 8a and 8b

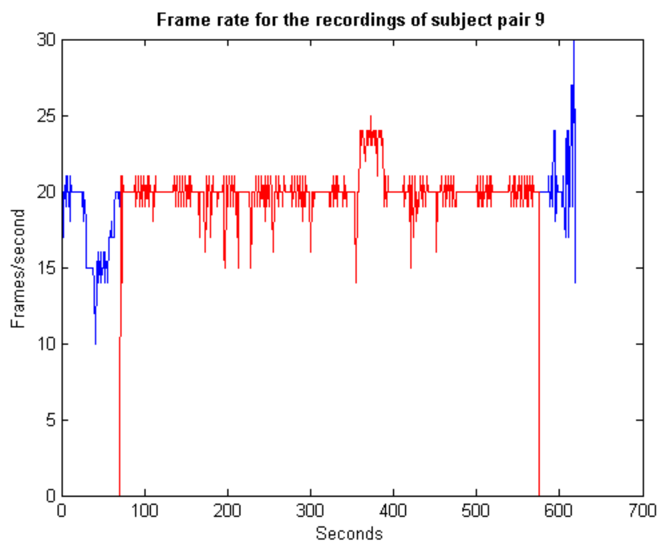


Figure 13: Frame rate per second for the saved frames of subject 9a and 9b

D Matlab Code: Find Frame Numbers for the Frames of Interest

```
function [output] = findFrames (frames, events, plusXMilliseconds)
%Function that finds the framenumbers for the frames with timestamps that match the
%given event timestamps.
%Timestamps: hh-mm-ss-milliseconds since 1970
%Frames; list of timestamps for frames
%Events; list of timestamps for events
%plusXMilliseconds; if the frame 200 milliseconds after the event is required use 200.
%for the frame at the time of the event use 0.

length = size(frames,1);
new_frames = cell(length, 1);

for i = 1:length
    temp = regexp(frames{i}, '(\d+)-(\d+)-(\d+)-(\d+)', 'tokens');
    time = temp{1}{4};
    new_frames{i,1} = time;
end

new_frames = str2num(char(new_frames));

len = size(events, 1);
new_events = cell(len, 1);

for i = 1:len
    temp = regexp(events{i}, '(\d+):(\d+):(\d+):(\d+)', 'tokens');
    time = temp{1}{4};
    new_events{i,1} = time;
end

new_events = str2num(char(new_events));
output = zeros(len,1);
new_events = new_events + plusXMilliseconds;

for i = 1:len
    search = new_events(i);
    [c index] = min(abs(new_frames-search));
    output(i,1) = index + 1;
end
```

E SPSS Output

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Measure	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser
Time	Neutral	.044	4608.440	5	.000	.421
	Happy	.027	5358.553	5	.000	.397
	Sad	.043	4646.434	5	.000	.411
	Scared	.008	7134.747	5	.000	.515
	Disgusted	.025	5475.342	5	.000	.381
	Angry	.066	4010.388	5	.000	.451
	Valence	.028	5266.509	5	.000	.398
	Surprised	.024	5498.244	5	.000	.408

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Measure	Epsilon[b]	
		Huynh-Feldt	Lower-bound
Time	Neutral	.428	.333
	Happy	.403	.333
	Sad	.417	.333
	Scared	.523	.333
	Disgusted	.387	.333
	Angry	.458	.333
	Valence	.404	.333
	Surprised	.414	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Pattern + Status + Pattern * Status
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Figure 14: SPSS output: Mauchly's test of sphericity

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df
Time	Pillai's Trace	.007	1.335	24.000	13305.000
	Wilks' Lambda	.993	1.337	24.000	12857.650
	Hotelling's Trace	.007	1.339	24.000	13295.000
	Roy's Largest Root	.006	3.601[c]	8.000	4435.000
Time * Pattern	Pillai's Trace	.037	.988	168.000	35520.000
	Wilks' Lambda	.963	.989	168.000	33318.269
	Hotelling's Trace	.038	.990	168.000	35450.000
	Roy's Largest Root	.015	3.238[c]	21.000	4440.000
Time * Status	Pillai's Trace	.009	.805	48.000	26628.000
	Wilks' Lambda	.991	.805	48.000	21816.281
	Hotelling's Trace	.009	.805	48.000	26588.000
	Roy's Largest Root	.005	2.938[c]	8.000	4438.000
Time * Pattern * Status	Pillai's Trace	.075	1.006	336.000	35520.000
	Wilks' Lambda	.927	1.010	336.000	34902.709
	Hotelling's Trace	.077	1.015	336.000	35450.000
	Roy's Largest Root	.035	3.735[c]	42.000	4440.000

Multivariate[a,b]

