Bio-Tenton Using Smart Hone For Real Time Applications

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Abstract
This study demonstrates the feasibility of measuring heart rate (HR) differences associated with emotional states such as anger and happiness with a smartphone. Novice experimenters measured higher HRs during relived anger and happiness (replicating findings in the literature) outside a laboratory environment with a smartphone app that relied on photoplethysmography.

Keywords—Human factors, portable devices, psychology, remote sensing

1 INTRODUCTION
The use of smartphones is continuously increasing. Applications allow recent generations of mobile devices to be used for a wide range of tasks that require computational power. Not surprisingly, people are enthusiastically exploring the possibilities that smartphones provide for scientific research [14]. For example, custom made smartphone applications allow cognitive scientists to collect data from more diverse populations than are typically used in laboratory experiments [4]. Technological advances continue to increase the possible applications of mobile devices. Using a smartphone camera, it is now possible to accurately measure a person’s heart rate (HR) using photoplethysmography (PPG). This optical as the capillaries in the tissue expand and contract with each heartbeat [11].

Although smartphone applications that measure HR are primarily developed for health-related purposes, HR is also an important physiological indicator of the emotional state of an individual. For example, HR increases during anger, anxiety, fear, and happiness, whereas HR decreases during sadness, anticipatory pleasure, and suspense-related emotions (for a review, see [10]). Smartphone applications that rely on PPG to measure an individual’s HR provide several advantages over more traditional HR measurement equipment. First, they are easy to use, and provide reliable measurements as long as experimenters follow simple instructions. Second, the use of mobile devices allows HR to be measured easily outside of a lab environment. Finally, the increasing availability of smartphones makes them a cost-effective way to measure HR for researchers with limited financial means.

The goal of the current study is to demonstrate how smartphones, and more specifically PPG applications that use the digital camera of a smartphone, can be used to measure differences in HR as a function of relived emotional experiences.

Although PPG techniques to measure HR have been available for nearly 80 years [3], it has primarily been used in clinical settings to monitor patients [1]. The goal of this paper is to highlight the possibilities PPG offers for emotion researchers.

First, an experiment where HR measurements were collected with a smartphone while participants relived anger or happiness emotions is presented.

Finally, recent technological advances that open up the possibility to measure a person’s HR using a video camera placed at a distance of several meters will be discussed. Following recent recommendations to incorporate

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replication studies in academic teaching [6] students of a first-year introduction to psychology course were asked to perform a partial replication of a classic study by Ekman et al. [5]. In their study, Ekman et al. measured the autonomic nervous system activity of participants for six emotions elicited by a relived emotions task and a directed facial action task. In the replication attempt, students only used the relived emotions task, where participants were asked to relive a past emotional experience, and participants’ HR was collected for only two emotions, namely anger and happiness. HR was measured using a free smartphone application, and students used their own smartphones. If first-year students can replicate results from the scientific literature with their smartphones, this would provide a strong demonstration of the usefulness and reliability of mobile devices to measure differences in HR caused by emotional experiences.

2 METHOD

2.1 Participants
Seventy-four students (54 men, mean age 20) at the Eindhoven University of Technology participated in the study in return for course credit. The sample size was determined by the number of students in the course.

2.2 Apparatus
HR was measured using an smartphone app by Azumio (available from http://www.azumio.com/apps/heart-rate) for Android (66 percent of the devices used) and iPhone (34 percent of the devices used), which relies on PPG. PPG can operate in reflection mode, where a LED placed next to the camera functions as the light source, or transmission mode, where environmental light shining through the tissue is recorded by the camera [1]. The two modes mainly differ in practical applicability, given that the reflection mode can be used on more sites of the body, such as the forehead. Eighty-seven percent of the PPG measurements were collected using the reflection mode operation, which required students to have access to a smartphone equipped with a camera with a LED light.

Studies that have compared PPG and traditional electrocardiograph (ECG) measurements of HR correlate highly [9], and similar high correlations with ECG measurements are observed when smartphones are used to collect the PPG signal [2], [7], [12], [19].

2.3 Procedure
Small groups of up to four students worked together to collect the data. Each student took part in the study as a participant, and each student was responsible as an experimenter for the data collection from one participant. The experimenter assigned participants to an order condition (anger first versus happiness first) based on a coin flip.

Participants were seated during the experiment, with one hand extended and resting palm-up on a table. The experimenter softly pressed the smartphone camera against the tip of a finger, and measured the baseline HR. Subsequently, the experimenter asked participants to relive the first emotion until they were told they could stop. After 10 seconds, the experimenter used the smartphone to measure the HR. The experimenter instructed the participant to stop when the measurement was successful, or after 60 seconds had passed when the HR measurement was not successful within this time period. After the HR measurement, participants rated the intensity of the felt emotion on a scale from 0 (absolutely not intense) to 8 (extremely intense), following Ekman et al. [5]. The experimenter waited at least 1 minute before repeating the procedure for the other emotion.

3 RESULTS
A spreadsheet file with the data can be found at http://dx.doi.org/10.4121/uuid:ab52261c-206b-4bed-a59d-026a16c04144.
The HR of six participants could not be accurately measured within 60 seconds for one of the tworelived emotions, and the data of these individuals is therefore excluded from the analysis. The HR of the remaining 68 participants was submitted to a 3 (emotion: baseline versus anger versus happiness) _ 2 (order: anger first versus happiness first) repeated measures ANOVA with emotion manipulated within, and order manipulated between participants. There was a clear main effect of emotion, F(2; 132) = 23.89, p < 0.001, _2p = 0.27. HR was higher while recalling the anger (M ¼ 72.06, SD ¼ 12.11) and happiness (M ¼ 69.00, SD ¼ 12.17) emotions, compared to the baseline measurement (M ¼ 64.59, SD ¼ 10.33), t(67) = 7.11, p < 0.001, _2p = 0.43 and t(67) = 5.34, p < 0.001, _2p = 0.30, respectively. In addition, HR increased significantly more when recalling anger than when recalling happiness, t(67) = 2.61, p = 0.011, _2p = 0.09. There were no significant correlations between the intensity of self-reported anger and happiness and the measured HR. Participants’ self-reports indicated the relived emotion happiness (M ¼ 5.27, SD ¼ 1.31) was experienced as more intense compared to the anger condition (M ¼ 4.03, SD ¼ 1.64), t(67) = 5.12, p < 0.001, _2p = 0.28.

