Detecting physiological responses in those exposed to real-life biochemical simulations

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Executive Summary:
Studying physiological responses under emotional and physical duress provides insight into decision-making, personal interactions, and handling of situations. This is especially important for those at high risk of chemical or biological toxin exposure. With the Iraq War and global terrorism a constant headline, it is vital to study the unique physiological responses of those exposed to hazardous biological and chemical agents.

Supporting evidence suggests that emotional states carry their own physiological signals, and finding these differences will determine someone's current psychological and physiological state (Lisetti et al., 2004). While there have been other ways to measure physiological responses, biosensors—which are less obtrusive and yield better accuracy—have become a popular alternative for recording physiological data (Rochman et al., 2008).

Introduction: Clinical biosensors detect physiological responses
The Exmovere *Empath* watch contains biosensors that detect and measure heart rate, skin temperature, galvanic skin response, and physical activity. These measures discern the body's response to different emotions. In prior psychophysiological studies, these same biological measurements have created a better understanding of emotional states and unique responses. For example, the heart rate is an essential physiological component to measure because it represents parasympathetic activation, or the body's ability to return to homeostasis after a stressful event. The relevance is that a body exposed to biological or chemical toxins may find it more difficult to return to homeostasis than a healthy individual.

The *Empath* measures skin conductance (also known as the Galvanic Skin Response). This measures sympathetic activation, or the body's "flight or fight" response, in a stressful event. In past studies, it was the skin conductance measurement that showed the physiological differences between anger and sadness (Rochman et al., 2008). Therefore, skin conductance will be a necessary measurement when collecting data on subjects' anger and depression symptomology.

It is also important to assess physiological safety when it comes to those in high-risk situations. The *Empath's* skin temperature feature will analyze the physiological response of negative emotions. Pinpointing how someone responds to situations is a vital step to changing negative physiological responses and finding healthier ways to respond.

The *Empath's* accelerometer feature measures movement and physical activity, which will define the relationship between emotional states and physical arousal. Comparing physiological responses during routine tasks with physiological responses under stress, will prove that movement does affect a person's emotions.

A fuzzy logic learning based software developed by Exmovere, known as the *Emotional Interpretation Engine*, will analyze our data. The program will learn—through training—to accurately label and categorize each emotional state and its physiological responses based on this study's emotional criteria. Wilson et al (2000) discusses an artificial neural network (ANN), which increases data's accuracy. This artificial network labels what emotional trial the subject is completing based on the physiological response. The accuracy of this program ranges from 84.9%-86%, depending on the workload. An artificial neural network will be incorporated to label and analyze the physiological data with top accuracy. It also eliminates inaccuracies due to human error. The only difference is that our research studies people's physiological responses in unobtrusive ways; therefore, we will not use EEGs, like past ANN studies, to capture data.

Research Component:
The main focus of this research is to record and analyze the physiological responses of four specific emotions—anger, fear, depression, and jubilation. Each emotion is objectively defined by its unique physiology (Albert Ax, 1953; Krumhansl et al., 1997; Schwartz et al.,):

Anger: This emotion will produce the fastest heart rate and the highest diastolic blood pressure. Skin conductance and muscle potential will also increase. Anger has more rises in skin conductance than fear, which will distinguish these emotions from one another.

Fear: There will be an increase in skin conductance (similar to anger), an increase in muscle potential (e.g. tension) that is *more* pronounced than anger, and an increase in respiration rate. Due to the significant muscle potential increase, data that mirrors this physiological response will be characterized as fear.

Depression: This response will produce a slow heart rate, the largest decrease in diastolic blood pressure and skin conductance. Also, both depression and fear will show the largest changes in finger temperature.

Jubilation/ Happiness: Being jubilated will produce the most significant decrease in respiration depth. Therefore, jubilation will produce the slowest heart rate of all. Also there will be a significant decrease in body temperature (e.g. skin conductance).

Exmovere's main focus is on three types of toxic exposure: exposure to toxic industrial chemicals (e.g. ammonia), exposure to Blister and/or Nerve Agents (e.g. mustard gas), and Biotoxin exposure (e.g. Ricin). This study will separate subjects into three groups: a healthy control group (Group A), an experimental group consisting of soldiers who have been exposed to war *and* biochemical toxins (Group B), and a second experimental group, consisting of soldiers exposed to war but *not* biochemical toxins (Group C).

The participants are healthy males and females between the ages of 18-55. Control subjects will never have been diagnosed with any psychiatric disorders, heart conditions, or other medical sconditions that could affect the data's accuracy. It is also imperative that those in the experimental groups were not diagnosed with psychiatric disorders, heart conditions, or relevant medical problems prior to exposure.

Subjects will be equipped with the *Empath* and instructed to wear it for the full length of the study but continue their normal routine. The watch can store 24 hours of data, a unique feature that will make data collection easier. This data will be transmitted to a computer equipped with the Emotional Interpretation Engine and artificial neural network, which will analyze and record each subject's baseline response.