Within Subjects Effect		Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[d]
Time	Pillai's Trace	.126	.002	32.039	.944
	Wilks' Lambda	.125	.002	31.015	.935
	Hotelling's Trace	.124	.002	32.126	.945
	Roy's Largest Root	.000	.006	28.808	.986
Time * Pattern	Pillai's Trace	.531	.005	165.919	1.000
	Wilks' Lambda	.526	.005	155.995	1.000
	Hotelling's Trace	.521	.005	166.360	1.000
	Roy's Largest Root	.000	.015	68.003	1.000
Time * Status	Pillai's Trace	.831	.001	38.616	.921
	Wilks' Lambda	.831	.001	31.676	.834
	Hotelling's Trace	.830	.001	38.651	.921
	Roy's Largest Root	.003	.005	23.501	.957
Time * Pattern * Status	Pillai's Trace	.458	.009	338.077	1.000
	Wilks' Lambda	.437	.009	333.901	1.000
	Hotelling's Trace	.416	.010	340.886	1.000
	Roy's Largest Root	.000	.034	156.882	1.000

Figure 15: SPSS output: Multivariate tests

Tests of Within-Subjects Effects

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df
Time	Pillai's Trace	.007	1.335	24.000	13305.000
	Wilks' Lambda	.993	1.337	24.000	12857.650
	Hotelling's Trace	.007	1.339	24.000	13295.000
	Roy's Largest Root	.006	3.601[c]	8.000	4435.000
Time * Pattern	Pillai's Trace	.037	.988	168.000	35520.000
	Wilks' Lambda	.963	.989	168.000	33318.269
	Hotelling's Trace	.038	.990	168.000	35450.000
	Roy's Largest Root	.015	3.238[c]	21.000	4440.000
Time * Status	Pillai's Trace	.009	.805	48.000	26628.000
	Wilks' Lambda	.991	.805	48.000	21816.281
	Hotelling's Trace	.009	.805	48.000	26588.000
	Roy's Largest Root	.005	2.938[c]	8.000	4438.000
Time * Pattern * Status	Pillai's Trace	.075	1.006	336.000	35520.000
	Wilks' Lambda	.927	1.010	336.000	34902.709
	Hotelling's Trace	.077	1.015	336.000	35450.000
	Roy's Largest Root	.035	3.735[c]	42.000	4440.000

Figure 16: SPSS output: Within-subjects effects

Tests of Within-Subjects Contrasts

Source	Measure	Time	Type III Sum of Squares	df	Mean Square	F
Time	Neutral	Linear	.001	1	.001	.153
		Quadratic	.000	1	.000	.686
		Cubic	1.372E-5	1	1.372E-5	.127
	Happy	Linear	.013	1	.013	2.542
		Quadratic	.001	1	.001	1.576
		Cubic	.000	1	.000	4.034
	Sad	Linear	.000	1	.000	.361
		Quadratic	1.666E-5	1	1.666E-5	.526
		Cubic	5.010E-6	1	5.010E-6	.579
	Scared	Linear	2.851E-7	1	2.851E-7	.030
		Quadratic	4.094E-6	1	4.094E-6	1.556
		Cubic	7.882E-7	1	7.882E-7	1.371
	Disgusted	Linear	4.073E-5	1	4.073E-5	.199
		Quadratic	9.459E-7	1	9.459E-7	.101
		Cubic	2.590E-8	1	2.590E-8	.005
	Angry	Linear	5.128E-6	1	5.128E-6	.098
		Quadratic	3.993E-6	1	3.993E-6	.516
		Cubic	1.377E-7	1	1.377E-7	.079
	Valence	Linear	.011	1	.011	1.911
		Quadratic	.001	1	.001	1.443
		Cubic	.001	1	.001	4.615
	Surprised	Linear	7.544E-5	1	7.544E-5	3.572
		Quadratic	1.182E-5	1	1.182E-5	4.985
		Cubic	9.994E-7	1	9.994E-7	3.502
Time * Pattern	Neutral	Linear	.023	7	.003	.689
		Quadratic	.004	7	.001	1.191
		Cubic	.001	7	.000	1.375
	Happy	Linear	.015	7	.002	.441
		Quadratic	.008	7	.001	3.016
		Cubic	.000	7	4.517E-5	.514
	Sad	Linear	.002	7	.000	.738
		Quadratic	.000	7	1.891E-5	.598
		Cubic	3.161E-5	7	4.515E-6	.521
	Scared	Linear	4.674E-5	7	6.677E-6	.700
		Quadratic	1.894E-5	7	2.706E-6	1.028
		Cubic	4.430E-6	7	6.328E-7	1.101
	Disgusted	Linear	.004	7	.001	2.525
		Quadratic	9.232E-5	7	1.319E-5	1.405
		Cubic	2.474E-5	7	3.535E-6	.645
	Angry	Linear	.000	7	2.795E-5	.534
		Quadratic	4.264E-5	7	6.091E-6	.787
		Cubic	8.420E-6	7	1.203E-6	.688

Figure 17: SPSS output: Within-subjects contrasts