Stress Reduction through Computer Games utilizing EDR

Sue Saunders, Fred Cummins, Gary Mc Darby, Daragh Mc Donnell

Department of Computer Science and Informatics
University College Dublin
Vyro Games Ltd

Abstract. This study explores the efficacy of computer games that are designed to reduce stress. The three games studied (Vyro Games) use changes in electrodermal response (EDR) to regulate game progress. We first ascertained that the EDR measurement was stable and reliable across subjects. Subjects then completed a series of tasks, and game completion time in one game (Relax and Race) was used to evaluate both rises in stress levels (after playing Tetris), and reduction in stress level (after playing two other EDR-based games). One of the two EDR-based games (The Loom) was found to be effective in lowering stress. Results for the other (Storm Chaser) were inconclusive. Small numbers of participants limit the present study, but it suggests that EDR-based game control may be effective in both monitoring stress levels, and as an active intervention to lower stress.

Keywords: Stress, Computer Games, Electrodermal Response, EDR, Vyro Games

1   Stress and the use of Biofeedback

1.1   The Stress Response

The term 'stress', as it is currently used, was first coined by Hans Selye [1] who defined it as 'the non-specific response of the body to any demand for change'. Stress is experienced when an individual undergoes change which results in having too many or too few challenges in life i.e. *not enough* or too many demands (emphasis supplied). [2] In a world characterised by rising unemployment and budget cuts, growing numbers of individuals are now experiencing increased stress due to unemployment, or due to increased demands and insecurity.

Against this background, physical and psychological problems associated with stress are increasing [3]. Psychological health problems lead to physiological changes in the body, resulting not only in illnesses such as hypertension and coronary heart disease, backache, headaches, but also in psychological problems such as anxiety disorders,

anger and depression.[4], [5] These problems are an important health and social issue and the cost to health services of managing stress-related illness is considerable. [6], [7]

In this study we examine the use of computer game technology as an aid to stress reduction. Stress-reduction techniques are not generally taught in our educational institutions, and as a consequence, stress reduction skills are determined arbitrarily. Often it is only as a result of physical or psychological problems that attention is focused on strategies for lowering stress levels.

Lifestyle and environmental issues, along with the individual's inability to manage anxiety, are the main causes of stress. Any perceived threat activates the 'fight or flight' system in the body, and the consequent increase in adrenaline and cortisol secretion cause the physical symptoms of heart racing, sweating, dry mouth and so on. [8] These automatic reactions are controlled by the Autonomic Nervous System (ANS). The ANS is divided into two subsystems - the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS).

The SNS is responsible for the excitation of the ANS. The PNS is complementary, serving to relax the ANS.[9] If we consider the SNS as 'fight or flight', then the PNS may be regarded as 'rest and digest'. This 'rest and digest' response promotes calming of the nerves, coupled with a return to regular function. The SNS and PNS work together to maintain homeostasis, a dynamic equilibrium in which continuous changes occur, yet relatively uniform conditions prevail. [10]

Short-term relaxation strategies can prevent the build-up of stress to unmanageable levels. These strategies, outlined by Lichstein, [11] are variations of meditative practices, and they include techniques such as autogenic relaxation, progressive relaxation and meditation. The difficulty with these strategies is that they are time-consuming and they require the individual to be aware of their own stress levels, and this often occurs only after stress has built up to a high level.

