EEG, HRV and Psychological Correlates while Playing Bejeweled II: A Randomized Controlled Study

Article *in* Studies in health technology and informatics · February 2009

Source: PubMed

3 authors, including:

Carmen Russoniello
East Carolina University
57 PUBLICATIONS **423** CITATIONS
SEE PROFILE

Kevin O'Brien
East Carolina University
96 PUBLICATIONS **2,343** CITATIONS
SEE PROFILE

Annual Review of Cybertherapy and Telemedicine

Volume 7 Year 2009 ISSN: 1554-8716

Advanced Technologies in the Behavioral Social and Neurosciences

Editors:
Brenda K.Wiederhold, PhD, MBA, BCIA
Giuseppe Riva, PhD, MS, MA

Interactive Media Institute

EEG, HRV and Psychological Correlates while Playing Bejeweled II: A Randomized Controlled Study

Carmen V. RUSSONIELLO[a,1], Kevin O'BRIEN[a] and Jennifer M. PARKS[a]
[a]*East Carolina University, Greenville, NC, USA*

Abstract. Stress related medical disorders such as cardiovascular disease, diabetes, depression, and anxiety are serious medical issues that can cause disability and death. Interventions to prevent their development and exacerbation are needed. Casual video games (CVGs) are fun, easy to play, spontaneous and tremendously popular. People report that they play these games because they decrease their stress and improve their mood. This study tested this theory by comparing people playing Bejeweled II a popular CVG with control subjects measured under similar conditions. Electroencephalographic (EEG) changes after playing Bejeweled II were consistent with increased mood and corroborated with similar findings on psychological reports. Moreover, heart rate variability (HRV) changes consistent with autonomic nervous system relaxation or decreased physical stress were also recorded. It is concluded, therefore, that playing a CVG like Bejeweled II can increase mood and decrease stress. These finding have broad implications and include the potential development of prescriptive interventions using Bejeweled II to prevent and treat stress related medical disorders. Finally, these findings demonstrate a method using EEG, HRV and psychological correlates to understand the psychophysiological or cybernetic interconnection between participant and video game.

Keywords. Bejeweled II, casual video games, electroencephalography (EEG), heart rate variability (HRV), physical stress, mood.

Introduction

Approximately 9.5 percent of the U.S. adult population has a mood disorder[1]. Stress related medical disorders such as cardiovascular disease and diabetes are major causes of disability and death in the United States[2]. Cost effective preventive interventions that improve mood, decrease stress and are self-motivating are in immediate need. Casual Video Games (CVGs) are games considered fun, quick to access, easy to learn, and require no previous special video game skills, expertise, or regular time commitment to play[3]. CVGs are extremely popular with estimates that they are now a 55 billion dollar per year industry[4]. When surveyed CVG players often indicated they played to reduce stress and improve their mood. To test this hypothesis we measured changes EEG,

[1] Corresponding Author: Ph.D., Psychophysiology Lab and Biofeedback Clinic: East Carolina University, Belk Building Suite 2501, Greenville, NC 27858: USA; E-mail: russonielloc@ecu.edu.

HRV and psychological correlates pre and post video game play and compared the results to a control group. The level of significance was set at $p<.05$.

1. Methods

The purpose of the study was to determine whether playing a specific CVG called Bejeweled II (BJW II) could improve mood and/or decrease stress. Bejeweled II (BJW II) is a matching, sequencing game where participants string together like jewels for points. In this study we tested the hypothesis that playing Bejeweled II would produce physiological and psychological changes consistent with increased mood and decreased physical stress. Sixty-nine (n=69) participants were randomized into either a control group or BJW II. Conditions for both groups were identical except instead of playing video games the control group was instructed to surf the internet looking for articles related to health and to put them into a file on the computer desktop. Participants completed psychological assessments and then opened an envelope that indicated their group assignment. Both Bejeweled II play and control Internet activity lasted 20 minutes.

