Timing of coping instruction presentation for real-time acute stress management

Long-term implications for improved surgical performance

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Abstract**—*The purpose of this project was to inform the presentation timing of coping strategies during an acutely stressful task, to be integrated into a visual real-time biofeedback display for stress management. We gathered skin temperature, electrocardiography, and electroencephalography data, and presented a coping instruction on various time schedules while participants played a first-person shooter computer game. Heart rate variability (HRV) preceding and following significantly elevated peaks of stress at times when a message was presented was compared to times of comparable stress when a message was not presented. In general, around times of significantly elevated heart rate (HR), presenting a coping instruction resulted in an increase in HRV. At analogous times of elevated HR when a message was not presented, the downstream results indicated a decrease in HRV in most cases. These results support that HRV over relatively short time windows before and after a peak of elevated stress can be a sensitive indicator of acute stress. We can confirm that the presence of a message at a physiologically-relevant time reduced physiological stress within the subset of peaks analyzed. The findings imply that presenting coping instructions at the time of an acute stress response restores downstream physiological indicators representative of stress, and that not doing so can be detrimental*.**

Keywords—heart rate variability; acute stress; coping instructions; real-time; timing of presentation

I. Introduction

Acute stress is a well-documented problem for surgeons and surgical performance [1, 2]. Physiological and cognitive effects of sympathetic nervous system (SNS) activation in the face of acute stress detrimentally impact cognitive processes integral in high performance [3]. Medical error in the United States is the third leading cause of death [4] and surgery represents an acute care setting particularly susceptible to errors [5]. Managing stress is imperative to optimize surgical performance and limit medical errors.

Other high stress industries have acknowledged the negative effects of acute stress and designed stress management training programs accordingly [1, 6]. Similar training in the healthcare domain is far less prevalent, but its need is increasingly recognized [7].

Historically, training has included various forms of feedback. Traditional performance feedback is most influential in instilling lasting change when it is immediate, specific, neutral, and corrective [9]. Biofeedback is gaining popularity as a stress management tool by providing individualized physiological information in real time to the user, meeting the requirements of immediacy and specificity.

Biofeedback alone, however, is not inherently assistive in nature, warranting the investigation of a supplemental coping instruction to present alongside biofeedback. The interface of this display must be evaluated and designed to ensure optimally usability.

The goal of the study reported, undergoing continued analysis, was to evaluate the most effective time to present coping instructions during an acutely stressful task. We hypothesized that receiving a brief coping instruction versus not receiving this instruction at physiologically-relevant times would result in a greater reduction in stress.

II. Approach

A. Participants

A total of 21 students (11 females) were recruited at a liberal arts college in the southeast. The participants included students from ages 18-23 years. All participants were required to have normal or corrected-to-normal vision. The experiments were approved by and conducted in accordance with the guidelines of the Roanoke College Institutional Review Board with subjects providing informed consent.

B. Equipment

Electroencephalography (EEG), electrocardiography (ECG) and skin temperature (ST) signals were recorded using a PoweLab 26T device from AD Instruments, Inc (Colorado Springs, CO). Fz, Pz, and O2 electrode sites of an EEG cap and two mastoid grounds from Electro-Cap International, Inc (Eaton, OH) transmitted voltage signals from the scalp of participants. Three lead-shielded electrode leads attached to disposable ECG electrodes transmitted voltage signals from the chest and wrist of participants. An ST sensor was placed on the non-dominant palm of participants. The presentation of stimuli was indicated by a signal sent from an external Cedrus StimTracker (San Pedro, CA) device to a separate monitor, which was also recorded by the LabChart 7 software. Biological signals were presented on an external 17” Dell monitor viewed by the researcher only. Stimuli were presented on the internal 15” monitor of a Dell laptop using SuperLab 4.5 (San Pedro, CA) placed in direct line of sight for participants. The task was carried out on an internal 12” monitor of a Lenovo Yoga 12 laptop computer.

C. Procedure

After reviewing the informed consent, participants were equipped with EEG, ECG, and ST sensors and played each of the two game modes of Counter-Strike: Global Offensive for three minutes to become familiarized. Participants then filled out a demographic questionnaire and form Y-2 of the State Trait Anxiety Inventory for Adults (STAI). Baseline data were acquired for five minutes while the participant relaxed in silence. The researcher calculated the average heart rate (HR) over the five minute baseline period, and two standard deviations above the average resting HR.