A method of becoming aware of unconscious bodily processes such as stress is biofeedback. [12] It has been used since the 1960s and has been shown to be effective in gaining control in these circumstances.[13] Biofeedback makes the invisible visible through using instruments to measure and amplify feedback on physiological information. The primary goal of biofeedback is psycho physiological self regulation, the process of learning and employing emotional, mental, and physiological skills and strategies to attain self-regulation of internal autonomic states. The feedback of information facilitates this learning, as with any acquired skill.[14]

In itself, the monitoring of bodily responses does not assist an individual. However, it can increase the awareness of the level of arousal of the ANS and this awareness can create valuable insights, allowing more control of bodily functions. It has been found to be very effective in assisting individuals with certain problems.[15] Biofeedback technology has been shown to be effective in many disorders such as irritable bowel syndrome or incontinence.[14] Stress reduction through biofeedback has also been shown to be effective with business managers.[16]

A recent technological development has been 'Affective Computing', a term coined by Rosalind Picard.[17] She describes 'affective computing' as: 'computing that relates to, arises from, or deliberately influences emotion or other affective phenomena'.[18] Picard's research investigates areas of human computer interaction (HCI) and she has developed novel ways for individuals to monitor and communicate affective (i.e. emotional) cognitive states. One of the methods used by Picard's research is biofeedback through electrodermal response (EDR).

An EDR machine is a device that measures sweat gland activity and calculates the electrical resistance across the skin, which is then used to monitor increases in ANS arousal. The changes are caused by the activity of the individual's sweat glands. The triggering of the SNS (stress response) increases the stimuli to the sweat glands and lowers the skin's resistance accordingly.[19], [20], [21], [22] So, as the individual relaxes, their skin will become dryer and the skin's electrical resistance will increase.[23] Conversely, as stress levels increase the skin sweats and the resistance decreases.[19], [24]

1.2   Study Rationale

Motivated by these recent advances and an interest in the benefits of stress reduction, it was decided to investigate the effectiveness of biofeedback through the measurement of EDR for stress reduction. It was also decided that an accessible medium be used.

Focus was confined to biofeedback through gaming. The games selected were developed by Vyro Games: 'Relax and Race' and 'Storm Chaser', both for use on mobile phone, and 'The Loom', a PC based game. The advantage of using mobile technology for this purpose is its very accessibility as it is a more popular medium than PCs worldwide; they are cheaper than PCs, and are also more numerous and more widely used.

Providing biofeedback to mobile phone technology and incorporating gaming and visual display was thought to promote a more engaging experience for the user, thus increasing the likelihood that the application would be used more often.

An initial exploration by interested individuals gave positive results and the practical application and benefit of such games was readily identified and added to the motivation for the study. A further motivation for this study was the accessibility of these games to children, who again responded favourably and enthusiastically. This was deemed significant as children represent a cohort of the population particularly difficult to treat with other stress reduction techniques.

2   Method

A number of games which use biofeedback as input have been developed by Vyro Games. The purpose of these games is stress reduction.[25] The biofeedback data is

gathered through EDR by using a PIP (personal input pod. See Figure 1a). This is then transmitted to a mobile phone using Bluetooth technology.
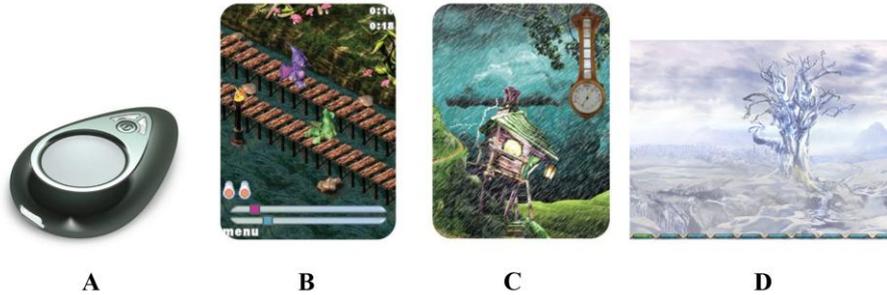

| A | B | C | D |

Fig. 1.. (a) PIP (Personal Input Pod), (b) Relax and Race, (c) Storm Chaser and (d) The Loom

'Relax and Race' [26] is a competitive racing game in which the player is represented by a small green dragon. The dragon has three modes (walk, run and fly), with each mode being faster than the preceding one. As the player relaxes, the dragon progresses through a series of movements: walking, running and finally flying. Should the player become stressed, the dragon will slow down. Therefore, the player who relaxes most wins the race. In the single-player version, the player competes against a 'ghost dragon' representing his most recent best score so that he can 'compete against himself' and improve his relaxation over time. Winning the race provides a motivating reward for achieving a relaxed state. Competitive games are associated with stress, so the player learns how to override this tendency.