2. Results

EEG monitoring was used to determine mood changes and followed a standard protocol for collection of alpha brain waves[5]. It was hypothesized that playing casual video games would result in decreases in left frontal alpha brain waves which would be indicative of improved mood [6, 7,8]. Results outlined in table 1 illustrate that playing Bejeweled II did indeed change brain waves towards a more positive mood when compared to controls. Experimental participants also reported a significant improvement in mood on Profile of Mood States[9] (POMS) assessment. The pre-post game reductions in total disturbed mood compared with the control group are presented in table 1. Changes in individual POMS variables were as follows: Tension significantly decreased after Bejeweled II (p=.000) but did not significantly differ from control; Depression significantly decreased pre-post Bejeweled II (p=.002) but also did not significantly differ from control. Positive changes in Anger; Vigor; Emotional Fatigue and Confusion were all significant when compared controls.

Table 1.POMS Variables

	md	se	df	p
Left Alpha Changes	†Significantly differs from control p=.032			
Control (n=26)	.985	1.5	30	.503
Bejeweled II (n=32)	-3.3	1.3	31	.014+
Reduction in Disturbed Mood	†Significantly differs from control p=.009			
Control (n=31)	-2.6	2.4	30	.284
Bejeweled II (n=38)	-11.3	2.2	37	.002+
Reduction in Anger				
Control (n=31)	-.77	.56	30	.169
Bejeweled II (n=38)	-2.2	.5	37	.000+
Increases in Vigor	†Significantly differs from control p=.007			
Control (n=31)	-1.4	.80	30	.080
Bejeweled II (n=38)	1.5	.72	37	.037

Decreases in Emotional Fatigue	Differs from control p=.053			
Control (n=31)	-1.4	.53	30	.010
Bejeweled II (n=38)	-2.8	.48	37	.000[+]
Decreases in Confusion	[†]Significantly differs from control p=.000			
Control (n=26)	.26	.46	30	.576
Bejeweled II (n=32)	-2.0	.42	37	.000[+]

Table 2. Heart Rate Variability Changes

Control (n=30)	md	se	df	p	B II (n=40)	md	se	df	p
HR	-.82	.61	29	.184		-1.6	.53	39	.003
TP	488	151	29	.002		394	130	39	.003
VLF	-106	100	29	.290		-198	87	39	.024
LFN	1.8	2.7	29	.521		5.8	2.4	39	.015
HFN	-1.7	2.7	29	.533		-6.3	2.3	39	.008
LF/HF	-.24	.30	29	.458		.60	.28	39	.034

Heart rate variability (HRV) reflects the state of sympathetic (stress, anxiety) or parasympathetic (relaxation, calmness) activation in the body[10]. HRV is considered a marker of cardiac activity and is of great interest to health care practitioners[11,12,13]. Participants who played BJW II experienced statistically significant decreases in ANS activity with corresponding increase in variables associated with positive cognitive engagement. Results are presented in Table 2.

3. Discussion

This study demonstrated that playing BJW II changes EEG brain wave activity consistent with enhanced mood. These changes along with the concurrent reports of improved mood indicated by scores on psychological tests support the hypothesis that playing BJW II improves mood. Significant changes in all HRV parameters were reported pre-post BJW II. Cohen's delta or d[14] was used to compare differences in HRV means in the BJW II and control groups relative to an assumed common variance. Results indicated very large changes pre and post BJW II including decreases in heart rate (d= 1.3), VLF (d= 1) and corresponding increases in LFN (d= 1.6) and LF/HF ratio (d= 1.2). These changes are consistent with a "more power with less effort" response also reported by researchers[15] as TP and LFN increases coupled with VLF activity decreases after the relaxation response and meditation exercises. The data supports the theory that BJW II decreases physical stress and increases efficiency in a manner similar to these self-regulation techniques.

The results of this study suggest a potentially important role for the use of games like BJW II in physical and psychological disorders such as diabetes and depression. Other interventions with similar inherent characteristics like meditation[16,17] and card/board games[18] have demonstrated positive stress reduction and mood elevating benefits when prescribed in clinical populations. Thus, protocols with prescriptive parameters need to be developed and tested against disorders such as depression to determine the efficacy of such an intervention in a clinical population. Moreover, the methods used in this study represent a much needed rubric to further understand unique responses of humans while playing video games and as such provides new

opportunities for researchers and clinicians to develop tools for diagnosing and treating various physical and mental disorders.

