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THE EFFECTIVENESS OF CASUAL VIDEO GAMES IN IMPROVING MOOD AND DECREASING STRESS

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Stress related medical disorders such as cardiovascular disease, diabetes and depression are serious medical issues that can cause disability and death. Techniques to prevent their development and exacerbation are needed. Casual video games (CVGs) are fun, easy to play, spontaneous and are tremendously popular. In this randomized controlled study we tested the effects of CVGs on mood and stress by comparing people playing CVGs with control subjects under similar conditions. Electroencephalography (EEG) changes during game play were consistent with increased mood and corroborated findings on psychological reports. Moreover, heart rate variability (HRV) changes were consistent with autonomic nervous system relaxation or decreased physical stress. In some cases CVGs produced different brain wave, heart rate variability and psychological effects. These finding have broad implications which include the potential development of prescriptive interventions using casual video games to prevent and treat stress related medical disorders.

Keywords. Casual Video Games, Electroencephalography (EEG), Heart Rate Variability (HRV), Psychological Mood

BACKGROUND

According to the Casual Video Game Association there are more than 200 million casual game players worldwide. Gamers from a multitude of cultures, ages, and lifestyles play electronic casual games using consoles, PCs and online communities, handhelds and mobile phones. One example of the popularity of casual video games can be found in the fact that Microsoft Solitaire for Windows is the most commonly opened application on Windows XP (Casual Games Association, 2008). Casual video games sometimes referred to as coffee-break or web games are a booming business that is expected to grow to $55 billion by 2009 (JWT Intelligence, 2006).

Casual video games (CVGs) defy a standard definition because of the diverse nature of the games. Instead the Casual Games Association, 2007 offers a functional definition that asserts that CVGs must be considered fun, quick to access, easy to learn, and require no previous special video game skills, expertise, or regular time commitment to play. CVGs are based around familiar game concepts that consumers played as children in arcades. They are usually easy to pause, stop and restart. Casual games are usually played in short increments at home and at work. Some people, however, play for hours on end (Casual Games Market Report, 2007).

According to anecdotal evidence and survey research, people play CVGs for varied reasons including cognitive exercise, fun, relaxation, and to reduce stress and improve mood. The Casual Games Association says CVGs are viewed as important in stress reduction during lunch or after work and CVG play has begun to replace TV in this respect. A survey of gamers conducted in 2006 (n= 2,191) revealed that casual game players (71% daily use) view CVGs as more important in their leisure time activities than TV, reading, or spending time with family and friends. The survey also found that 88% of respondents derived stress relief from playing. While casual gaming is popular among all groups they are particularly attractive to women over 30. Retired men and woman also represent a large group of casual gamers (Casual Video Games Association, 2007).

Stress and Health

A strong link between physical health and stress was established more than a quarter century ago when researchers

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noted that exacerbation of tumor growth occurred following acute exposure to uncontrollable stress (Sklar & Anisman, 1979; Sklar & Anisman, 1981). It was postulated that stress influenced neurochemical, hormonal and immunological changes which, in turn, exacerbated the tumor growth but the mechanisms were not well understood. Researchers exploring underlying causation began focusing on the physiology of emotional response to psychosocial stimuli adding to the understanding of how neurochemical, hormonal and immunological changes occur and contribute to dysfunction. These insights have led to the current theory on human reactions to stress now characterized as the "defense/fight or flight" and "defeat/immobilization" responses (Folcov, 1988). In this model limbic-hypothalamic patterns of response are integral and serve to protect a person from adverse stimuli by mobilizing biochemicals to aid in the response (Kudielka & Kirscbaum, 2007). Untoward stress or "distress" has a deleterious impact on people and can directly affect both psychological and physical conditions. If stress is not ameliorated it will contribute to the development and/or exacerbation of illness and disease (Sapolski, 2004).

The term allostasis relates to a person's ability to adapt to adverse stimuli (McKewen, 1998). Allostatic load is considered the neurochemical, hormonal and immunological costs of adapting to stress (Sternberg, 1997). The allostasis model consists of four different causes of allostatic load that require biological responses. 1. Frequent exposure to stress 2. Inability to habituate to repeated challenges 3. Inability to terminate a stress response and 4. Inadequate allostatic response (Webster, Tonelli & Sternberg, 2002). Under normal circumstances a person can manage their allostatic load. However too often the demands of life overwhelm a person's normal coping abilities and additional help is needed. Unfortunately, these self prescribed interventions often involve potentially devastating after effects i.e. the use of food, alcohol or drugs. Hence, people need to learn and practice healthy methods to decrease stress and improve mood.