Participants then played ten minutes of each condition, the order of which was randomized. The message reading “Take a deep breath.” was displayed on various time schedules: fixed intervals, randomly, elicited by an elevation of two standard deviations above resting HR, or not at all. The stress level varied according to the game mode played. Weapons Course was considered the low stress mode, in which participants partook in the game tutorial. Arms Race was the high stress mode, which consisted of a team-based, first-person shooter game with high visual-spatial demands and only one winner. The experimental design was thus a 4 (presentation timing) x 2 (stress level) within-subjects design.

Between each condition, participants filled out form Y-1 of the STAI and the NASA-TLX.

D. Analysis

Analysis was completed using LabChart Reader and Microsoft Excel. Heart rate variability (HRV) was derived from the raw ECG trace by calculating duration between R-R peaks for the minute leading up to a substantial elevation in HR and for the minute following a substantial elevation in HR. This was done on an individual basis for times in which a message was displayed (in the physiologically-triggered conditions) and compared to analogous moments of stress when a message was not displayed (all other conditions).

Standard deviation from normal-to-normal (SDNN) was also calculated for a subset of peaks, according to a filtering system, for 30-second time windows preceding and following peaks of elevated stress.

III. Preliminary Results

Early-stage analysis of these data provide compelling evidence to support our hypothesis. HRV tended to be enhanced in the minute following coping instruction presentation compared to the minute preceding stimulus presentation. When physiological indicators of stress were substantially elevated but an instruction was not presented, this was not the case.

Analysis of SDNN immediately preceding and immediately following elevations in stress across conditions in 30-second time windows revealed that in most cases HRV increased following instruction presentation when it was physiologically-induced and decreased following a lack of instruction presentation at times of physiological elevation (see Fig. 1). When the opposite trend was observed, in-game behavior could account for these contradictions.

IV. Conclusions

Results have suggested that when comparing HRV of one individual immediately before and immediately after significant elevations in HR, receiving a message at this time of elevated physiological stress resulted in better recovery from the stressor, whereas not receiving a message at this time resulted in worsened signs of stress. These results help to inform the appropriate timing scheme of coping instructions amid acutely stressful experiences.

This has direct implications for the presentation of assistive information in acute stress settings. The acquisition of these results in a tightly controlled setting lays the groundwork for a similar evaluation within a more applied setting, such as health care. The importance of this type of work cannot be understated, as an inappropriate design of such a display could lead to too many interruptions, distracting or extraneous information, and ambiguous or unhelpful coping instructions [10], pointing to the potential to exacerbate stress rather than ameliorating it [11].

Acknowledgments

We would like to thank the Agency for Healthcare Research and Quality (R18HS023465-02 [PI- Parker]) and Dr. David F. Nichols and the Psychology department of Roanoke College.

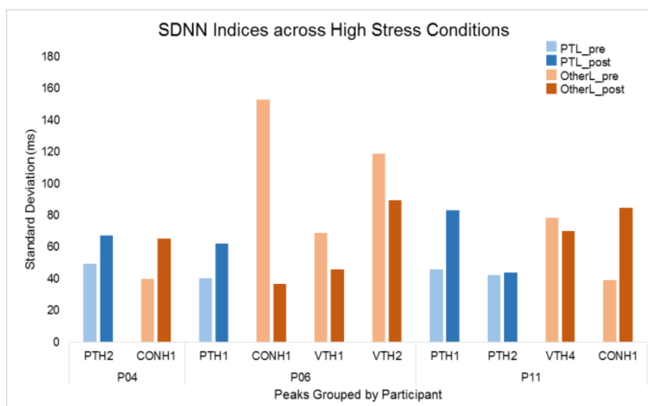

Fig. 1. *SDNN indices over a 30-second time window before and after each peak in high stress conditions for each participant. 100% of PT peaks resulted in enhanced variability following the message, while 67% of other peaks showed the opposite trend. Behavior in-game explained for all trends that contradicted expectations. Labels indicate which condition the peak comes from (e.g. PTH2=the 2nd physiologically-triggered peak in the high stress game mode; FT=fixed time schedule; VT=variable time schedule; CON=control condition).*

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