'Storm Chaser' is a single-player game which commences with a visual scene of a small house in a violent storm. The objective of the game is to 'calm the storm'. This is achieved via learning to relax and use of PIP. As the player relaxes, the storm calms through four stages, until finally the house is in sunshine and birds are singing.

'The Loom' is similar to Storm Chaser, and is currently run on a PC. The game begins with an image of a frozen snow covered scene. As the user relaxes, the snow and ice in the image begin to melt; the scene then moves through spring and summer until, finally, it becomes a sun drenched rustic scene.

2.1   Stability

As stated above, the three selected games have different designs. Relax and Race includes a competitive element and is timed. It completes within two minutes as this is the maximum time the dragon takes to complete the track. The dragon slows down if the player is stressed, but does not stop or go into reverse. Storm Chaser operates differently: if the player relaxes the storm will abate, whereas if the player initially relaxes and then becomes stressed the storm begins to build up again, and the player may revert back to the starting position. It can be completed within two minutes, but can also take considerably longer. The Loom takes longer to play, (minimum

approximately 8 minutes) and although it doesn't reverse if the player gets stressed, it can stop at a point and not progress and as a result playing times is increased.

Based on the game's structure it was decided that for the purposes of the experiment Relax and Race would be used as a measure and Storm Chaser and The Loom would be used as interventions.

2.2   Pre Experiment Stability Tests

An initial test was carried out to establish the stability and reliability of Relax and Race. This was conducted with 4 individuals over 10 consecutive days. Each subject used the games daily on waking in order to approximate as similar circumstances as possible i.e. same time of day, same mood etc. The daily game time results were recorded and when analysed stability was established.

The variance per subject ranged from 2.2 to 5.8, whereas the variance across all samples was 11.7. The variance across subjects for a given day ranged from 8.5 to 29.6. Clearly, it is evident that Relax and Race is a stable measure for a subject and it continued to accurately measure the difference across subjects.
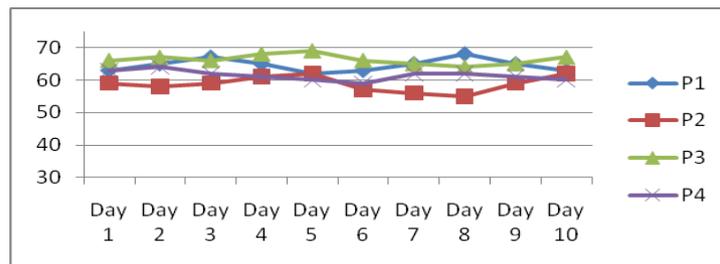

Fig. 2. Relax and Race Stability Test

2.3   Experiment Design

Thirty adult volunteers interested in stress reduction participated in the study (16 male, 14 female, ages 18-60). Each individual participated in a 30 minute trial. The questionnaire and health form was used to determine the experience of the participants of playing computer and mobile phone games and to determine if there were any underlying heart problems which would exclude them from undergoing the test. The GAD 7 (Generalised Anxiety Disorder) [27] form was selected to measure the current state of anxiety or stress experienced by the participant.

The apparatus involved was a sphygmomanometer to measure blood pressure and pulse rate, a PIP (Personal Input Pod) for use with Vyro games, a laptop and a mobile phone both with Vyro game software installed.

The data collected for each participant was blood pressure, pulse rate, GAD 7 form and health and experience questionnaire. The popular computer game 'Tetris' was used as a potential stressor, Relax and Race was used a measurement, and Storm Chaser and The Loom were used as interventions. A cognitively stimulating task of a maze puzzle was used as a control.

