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Name: Rohan Chaudhury

UIN: 432001358

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1. SUMMARY:

a. Problem Statement:

The authors of this research have proposed a unique way for teaching people how to regulate stress through the use of an adaptive biofeedback game. Stress is a serious concern that affects individuals of all ages both mentally and physically. The research in this paper aims to help with the problem of stress management and increase the overall wellbeing of an individual.

Biofeedback techniques available for teaching individuals about relaxation techniques and stress management involves monitoring and displaying patient's physiological conditions while he/she conducts techniques for relaxation under professional therapist supervision. These methods consume a lot of time, resources and only teach stress regulation in environments that are relaxed and quiet whereas they are actually needed in stressful situations. To solve these issues, the authors have proposed their solution involving the use of video games which are highly alluring to the masses, and the availability of cheap wearable sensors. Combining these two the authors have come up with a solution owing to which, individuals should be able to practice stress reduction based on biofeedback anywhere and at any time. They have proposed that the learned skill can also be transferred for use in real-world scenarios.

b. Proposed solution:

In their proposed method, the physiological conditions of an individual are monitored while he/she is playing the biofeedback game. The user's behaviors exhibiting states of relaxation are rewarded while behaviors involving states of high arousal are penalized, thus establishing a positive feedback loop. For evaluating their approach the authors have used 3 different biofeedback modalities which can be measured using wearable sensors: (1) Breathing Rate (BR), which isn't a direct indicator of stress, (2) heart rate variability (HRV), which is a partial indicator of stress and, (3) electrodermal activity (EDA), which is a great indicator of stress.

Four components make up the system for game biofeedback (GBF) used by the authors in this paper: (1) a video game that the patient plays, (2) wearable sensors that measure the patient's physiological state, (3) algorithms for conversion of these sensor signals into a stress level estimation of the patient, (4) algorithms to modify the gameplay based on the stress level estimate. The authors have used the Frozen Bubble game for developing the biofeedback game in their proposed method. Different wearable sensors were used to measure the 3 different biofeedback modalities. AgCl electrodes and shimmer sensor was used to monitor the electrodermal activity of the patient which

is a reflection of the skin surface conductance variations produced by sweat gland activation. A bioharness BT chest strap sensor was used to measure both the heart rate variability and the respiration signal.

The authors conducted experimental trials on 25 participants to measure the efficiency of their game biofeedback method in producing relaxation and facilitating skill transfer. Their experiments had four different phases: (1) In phase 1 the patients were instructed to breathe at a certain slow rate for 2 minutes while listening to an audio signal. This data served as a baseline for the 3 biofeedback modalities. (2) Phase 2 served as a pretest that provided the data on the patient's response to stress before the treatment by making the patients perform a modified CWT (Stroop color word test) for four minutes. (3) In Phase 3 the treatment procedures were followed. The patients were divided into five groups: three groups (EDA-GBF, HRV-GBF, BR-GBF) who played three different biofeedback games which were given feedback by the corresponding bio-feedback modalities, a group (GO) playing a game with no feedback, and another group (DB) that didn't play a game but received guided deep breathing treatment. (4) Phase 4 served as a posttest to examine the transmission of relaxation skills where patients were asked to take the CWT for four minutes.

c. Results:

The authors did an analysis of the BR, HRV, EDA data during the pretest phase, treatment phase, and posttest phase to evaluate the efficiency of the five methods aimed at teaching relaxation skills. On comparing the breathing rates during the treatment phase and the pretest phase the authors found that (1) DB and BR-GBF groups experienced lower breathing rates during treatment (2) HRV-GBF and EDA-GBF groups had a slight decrease in breathing rates during treatment (3) GO group had a slight increase in their breathing rates during treatment. When the authors compared the posttest results, they found only that patients in BR-GBF and DB groups still had low breathing rates as compared to the pretest phase. This suggested that the deep breathing skill had been transferred in these 2 groups but not in the other groups. The lowering of breathing rates was more profound in the patients of the BR-GBF group than in the patients of the DB group suggesting that the relaxation skill transfer was lesser in the DB group. EDA-GBF and HRV-GBF groups didn't have a significant difference in the pre test, treatment, and post test phases and the patients in the GO group had higher values both during treatment and post test phases.

These results were a clear indication that the breathing based game biofeedback is more efficient in lowering stress during treatment and post treatment transference of relaxation skills than the other four methods used. This also suggests that the physiological characteristics that a patient can directly influence provide more aid in the learning of stress regulation skills in biofeedback games as breathing rate (BR) could be directly controlled by the patients as compared to the other 2 biofeedback modalities (EDA and HRV).

2. CRITIQUE:

a. Pros:

- i. Mental stress is a global concern and many individuals from kids to old people suffer from this. Their solution that allows individuals to practice stress reduction on their own will help people of all ages.
- ii. Professional therapy sessions are time-consuming and demand professional guidance that leads to patients leaving their therapy sessions. The adaptive biofeedback game solution can be used by the patient at any time without any professional guidance making it highly accessible and easy to use.

- iii. Professional therapy sessions are costly whereas the solution described in this paper is not that expensive.
- iv. Modern biofeedback and other techniques to reduce stress are taught in low-stress situations to the patients whereas these skills are necessary for high-stress situations. These situations can somewhat be simulated by the video-games.
- v. The gameplay is changed based on the feedback of the patients' physiological conditions. By doing that, the games make the stress management training engaging by removing the patient's need to monitor their stress levels and by allowing them to focus entirely on the game itself.
- vi. The authors have conducted a thorough study of the previous research in this domain which has provided a strong base for their work in this paper

b. Cons:

- i. Although the video-games aim to simulate high-stress situations for the patients, they can never come close to the real-life stressful situations that a person faces in his day-to-day life.
- ii. The number of participants in the experiment was very less.
- iii. More research on finding different biofeedback modalities that are highly indicative of stress can be carried out. Out of the 3 biofeedback modalities used; one is not a direct indicator of stress (breathing rate) and another is a partial indicator of stress (heart rate variability).
- iv. Modern methods of biofeedback training provide an accurate indication of the stress levels of an individual by displaying them visually whereas the stress levels indications in their game are not visible which may be necessary to monitor at times.
- v. Attaching wearable sensors to a user's body is not always practical, instead, the games can make use of computer vision to figure out the stress levels of an individual from his/her facial expression.

3. FOLLOW UP:

- a. Research can be done on identifying more biofeedback modalities that are a direct indicator of stress. This would indirectly lead to an increase in the quality of the stress reduction teaching techniques.
- b. Instead of using wearable sensors to monitor a patient's physiological conditions, computer vision techniques can be used to get an approximation of the stress levels from the patient's facial expressions.
- c. Experiments can be conducted after providing the proper instructions to the participants on which bio-feedback modality is controlling the game and how to regulate it via different techniques instead of only using deep breathing.
- d. The same research can be carried out using different types of games or other kinds of engaging tasks to evaluate and find which type of game or task works the best for stress management.