Psychological experiences can cause or be caused by stress. Fear is a good example because it can be either real or imagined. The body reacts as if it were real regardless. This experience in turn influences immune function and ultimately the course of a disease. For instance, when a person encounters a stressful circumstance, cortisol increases turning up energy producing mechanisms, while inhibiting less essential functions. Specifically, cortisol has a significant effect on numerous processes including metabolism, fluid regulation, emotional and cognitive functioning and the immune system (Thayer & Sternberg, 2006). Researchers applying the Tier Social Stress Test for example, found cortisol levels increased two to three-fold in about 70-80% of subjects within 1 to 20 minutes after task demonstrating a link between a psychosocial task and allostatic response (Hjemdahl, 2002). When this short-term response is not curtailed through the hypothalamic-pituitary-adrenal (HPA) feedback loop or when the demand exceeds the person's capacity to respond, a number of changes occur which can sometimes lead to physical and mental illness (Adinoff, Iranmanesh, Veldhuis & Fisher, 1998).

Stress and Mood

Everyone at some point experiences sadness or the blues. There are multiple causes for these feelings including situational circumstances such as losing a loved one, a job or even by the weather which when wet and dreary can cause a condition known as seasonal affective disorder syndrome (SADS). Generally people will find social support, or a coping activity that help them to improve their mood. These activities vary from shopping to movies, exercise, and recreational activities. The growing use of CVGs may be directly related to their ability to assist in decreasing stress and improving mood without the potential negative side effects of other choices.

Depression is a clinical term used to describe extreme negative mood characterized by persistent sadness and impairment in functioning. According to the National Institute of Mental Health approximately 20.9 million American adults, or about 9.5 percent of the U.S. population age 18 and older in a given year, have a mood disorder. Major depression affects 14.8 million adults and is the leading cause of disability for ages 15-44. Dysthymic disorder affects approximately 1.5 percent of the U.S. population age 18 and older in a given year or 3.3 million American adults. The median age of onset of both disorders is approximately 30 years (National Institutes of Mental Health, 2008).

While individuals experiencing depression do not all exhibit the same symptoms or the intensity, frequency and duration there are commonalities that provide criteria to define the disorder and those are: persistent sad, anxious or "empty" feelings; feelings of hopelessness and/or pessimism; feelings of guilt, worthlessness and/or helplessness; irritability, restlessness; loss of interest in activities or hobbies once pleasurable, including sex; fatigue and decreased energy; difficulty concentrating, remembering details and making decisions; insomnia, early–morning wakefulness, or excessive sleeping; overeating, or appetite loss; thoughts of suicide, suicide attempts.

Stress and depression are inexorably intertwined. The combined effect has dramatic physical and psychological consequences. It is important therefore to develop and test new interventions to determine if they can decrease stress and/or improve mood. These interventions may eventually help people manage their allostatic load and help ameliorate symptoms of stress related medical disorders like cardiovascular disease and depression.

Preliminary evidence suggests that non-pharmacological interventions can help facilitate ANS and HPA balance and thereby decrease stress and improve mood. For example mindfulness-based stress reduction significantly improved quality of life, symptoms of stress and sleep in those with early stage breast and prostate cancer (Carlson, Speca, Patel & Goodey, 2003). When researchers measured cytokine changes they found that T cell production of IL-4 increased and IFN-y decreased. In addition, NK cell production of IL-10 also decreased, prompting them to conclude that there was a shift from one immune profile associated with depressive symptoms to a more normal immune profile. Using the same intervention another study reported an overall reduction in mood disturbance (65%) and a (31%) decrease in stress symptoms (Speca, Carlson, Goodey & Angen, 2000).

Other novel interventions like music have been shown to positively affect the immune system. Significant increases in secretory immunoglobulin-A (S-IgA) were found after listening to recorded, classical music (Abrams, 2001) and using music as a vehicle for relaxation, researchers found IL-6 levels were significantly lowered afterwards whereas IL-1b, Il-10 remained unchanged (Stefano, Zhu, Cadet, Salamon, Manitone, 2004). Esch and colleagues report that complementary and alternative medicine (CAM) therapies are important in producing ANS & HPA balance as well as positively impacting the immune response (Esch, Massimo, Bianchi, Zhu & Stefano, 2003; Esch, Fricchione & Stefano, 2004).