The participants were asked to complete all forms and blood pressure and pulse readings were taken. When it was confirmed that there were no excluding factors, each participant played Relax and Race (R&R1) and the time was recorded. They then played Tetris for 2 minutes followed by another Relax and Race (R&R2) game. The participants were then divided into three random groups as follows:

- Group A: n=10 Mobile Phone Game 'Storm Chaser' (approx duration 2 minutes)
- Group B: n=10 played using PC Game 'The Loom' (approx duration 12 minutes)
- Group C: n=10 completed the maze puzzle (approx duration 2 minutes)

This was then followed by another Relax and Race game (R&R3). An informal interview was conducted and the comments on the subjective effectiveness and appeal of the game were recorded.

3   Results

The data collected was analysed and the following results were obtained. The GAD7 scores and the first Relax and Race game (R&R1) scores were correlated and analysis showed no significant correlation between the two scores ($P<0.2$). There was also no correlation between pulse rate and R&R1 ($P<0.3$). Correlation with age also shows no significance: (p-value <0.3), and correlation with sex showed no significance either (p-value < 0.2).

However the correlation between blood pressure measurements systolic (BP1) and diastolic (BP2) and R&R1 showed that there was a significant correlation ($P< 0.002$ and $P< 0.006$ respectively).

A correlation also exists between the Relax and Race scores before and after playing Tetris (R&R1 and R&R2), showing a significant correlation ($P<0.007$). This suggests that Tetris had the effect of stressing the majority of people.
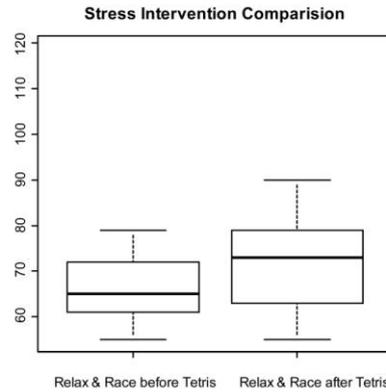
Fig. 3. Comparison Relax & Race Scores Before and After 'Tetris'

Paired comparisons were made between the interventions Storm Chaser and The Loom, and these showed no significance. Comparison between the maze puzzle (control) and Storm Chaser were marginally significant, $t(9.6)=-2.3$, $p<.04$, which is no longer significant after Bonferroni correction for multiple comparison.

Whereas the paired comparison between the maze puzzle (control) and The Loom showed a strong significance $t(15.9)=-6.4$, $p<.001$, which remains significant after Bonferroni correction for multiple comparisons.
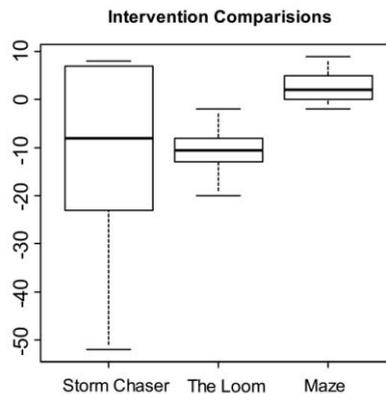

Fig. 4.. Comparison Storm Chaser, The Loom and Maze

4   Discussion

Our results confirm that biofeedback in the form of EDR in combination with software applications can be effective in reducing stress. The results suggest that the design of the application along with the mode of delivery seem to be of significance.

These results are important, not only in that they support the hypothesis that technology can be effective in stress reduction, but also in that they can provide an alternative method of relaxation for those individuals who are predisposed to using technology. The results for The Loom application suggest that the slow rate of change of the image and the time required completing the game, supporting the individual to get into a meditative relaxation. The mobile phone game Storm Chaser, which is of shorter duration and has less relaxing imagery may not be as effective.