4 DISCUSSION
First-year students used their smartphones to measure the HR of participants who relived an event during which they felt angry or happy. The results confirmed findings in the literature that HR increases when people relive experiences related to anger or happiness [13], [17], [18], [20]. These results demonstrate the usefulness of smartphones for scientific research: Smartphones provide an easy to use and cost effective way to measure HR, even by relatively inexperienced researchers. The stronger increase in HR in the anger compared to happiness condition replicates earlier findings [18]. Because the use of smartphones allows researchers to collect physiological measures from a larger group of participants with relative ease, mobile devices might be a way to more easily and efficiently examine HR differences between emotions that have a smaller effect size, while collecting enough participants to have sufficient statistical power. It should be noted that the students (who were both the participants and the experimenters) had read the research article by Ekman et al. [5], and were therefore not blind to the hypothesis. However, the fact that an increase in HR during relived happiness was observed (in line with the literature, but not in line with the findings in the experiment by Ekman et al.) speaks against the presence of experimenter bias in the current study. Measuring HR through PPG with the camera of a smartphone has great potential for scientific research. At the same time, limitations should be noted. First of all, PPG has several limitations regardless of the device used to perform the measurements, such as the susceptibility to differences in room temperature, or individual differences in vessel anatomy [8]. These factors can increase variability in HR measurements between subjects. Furthermore, it is currently not possible to collect more detailed information about cardiac function with a smartphone, such as the projection period, and low video sample rates might limit the accuracy of measurements [19]. Therefore, a smartphone should be seen as a research tool that provides new opportunities for data collection in addition to existing measurement devices. At the same time, by replicating previous findings of relived emotions on changes in HR, the current study demonstrates the feasibility of using a smartphone to investigate emotional experiences. PPG has an important benefit over other techniques to measure HR, because recent technological advances have
made it possible to use PPG remotely. The plethysmographic signals can be calculated from video recordings of a human face when the camera is positioned 1.5 m away [21]. Recent advances in video magnification have made it possible to extract HR information from video recordings in real time, even under noisy circumstances [22], and smartphone apps that use noncontact PPG are already available [12]. Being able to measure HR from a distance makes it possible to collect a physiological measure that could provide an indication of the emotional state of an individual unobtrusively through camera recordings.

Obviously, the use of such a technique deserves careful ethical considerations. Given that devices such as smartphones, computers, video game consoles, and televisions are often already equipped with a camera, these devices should currently be able to calculate HR signals through noncontact PPG from video information and, thus, use HR information as a correlate of the emotional state of individuals interacting with these devices. Obviously, changes in HR do not necessarily imply changes in emotional experiences but can also be due to other factors, such as physical exercise. HR measurements can also be influenced by factors unrelated to the emotional state of individuals, such as movement artifacts [1]. However, these possible confounds are often quite stable when people sit in front of their computer, video game console, or television. This provides interesting possibilities to develop applications that derive correlates of emotional experiences in these situations by measuring HR changes through noncontact PPG.

Although such applications are potentially interesting, it remains a challenge for future research to determine the real-life circumstances under which HR information can be used to infer emotional experiences. Advancements in PPG signal processing, analysis to remove motion artifacts [15], will improve the applicability of PPG to measure HR differences in daily life. To improve the correlation between HR changes and experienced emotions, applications might need to incorporate contextual information, such as knowledge of the specific information the computer is presenting at a given moment. For example, computer software could collect HR measurements through the webcam of a computer while different songs are playing. Based on the knowledge of when a different song starts and ends, this program can calculate relative HR differences between songs, and use these measurements to categorize songs as either “happy” or “sad,” see [23]. Although HR might be able to distinguish between certain emotional states (e.g., sadness and anger), it cannot by itself be used to differentiate between other emotions (e.g., anger and disgust). More detailed physiological information such as respiration rate (RR) and heart rate variability (HRV) might allow for a better differentiation between different types of emotions. For example, increased HRV can be used to distinguish experienced disgust from other negative emotions such as anger or anxiety [10]. Recent advances in noncontact PPG have provided initial support for the feasibility of measuring RR [19] and HRV from a distance of 0.5 m [16], which might be used to determine different emotional states of individuals more accurately. Researchers might also be interested in the possibility to extract HR information from existing high-quality video recordings, such as presidential debates. In addition, video sites such as YouTube might provide a wealth of data where HR might be extracted to answer novel research questions. Although researchers should be very careful when interpreting changes in HR as an indicator of the emotional state of an individual, and more research is needed to carefully examine the reliability of the emotion indicators derived from such video analyses, these techniques are

Such as applying independent component
likely to provide many opportunities for researchers interested in emotions.

5 CONCLUSION

Technological advances have made it possible to accurately measure an individual’s HR using a smartphone camera [7], [19]. The current study demonstrates that smartphones can be used to measure HR differences associated with relived experiences of anger and happiness. Smartphones provide an easy-to-use, portable, and readily available measurement tool for emotion researchers. In addition, the current experiment demonstrates that smartphone applications allow even inexperienced experimenters to collect reliable physiological data.

REFERENCES


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