References

[1] National Institute of Mental Health. The Numbers Count: Mental Disorders in America. Retrieved from internet source: http://www.nimh.nih.gov/health/publications/the-numbers-count-mental-disorders-in-america.shtml on July 10, 2008.

[2] Center for Disease Control; National Center for Health Statistics: Classifications of Diseases and Functioning and Disability. Retrieved from Internet source http://www.cdc.gov/nchs/icd9.htm on February 1, 2009.

[3] JWT Works in Progress: Gaming 2008. Retrieved from internet source https://016fd0d.netsolstores.com/index.asp?PageAction=VIEWPROD&ProdID=4&gclid=CI_Pi-OfpJYCFR-uQAodCnKs7A on January 15, 2009.

[4] Casual Games Association. Casual games market report 2007. Retrieved form internet source http://www.casualconnect.org/newscontent/11-2007/CasualGamesMarketReport2007_Summary.pdf on January 15, 2009.

[5] R.J. Davidson, EEG Measures of Cerebral Activation: Conceptual and Methodological Issues, *International Journal of Neuroscience* **39** (1988), 71-89.

[6] R.J. Davidson, P. Ekman, C.D. Saron, J.A. Senuslis, W.V. Friesen, Approach-Withdrawal and Cerebral Asymmetry: Emotional Expression and Brain Physiology, *Journal of Personality and Social Psychology* **58** (2) (1990), 330-341.

[7] N.A. Fox, If it's not left, it's right: Electroencephalogram asymmetry and the development of emotion, *American Psychologist* **46** (1991), 863-872.

[8] P. Marshall, and N.A. Fox, Emotion, Regulation, Depression, and hemispheric Asymmetry. In Stress, Coping, Depression, Edited by Johnson SL, Hayes AM. Mahwah, NJ: Lawrence Erlbaum Associates, 2000.

[9] D.M. McNair, M. Lorr, and L.F. Droppleman, *Profile of Mood States*, San Diego: Educational Testing Service, 1981.

[10] Task Force of the European Society of Cardiology and the North American Society of Pacing and Electro physiology. Standards of measurement, physiological interpretation, and clinical use, *Circulation **93*** (1996), 1043-1065.

[11] A. Malliani, F. Lombardi & M. Pagani, Power spectrum analysis of heart rate variability: a tool to explore neural regulatory mechanisms, British Heart Journal **71** (1) (1994), 1–2.

[12] R.E. Kleiger, P.K. Stein, M.S. Bosner & J.N. Rottman, Time domain measurements of heart rate variability. *Ambulatory Electrocardiography* **10** (3) (1992) 487-498.

[13] B. Pomeranz, J.B. Macaulay, and M.A. Caudill, Assessment of autonomic function in humans by heart rate spectral analysis, *American Journal of Physiology*. **248** (1985), H151-H158.

[14] J. Cohen. *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum, 1988.

[15] C.K. Peng, I.C. Henry, J.E. Mietus, J.M. Hausdorff, G. Khalsa, H. Benson, and A.L. Goldberger, Heart rate dynamics during three forms of meditation, *International Journal of Cardiology* **95** (2004), 19-27.

[16] M. Speca, L.E. Carlson, E. Goodey, and M. Angen, A randomized, wait-list controlled clinical trial: The effect of a mindfulness meditation-based stress reduction program on mood and symptoms of stress in cancer outpatients, *Psychosomatic Medicine* **62** (2000), 613-622.

[17] T. Esch, G.G. Massimo, E. Bianchi, W. Zhu, and G.B. Stefano, Commonalities in the central nervous system's involvement with complementary medical therapies: limbic morphineric processes, *Medical Science Monitor* **10** (6) (2004), MS6-17.

[18] C.V. Russoniello, The effectiveness of prescribed recreation in reducing biochemical stress and improving mood in alcoholic patients, *American Journal of Recreation Therapy* **7** (3) (2008), 1-11.