Our findings replicate the results found by Allen et al [16] in their studies on the effects of biofeedback on business managers. They included EMG biofeedback and self reports, (our study uses EDR) and they found there to be a positive effect.

Baldwin's study of biometrics [28], [29] report similar results and replicate the findings of the efficacy of biofeedback for 'any physiological process that responds to stress'. [15]

In contrast a study by Sharry [30][25] consisted primarily of a single case study with the Relax to Win (a PC version of the Relax and Race game) and found it to be effective only as part of a broader therapeutic intervention.

Yucca et al [26] confirmed that the accessibility and portability of biofeedback was an important consideration in determining efficacy and although not specifically investigated in this study these aspects could be interesting for future research. Wilkinson's research [31] into online gaming for therapeutic purposes also confirms the importance of accessibility and gratification in the effectiveness of these media.

The findings may point to time duration being an important variable with regard to relaxation, that a minimum time interval is required to show significant effects of the games. An interesting exercise would be to compare Storm Chaser and The Loom, but ensure that the participants used the games for the same period of time. So the repeated use of Storm Chaser and The Loom for a set time period, e.g.15 minutes may clarify the time variable. Another variation could be a comparison of the effect of the game interventions on the same individual. The significance of The Loom may also be due to the difference between the technology platforms, with the PC giving a more immersive experience.

Some obvious limitations of this study are the small number of participants (n=10) and the fact that measurements were taken after the first attempt at playing the game. It would be valuable to repeat this study with individuals who are given a training period with the game so that they not only familiarise themselves with the operation of the game, but also that any performance anxiety experienced by the participants would be minimised.

In this study we used only healthy subjects to minimise confounding variables. Future research could include testing subjects with higher GAD scores or participants with a diagnosis of General Anxiety Disorder or other mental health difficulties associated with anxiety e.g. panic disorders, phobias, post traumatic stress disorder etc.

Stress is a common experience for all of us, and certain interventions may positively affect our ability to manage the inevitable stress of everyday life. Healthcare practitioners need to be aware of not only the risk factors of stress but also the numerous effective methods available for assisting in managing it. These methods, while not experienced as particularly attractive to some, may have immediate appeal and effect on the younger more technologically savvy section of the population and as a result have positive consequences for both themselves and those in their environment. Those individuals suffering from mental health difficulties could benefit from more collaborative efforts between the psychotherapeutic profession and the engineering community in developing applications and interventions that assist individuals in acquiring new skills in psycho-physiological maintenance.

References

1. Selye, H.: A Syndrome Produced by various Noxious Agents. Nature, **138** (1936) 32-33

2. Lupien, S., Maheu, F., Tu, M. et al.: The Effects of Stress and Stress Hormones on Human Cognition: Implications for the Field of Brain and Cognition. Brain Cogn., **65** (2007) 209-237

3. Lupien, S. J., McEwen, B. S., Gunnar, M. R. et al.: Effects of Stress Throughout the Lifespan on the Brain, Behaviour and Cognition. Nature Reviews Neuroscience, **10** (2009) 434-445

4. Ellis, B. J., Jackson, J. J., Boyce, W. T.: The Stress Response Systems: Universality and Adaptive Individual Differences. Developmental Review, **26** (2006) 175-212

5. Ellis, B. J., & Boyce, W. T.: Biological Sensitivity to Context. Current Directions in Psychological Science, **17** (2008) 183-187

6. Cohen, S., Tyrrell, D. A. J., Smith, A. P.: Negative Life Events, Perceived Stress, Negative Affect, and Susceptibility to the Common Cold. J. Pers. Soc. Psychol., **64** (1993) 131-131

7. Cohen, S., Tyrrell, D., Smith, A. P.: Psychological Stress and Susceptibility to the Common Cold. Psychosocial Processes and Health: A Reader, (1994) 171