Recreational activities provide a wide array of health benefits and, as a result, have been used by humans since the beginning of recorded history for excitement, relaxation, fitness, sport, meditation and fun (O' Morrow, 1989). Among the numerous studied benefits are social interaction and physical activity(Wankel, L. M., & Berger, B. G. 1990), mental distraction (Wassman & Iso-Ahola, 1985), and laughter (Stone, 1992). In general, good things happen to people when they are having fun. Psychological constructs attempting to explain the benefits of recreation include a positive mental state coupled with a feeling of relaxation and being in balance. One psychologist called this hyper-focused state "flow," noting that participants in a variety of recreational activities consistently report positive mental outcomes (Csikszentmihalyi, 1997). The physiological processes that underlie the psychological balanced state known as flow are very important as knowledge of them will help with the understanding of these types of interventions but we are just beginning to see the connections.

A preliminary link between the HPA (hypothalamic-pituitary-adrenal) axis, mood and recreation has been established with decreases in cortisol and mood reported after therapist directed recreational activity (Russoniello, 1991; 2008). According to the findings of these studies, which involved adults being treated for acute alcoholism, recreational activities can decrease stress and improve mood. The findings revealed that plasma cortisol levels were significantly lowered after participation in low physical intensity board games/card games and produced an autonomic nervous system relaxation response. Casual video games have become the board and card games of today. Many are very similar to the board games of yesteryear, they are simply modernized for today's Internet based world. This study tested whether there would be a similar autonomic nervous system response while playing CVGs. If there is a consistent integrated positive HPA axis response while playing casual video games similar to board games then this poses the intriguing possibility of prescribing CVGs to ameliorate stress related medical disorders.

Formal research surrounding video gaming has been focused primarily on negative effects such as violence and addiction (Anderson & Bushman, 2001; Lee & Vessey, 2000; Clay &. Richards 2005; Funk, 2005; Wallenius, Punamäki & Rimpelä. 2007). There are just a few studies that mention positive effects of gaming such as a means to; develop social relationships (Hutchinson, 2007), facilitate education (Simpson, 2005) development skills and multi-tasking (Agosto, 2004). Little is known about the positive health effects of CVG play and even less about the physiological processes or health benefits that underlie participation.

METHODS

The purpose of the study was therefore to determine whether casual video games could improve mood and/or decrease stress in players using valid and reliable psychological and physiological measures. Specifically this study tested whether playing three popular casual video games; Bejeweled 2 (BJW 2), Bookworm Adventures (BWA) and/or Peggle (PGL) could change the autonomic and central nervous systems consistent with decreased stress and improved mood.

Subjects

One hundred and forty three (n=143) participants were recruited for the study and one hundred and thirty four (n=134) were included in the data analysis. Nine participants were excluded, as data was unsalvageable due to improper data collection (sensor came off, software was mistakenly not started). There were 57 females and 44 males. The average age of all participants was 24 years. Participants were recruited from fliers placed in and around the campus community. Most of the subjects were students, faculty members and staff at the university. The study was explained to the participants who signed an informed consent form before being included. Participants then supplied demographic information and completed the Profile of Mood States questionnaire. At this point, an envelope with random assignments was opened by the participants. This revealed their designated group. If assigned to the experimental group participants chose one of three casual video games to play. If assigned to the control group participants completed an Internet task that involved searching for articles on health related topics and placing them in a folder on the desktop.

Experimental participants chose which game that they wanted to play from three popular video games that met the functional definition of a CVG. BJW 2 is a matching, sequencing game where participants string together jewel-like objects for points. PGL is a pachinko/pinball type of game that allows participants to gain more control as they clear strings of multi-colored balls for points and BWA is a crossword/scrabble type puzzle game where participants gather points by building words and progress through an animated adventure. Once a game was chosen, sensors were connected and signals were checked, participants played the game uninterrupted for twenty minutes.

The control participants were seated in front of the same computer in the same chair and hooked to measuring equipment in the exact manner as the experimental group. The control group was then instructed to surf the internet looking for articles related to health and to put them into a file on the desktop for twenty minutes.

Measurement of Mood

It was hypothesized that playing casual video games would result in decreases in left frontal alpha power, increases in right frontal alpha power and overall alpha symmetry when compared to controls. Increases in alpha power in the left hemisphere are associated with negative mood, depression and avoidance/withdrawal behaviors. Conversely, decreases in left alpha power improve mood and decrease avoidance/withdrawal behaviors. Decreases in right hemisphere alpha power are also associated with negative mood. Conversely, increases in right alpha power improve mood and increase approach/engage behaviors. The ratio between right and left brain alpha has also been used to measure emotional stability/mental relaxation (Davidson, 1988: Fox, 1991 and Monastra, 2003).