Palm pilots give subjects the freedom to continue their daily routine without interruption (Piasecki et al., 2007). Therefore, daily subject self-reports will be recorded via palm pilot. PDAs will increase compliance and also account for subjects without computers. To collect a baseline, the PDA will alert subjects, via alarm, to complete specific tasks and then answer questions. The PDA's alarm will sound at 8 pm every evening. These tasks consist of: Cleaning dirty dishes without a sponge for ten minutes (Anger); dunking your head under water while counting to 100 (Fear); sitting alone in the dark listening to sad music for ten minutes (depression); and watching ten minutes of your favorite comedic movie (jubilation). The PDA will prompt subjects before each task, the *Empath* will alert the subject when their time is up, and then they will answer questions. The questions ask how intense (on a scale of 0-10) each emotion (Anger, fear, depression, and jubilation) was during that specific task. Baseline data will produce the lowest emotional intensity, and we predict that the experimental groups will have a higher intensity baseline than the controls group. Also, the exposed experimental group will have the highest intensity baseline.

Second day: In the lab, subjects will be exposed to emotion-provoking visual stimuli while the *Empath* records real-time physiological responses. There will be four, 30-second trials to measure each emotion. Having multiple images for each trial might lead to a break in the subject's emotional response; therefore, there will be only one image per trial. The visual stimuli will be accompanied by emotionally relevant sounds produced by Hyper Sonic Sound Beam Technology. These sound beams direct audio to a specific location and nowhere else, which cuts down on noise pollution and creates a more emotional response.

Visual and Audio Stimuli

For anger, an image of Osama Bin Laden will be paired with sounds of people cheering. Not only will the image of a negative figure create anger, but hearing people cheering will also intensify the emotion. For fear, an image of planes striking the World Trade Center will be paired with sounds of screaming. For depression, an image of deceased soldiers will be paired with crying. Lastly, for jubilation an image of soldiers hugging their children will be paired with sounds of children laughing.

After each visual task, the subjects will rate the intensity of each emotion from 0-10. These results will be compared to the baseline results. These self-reports should show higher emotional intensity than the baseline reports. We expect an increase in the physiological responses of all three groups after this task; however, the physiological responses should be more exaggerated in the experimental group, particularly the exposed group.

At 8pm, subjects will be prompted by their PDA to complete the same exact tasks as the previous night, including a self-report of emotional intensity. Overall, there should be higher intensity ratings the second night than at baseline. With the introduction of the visual task, subjects' physiological responses should be more intense than the previous night. The highest intensity change will be in the experimental group, with the exposed experimental group showing the most significant increase.

Real-Life simulations provide insight into situational awareness

On the third day, subjects will be exposed to real-life simulations. Hired actors will take on the roles of medical personnel, civilians (both injured and non-injured), soldiers, hostages, and terrorists. These simulations are frequently utilized by the government and have proven effective for recording subjects' reactions and solutions. Scenarios include: handling a hostage situation where terrorists threaten to release Ricin if their commands aren't followed (Fear); subjects attempt to seek medical help for soldiers exposed to mustard gas, but face inattentive and unhelpful medical staff (Anger); having civilians and soldiers who are exposed to toxic levels of ammonia die while subjects attempt to save them (Depression). With all these negative emotional states jubilation may seem hard to elicit; however, since subjects have been helping injured and dying soldiers seek medical attention, it would seem extremely gratifying to have the injured graciously thank subjects for saving their lives. Dialogue can easily be created for these actors to elicit jubilation in subjects (e.g. “I will get to see my children grow up now thanks to you”). While these simulations are running, the *Empath* is recording each subject’s physiological response. The data will then be analyzed by the Emotional Interpretation Engine which will accurately label the results. At 8pm, the subjects’ PDAs will alert them to complete the same evening tasks and answer questions.

On the fourth day all subjects will be instructed to continue their daily routine and complete PDA assignments. The fourth day will provide 24 hours of physiological data post-simulation. All subjects will be asked to repeat the same PDA tasks that evening. On the fifth day, the subjects will be asked to return to the facility to return the watch and palm pilot and be debriefed.

Results

The self-reports will show that emotional intensities will be lower pre-simulation than post-simulation. The control group will continue to report the lowest emotion intensity as compared to the experimental groups. The self-reports with the highest emotional intensity will be those in the experimental group, with the majority in the exposed experimental group. With self-reports versus physiological data, it is predicted that the majority of subjects’ self-reports will rate their emotional intensities as lower than the actual physiological data. Subjects may be unwilling to admit their true emotion, especially soldiers who have been taught to control their emotions and remain neutral in all situations. Based on this assumption, those in the experimental groups—especially the exposed experimental group— will downplay their emotional intensities more than the control group.

Conclusion

By creating technology—like the *Empath*—to monitor physiological responses, transformation within military operations will strengthen. Extreme emotions can often lead to bad judgment and negative consequences. With the experimental groups producing the strongest emotional responses, it is a concern that soldiers will exhibit this unpredictable emotional behavior during times of stress. The *Empath* can alert the military to these overly intense emotional reactions so tasks may be reassigned until the emotions have subsided. This will significantly decrease the number of accidents and injuries that occur due to stress and human error, while also increases productivity.

Also soldiers are readily diagnosed with Post Traumatic Stress Disorder, which carries with it an increased startle response. This startle response—especially during wartime—could lead to poor planning and threaten lives. Knowing and understanding the physiological conditions of soldiers will provide faster, relevant, and more accurate evaluations of emotional reactions and decision-making on the battlefield. This physiological data will increase military operational intelligence by providing insight into emotions, an essential—and often ignored—aspect that can greatly affect outcomes. And by utilizing these data, the military can create more effective medical and therapeutic treatments for soldiers that will produce better awareness of themselves, their emotions, and how to handle future situations.

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