8. Garcia-Leal, C., Parente, A. C. B. V., Del-Ben, C. M. et al.: Anxiety and Salivary Cortisol in Symptomatic and Nonsymptomatic Panic Patients and Healthy Volunteers Performing Simulated Public Speaking. Psychiatry Res., **133** (2005) 239-252

9. Benson, H., & Klipper, M. Z.: The relaxation response. Harper Paperbacks (2000)

10. Fox, S. I.: Human physiology,. 5th edn. edn. William C Brown (1996)

11. Lichstein, K. L.: Clinical relaxation strategies. Wiley New York (1988)

12.	Fuller, G. D.: Biofeedback: Methods and procedures in clinical practice. Biofeedback Press San Francisco (1977)

13.	Gatchel, R. J., & Price, K. P.: Clinical applications of biofeedback: Appraisal and status. Pergamon (1979)

14.	Basmajian, J. V.: Biofeedback: Principles and practice for clinicians. Williams & Wilkins (1989)

15.	Yucha, C., & Gilbert, C.: Evidence-Based Practice in Biofeedback and Neurofeedback. Wheat Ridge, CO: Association for Applied Psychophysiology and Biofeedback, (2004)

16.	Allen, J. K., & Blanchard, E. B.: Biofeedback-Based Stress Management Training with a Population of Business Managers. Appl. Psychophysiol. Biofeedback, **5** (1980) 427-438

17.	Picard, R. W.: Affective computing. The MIT Press (2000)

18.	Picard, R.: Affective Computing. **2010** (2010)

19.	Critchley, H. D.: Electrodermal Responses: What Happens in the Brain. Neuroscientist, **8** (2002) 132

20.	Critchley, H. D., Melmed, R. N., Featherstone, E. et al.: Volitional Control of Autonomic Arousal: A Functional Magnetic Resonance Study. Neuroimage, **16** (2002) 909-919

21.	Critchley, H. D., Wiens, S., Rotshtein, P. et al.: Neural Systems Supporting Interoceptive Awareness. Nat. Neurosci., **7** (2004) 189-195

22.	Critchley, H. D., Elliott, R., Mathias, C. J. et al.: Neural Activity Relating to Generation and Representation of Galvanic Skin Conductance Responses: A Functional Magnetic Resonance Imaging Study. J. Neurosci., **20** (2000) 3033-3040

23.	Yamamoto, Y., & Isshiki, H.: Instrument for Controlling Drowsiness using Galvanic Skin Reflex. Medical and Biological Engineering and Computing, **30** (1992) 562-564

24.	Critchley, H. D.: Neural Mechanisms of Autonomic, Affective, and Cognitive Integration. J. Comp. Neurol., **493** (2005) 154-166

25.	Vyro Games: Personal Input Pod - A Revolution in Stress Management. **2010** (2007)

26.	Sharry, J., McDermott, M., Condron, J.: Relax to Win Treating Children with Anxiety Problems with a Biofeedback Video Game. EISTEACH, **2** (2003) 22-26

27.	Spitzer, R. L., Kroenke, K., Williams, J. B. W. et al.: A Brief Measure for Assessing Generalized Anxiety Disorder: The GAD-7. Arch. Intern. Med., **166** (2006) 1092

28.	Baldwin, T., Christodoulou, A., Gillenwater, C. et al.: Click/Talk/Touch/Look/Think here: User Interface with Virtual Space. (2007)

29.	Fogg, B.: Persuasive technology: Using computers to change what we think and do. 2003. San Francisco: Morgan Kaufmann Publishers (2003)

30.	Fletcher, R., Dobson, K., Goodwin, M. et al.: ICalm: Wearable Sensor and Network Architecture for Wirelessly Communicating and Logging Autonomic Activity. submitted to IEEE Transactions on Information Technology in Biomedicine, (2009)

31.	Wilkinson, N., Ang, R. P., Goh, D. H.: Online Video Game Therapy for Mental Health Concerns: A Review. Int. J. Soc. Psychiatry, **54** (2008) 370