Some therapies have been successful in helping people change dysfunctional brain activity associated with depression and stress to positive states associated with relaxation and alertness (Field, Grizzle, Scafidi, Abrams, Richardson, Kuhn, & Schanberg, 1996; Field, Grizzle, Scafidi, & Schanberg, 1996; Field, Ironson, Scafidi, Nawrocki, Goncalves, Pickens, Fox, Schanberg & Kuhn, 1996 and Marshall & Fox, 2000). In this study the effects of CVG play on mood were tested to determine if they would produce similar results using EEG measurements and following the alpha/mood assessment protocol established and tested by Davidson (1988). Changes in the CNS or alpha brain wave activity were recorded using a 10 channel electroencephalography device (Mind Media Corporation, 2008).

All participants were prepared by locating and marking F3, F4 and CZ using the 10/20 standard measurement cap. The sensor placement sites were cleaned using alcohol pads. Active EEG leads were placed at F3 and F4. The reference sensor was placed at CZ. The ground lead placed on C7. Signal impedance was kept below 25,000K Ohm per manufacturers recommendations for alpha recordings. In addition, the EEG signal was visibly inspected prior to recording for extraneous signal noise. If necessary, adjustments were made before data recording began.

PROFILE OF MOOD STATES

To quantify emotional changes participants completed a self-administered psychological assessment of mood using the Profile of Mood States (POMS) assessment. The POMS (McNair, Lorr & Droppleman, 1981), is a factor analytically derived inventory that measures six subscales: tension, depression, anger, vigor, fatigue, and confusion and can be used with "Last Week" and "Right Now" administrations. Internal consistency for the POMS has been reported at .90 or above. Test re-test reliability is reported between .68 and .74 for all factors. Construct and predictive validity have been established in four areas: brief psychotherapy, controlled outpatient drug studies, studies of response to emotional conditions and studies of concurrent validity coefficients and other POMS correlates (McNair, Heuchert & Shilony, 2003).

Measurement of Physical Stress

Heart Rate Variability (HRV) is a physiological measurement that directly reflects a balance of the autonomic nervous system regulation, which has control over the human body. HRV is a multidimensional measurement of sympathetic and parasympathetic nervous system innervations of the heart. HRV reflects the state of sympathetic (stress, anxiety) or parasympathetic (relaxation, calmness) activation in the body. Heart rate variability (HRV) is considered a marker of cardiac parasympathetic and sympathetic activity and is of great interest to health care practitioners (Malliani, Lombardi & Pagani, (1994); Kleiger, Stein, Bosner & Rottman, (1992); Pomeranz Macaulay & Caudill, (1985).

Heart rate variability (HRV) provides an accurate assessment of autonomic nervous system stress based upon variability in the inter-beat interval of heart beats (Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). A robust HRV is associated with balance between the sympathetic and parasympathetic branches of the autonomic nervous system (ANS). In this study HRV changes were used as a measure of ANS change (Hayano, Sakakibarea, & Yamada, Yamada, Mukai, Fujinami, Yokoyama, Watanabe & Takata, 1991). HRV was recorded during the entire session using a small ear clip sensor. Both time and frequency parameters of HRV were used to determine the effects of CVGs on the ANS.

HRV was recorded using photoplethysmography (PPG) technology. PPG was developed in the 1960's and 1970's by psychophysiology researchers. PPG is based upon the premise that all living tissue and blood have different light-absorbing properties. PPG works by placing a photocell clip on the participant's ear that converts light to electrical energy. The blood in the ear lobe scatters light in the infrared range, and the amount of light reaching the cell is inversely related to the amount of blood in the ear lobe. Hence, when blood vessels in the earlobe dilate, the increased blood flow allows less light to reach the photocell, when blood vessels constrict, blood flow is decreased and increased light reaches the photocell (Cohen, 1995).

PPG measures pulse volume or phasic changes, which are related to beat variations in the force of blood flow. These beat-to-beat changes in peripheral blood flow reflect the heart's interbeat intervals similar to ECG. PPG therefore, gives summary information reflecting both cardiac and blood vessel components and is an accurate measure of cardiac function when compared to electrocardiography (Cohen, 1995; Russoniello, Mahar, Rowe, Pougatchev & Zirnov, 2003).

