The CDV*Plex* Biometric Cinema: Sensing Physiological Responses to Emotional Stimuli in Film

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Abstract. We describe a study conducted to investigate the potential correlations between human subject responses to emotional stimuli in movies, and observed biometric responses. The experimental set-up and procedure are described, including details of the range of sensors used to detect and record observed physiological data (such as heart-rate, galvanic skin response, body temperature and movement). Finally, applications and future analysis of the results of the study are discussed.

1 Introduction

Physiological responses to emotional stimuli and to exercise are quite similar, and can be recorded and studied using a range of biometric measurement tools. By measuring and recording the physiological reactions of movie viewers as they watch a film, we can use this to explore new dimensions in automatic analysis of video. In this study we used new sensor technology and adapted established biometric measurement techniques originally developed by researchers in health and sports science. Using these methods we have gathered data, and are now attempting to detect the emotional highlights in a film, concentrating on highlights in film music and film events. This allows us to correlate the two, which should help to validate the accuracy of the observed data. This paper does not present an analysis of observed responses, only the details of how data was gathered.

2 Experimental Set-Up

The aim of this experiment was to provide a ground-truth of movie viewers' physiological reactions over multiple full-length feature films, by gathering biometric data from viewers in a controlled cinema-like environment known as the"CDV*Plex*". In total, 37 movies were shown over a 10-week period resulting in over 500 hours of recorded biometric observations, half as baseline observations, and half involving people watching movies. The 37 full-length feature films used in this study were chosen to encompass a range across 7 decades (1939–2004) and 10 movie genres (see Table 1).

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Movie Genre	Sample Movies
Action/Adventure	Indiana Jones, Lawrence of Arabia
Animation	Finding Nemo, Shrek
Comedy	Who Framed Roger Rabbit?, Toy Story
Documentary	Roger and Me
Drama	The Godfather, Pulp Fiction
Foreign/World Cinema	Das Boot, Il Postino
Horror/Suspense	Alien, The Changeling
Romance	Casablanca, The English Patient
Science Fiction/Fantasy	Star Wars, The Lord of the Rings
Thriller/Mystery	Minority Report, Clockers, Leon

Table 1. Some of the movies used in the CDV*Plex* experiment

The participants in this experiment were 43 volunteers from across the university's population of staff and graduate students. Film showings were advertised daily using posters and email bulletins. An online booking system and website were provided where interested parties could view the schedule and the availability of places, and book a place for viewing a film. Participation was limited to between 2 and 4 movies per person.

In order to obtain as accurate results as possible our aim was to encourage viewers to relax and to essentially forget that they were participating in a laboratory experiment. Therefore it was decided to recreate an environment that was as close to a true cinematic experience as possible. The CDV*Plex* was constructed in an air-conditioned windowless room in which a 5.1 surround sound system, DVD player and large-screen digital projector were installed. It seated up to four people and the movie was rear-projected onto a large screen at one end of the room. Each of the chairs was outfitted as a Smart Chair (see Section 3).

On the day of viewing, subjects wore two portable sensors (a heart-rate monitor and a BodyMedia Armband, see section 3) from 11am for approximately 5 to 6 hours or until after the film ended. The data recorded in the hours leading up to the film viewing established a baseline of biometric responses for that person. Subjects were asked not to engage in strenuous activities such as physical exercise (e.g. jogging) during this period, which would skew the readings.

On entering the CDV*Plex* at 2pm, viewers completed a short questionnaire detailing some personal information such as age and gender, their cinema attendance and preferred film genres, and also whether they had previously seen the film they were about to watch. The procedure was explained and at 2:30pm the room was darkened, the film was started with each viewer synchronising the timestamp buttons of both wearable devices. At the end of the film, once the credits had finished rolling, the timestamps were again synchronised. Participants were then asked to complete another short questionnaire on which aspects of the film they most enjoyed (plot, music, etc) and were asked to give their top five highlights from the film and how each made them feel. The devices were then removed and the biometric data downloaded and stored.

3 Sensors Used in the CDV*Plex*

There were three different sensor devices used to gather observational data:

Heart-rate monitor: the Polar S610i^{TM} heart-rate monitor is a device which consists of a fabric band which fits around a person's chest and detects their heartbeat. It stores its measurements by transmitting them to an accompanying wristwatch and thus tracks a person's heart-rate over time. Heart-rate responds quickly to stimuli and fluctuations of more than $\pm$ 10% of the b.p.m. value can be interpreted as a response to a stimulus [1]. Large spikes in the heart-rate graph (for example, a subject's heart-rate jumping by greater than 20% and returning to normal level within one minute) can indicate that the subject was surprised or shocked. Similarly, a sustained period with an increased heart-rate can indicate continuous excitement.

BodyMedia Armband Sensor Array: the BodyMedia SenseWear® PRO2 is a light-weight and unobtrusive armband worn on the right upper arm. Each was configured to record and store up to 6.5 hours of biometric data as detected by an array of onboard sensors. For our experiments we chose to record galvanic skin response, a measure of skin conductivity which is affected by perspiration such as that caused by emotional stimuli. Changes in the eccrine sweat glands causing perspiration have been linked to measures of emotion, arousal and attention [2]. We also recorded skin temperature, which is linearly reflective of the body's core temperature activities, as well as heat flux which is the rate of heat being dissipated by the body. Changes in skin temperature can be due to an emotional or physical response but typically they take longer to manifest than heart-rate changes, and fluctuations will not be as great. The final component in the BodyMedia armband we used was an accelerometer which measures motion, and by taking into account the context in which the armband was worn (e.g. lying down, etc.), the amount of subject movement can be derived.

Smart Chairs: each of the four chairs used in the experiment had a foam-based pressure sensor integrated into its backrest to record movements and changes in the subject's posture. This uses a polypyrrole-coated polyurethane foam developed within our sensors laboratory [3], the electrical conductivity of which changes when it is compressed. Movements such as sitting back, forward or shifting from side to side in the chair result in pressure changes on the backrest, causing the polyurethane foam to compress and relax and the resulting changes in the electrical current were recorded. This allowed for fine-grained monitoring of subjects' movements throughout the film.

4 Data Analysis and Next Steps

Having gathered over 500 hours of biometric observational data, we have now started to analyse the huge volume produced by this experiment, to allow for statistical analysis. We are presently examining different machine learning techniques that may aid in detecting trends within the data. Detecting emotional highlights in the film (i.e. periods of high emotional stimulation) is possible;

however we cannot, as yet, distinguish between positive and negative emotions, though this will be an area for future work.
The main focus for the analysis of the data gathered will be in detecting movie events and highlights. There are three different areas we are concentrating on.

Movie Music

One of our interests is to investigate the relationship between film music and the emotional experience of movie viewing [4]. Our focus is on automatically analysing a movie soundtrack to identify patterns of musical characteristics based on pitch, beat and timbre in order to subdivide the soundtrack (and hence the movie) into logical segments based on the emotion suggested by the associated music. We can then examine correlations between emotional physiological events as observed in the CDV*Plex* and emotional segments in the movies.

Movie Event Types

By automatically detecting the presence of various event types (such as conversations [5], exciting events [6] or montages) in each movie, we can investigate how audience reaction differs depending on the on-screen activities. For example, of fast-paced editing and high amounts of camera movement is regularly used by film-makers to portray intensity [7]. By correlating areas such as these with the biometric observations, the physiological response of viewers can be detected.

Emotive Annotation

In this work we investigate correlations between biometric measurements from the CDV*Plex* and automatically generated affective content annotations of video based on its audio content. This is achieved by analysing the language used in Audio Descriptions of the same movies shown in the CDV*Plex*.

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