STATISTICAL ANALYSIS

A repeated measures design was employed to study the impact of different games on the variables and to contrast with the control group. Since the experimental and the control group both did activities requiring similar physical and cognitive involvement, and the study was exploratory in nature, the level of significance was set at $p=<.1$. The least significant difference (LSD) was used for the post hoc analysis. Cohen's Delta or d (Cohen, 1988) is a measure of effect size or the standard mean difference. Cohen's d is a standard measure used to calculate treatment effect and describes differences in means relative to an assumed common variance. According to Cohen, effect size changes can be classified as: small (.20); medium (.50); and large (.80). In this study Cohen's d was used to show large changes otherwise not detected due to large variances.

RESULTS

Participating in CVGs produces changes in brain waves consistent with improved mood. Remarkably, different games affected brain waves in unique ways. For example BJW 2 players (Table 1) experienced significant decreases in left alpha power when compared to controls. Participants who played PGL experienced significant increases in right alpha power while playing (Table 2) but did not statistically differ from the control group due to very large variations in individual brain waves. Cohen's d, used to statistically equalize differences between groups (d= 1.8), illustrates there was a very large difference between PGL and control groups.

Table 1

Left Alpha Changes	md	sd	df	p
Control Group (n=22)	.99	1.5	25	.50
Bejeweled 2 (n=28)	-3.3	1.3	31	.014†

†Significantly differs from control p=.032

Table 2

Right Alpha Changes	md	sd	df	p
Control Group (n=22)	.427	10	21	.996
Bejeweled 2 (n=29)	17.9	9	28	.048

Table 3

Right/Left Alpha Ratio Changes	md	sd	df	p
Control Group (n=22)	.17	.19	21	.37
Bejeweled 2 (n=26)	.31	.19	25	.093†

†Significantly differs from control p=.071

Playing BWA significantly improved the right/left brain alpha ratio (Table 3) another indicator of improved mood and the changes were significantly different from control. All three games improved mood and affected alpha brain wave activity differently.

Changes in psychological mood reported on the POMS corroborated EEG findings as the overall impact of all three games significantly differed from the control group (p=.007). BJW, BWA and PGL pre-post game changes and comparisons with the control group are presented in (Table 4).

Table 4

Overall POMS Changes	md	sd	df	p
Control Group (n=31)	2.6	2.4	30	.284
Bookworm Adventures (n=29)	7.9	2.5	28	.000
Bejeweled II (n=38)	-11.3	2.3	37	.002†
Peggle (n= 36)	-14.9	2.3	35	.000††

†Significantly differs from control p=.009

†† Significantly differs from control p=.000

Individual POMS subscales, tension, depression, anger, vigor, fatigue and confusion changed as follows.

Participants reported significant decreases in POMS tension (Table 5) after each game. Overall, CVGs reduced tension versus control (p=.003). Participants that played PGL reported the largest decreases in tension.

Table 5

Changes in Tension	md	sd	df	p
Control Group (n=31)	-1.6	.70	30	.022
Bookworm Adventures (n=29)	-7.9	2.5	28	.005
Bejeweled II (n=38)	-11.3	2.2	37	.000
Peggle (n= 36)	-14.9	2.3	35	.000†

†Significantly differs from control p=.026

Participants reported decreases in the POMS Depression sub scale scores after all three games (Table 6). While none of the games statistically differed from the control, secondary analysis with Cohen's d revealed large decreases in depression scores after all three, PGL (d= 1.4); BWA (d= 1.2); BJW 2 (d= 1.1) games when compared with the control group.

Table 6

Changes in Depression	md	sd	df	p
Control Group (n=31)	-1	.58	30	.084
Bookworm Adventures (n=29)	-1.7	.59	28	.004
Bejeweled II (n=38)	-1.6	.52	37	.002
Peggle (n= 36)	-1.8	.53	35	.001

POMS Anger scores decreased after all three CVGs (Table 7). BJW 2 and PGL significantly differed from the control group. The reductions in anger are contradictory to the notion that all video games provoke violence.

Table 7

Changes in Anger	md	sd	df	p
Control Group (n=31)	-.77	.56	30	.169
Bookworm Adventures (n=29)	-1.0	.58	28	.076
Bejeweled II (n=38)	-2.2	.50	37	.000††
Peggle (n= 35)	-2.1	.53	34	.000†

†Significantly differs from control p=.084.
††Significantly differs from control p=.069.

The overall effect of all three CVGs and control in increasing vigor was statistically significant (p=.018). Individual games changes are presented in Table 5. Changes in vigor after playing BJW 2 were statistically different from the control group.

Table 8

Changes in Vigor	md	sd	df	p
Control Group (n=31)	-1.4	.79	30	.180
Bookworm Adventures (n=29)	-1.5	.72	28	.865
Bejeweled II (n=38)	-.14	.81	37	.037†
Peggle (n= 36)	-.34	.74	35	.643

†Significantly differs from control p=.007

The overall effect of CVGs on fatigue versus control was statistically significant (p=.061). Individual games changes are listed in Table 9. BJW 2 and PGL both had significant positive impacts on fatigue versus control.

Table 9

Changes in Fatigue	md	sd	df	p
Control Group (n=31)	-1.4	.53	30	.010
Bookworm Adventures (n=29)	-.18	.55	28	.001
Bejeweled II (n=38)	-2.8	.48	37	.000†
Peggle (n= 36)	-3.6	.49	35	.000††

†Significantly differs from control p=.053
††Significantly differs from control p=.003

The overall effect of all three games on confusion (Table 10) was statistically significant (p=.09). BWA, BJW 2 and PGL all significantly decreased confusion when compared with the control group. The improvement in cognition was very dramatic and begs the question of whether these games could assist in Alzheimers and other dementia type disorders.

Table 10

Changes in Confusion	md	sd	df	p
Control Group (n=31)	-.26	.46	30	.576
Bookworm Adventures (n=29)	-1.2	.48	28	.010†
Bejeweled II (n=38)	-2.0	.42	37	.000††
Peggle (n= 36)	-2.3	.43	35	.000††

†Significantly differs from control p=.025
††Significantly differs from control p=.000

PHYSICAL STRESS CHANGES

In this study the game BJW 2 had the greatest impact of all three games on physical stress. Participants who played BJW 2 experienced statistically significant decreases in ANS activity with corresponding increase in variables associated with positive cognitive engagement. All HRV parameters changed significantly when measured pre-post game play including TP (p. = 003). When compared to control participants BJW 2 players experienced 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 findings support the theory that some CVGs do decrease physical stress and presents a possibility that CVGs produce a "more power with less effort" ANS effect.

Table 11. 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
HF/LF	-.24	.32	29	.46		.6	.28	39	.034†

†Significantly differs from control (p= .051)

DISCUSSION

Changes in EEG recorded in this study support the hypothesis that playing a CVG of your choice can improve your mood and decrease your stress. Remarkably all three games had different yet complimentary mood lifting effects. BJW 2 decreased left alpha brain waves associated with a decrease in withdrawal and depressive type behaviors and PGL increased right alpha brain wave activity associated with excitement or euphoric behaviors. BWA on the other hand increased the stability of alpha brain waves between the left and right side of the brain.

The POMS scores on Total Mood Disturbance significantly changed for all three games supporting the theory that while there were effects on brain wave activity in different parts of the brain, the end result was improved perceived mood. Significant subscale changes in anger, tension, vigor, depression, fatigue and confusion by different games and not by others again seems to infer that there are specific changes associated, to a degree, with particular games and not so much with others. If these finding are consistently upheld then protocols with treatment specificity could be developed to take advantage of CVGs that produce specific results.

Changes in HRV during BJW 2 were consistent with a recent report by Peng, Henry, Mietus, Hausdorff, Khalsa, Benson, & Goldberger, (2004) in which they revealed that TP and low frequency norms increased while very low frequency activity decreased after the relaxation response and meditation exercises. When changes after BJW 2 were compared with the control group a similar "more power with less exertion" profile emerged, which provides a potential framework for future research.

Many modern medical disorders are stress related and the need for effective interventions that are low cost and help ensure compliance is high. The potential of CVGs to become an intervention is encouraged by the results of this study. Future studies can build upon this work by studying the impacts of CVG play on conditions such as depression, anxiety, autism, and stress related medical disorders such diabetes and cardiovascular disease.

The limitations of this study included a lack of measurement for respiration and the variability of physiological data which, in some cases, made it difficult to determine changes if they existed. In future studies blue tooth technology should be used to reduce lead noise. Respiration rate should be recorded to determine its impact on HRV variables. When possible neuroendocrine markers like cortisol or salivary amylase should be added to get a psychoneuroendocrine picture of changes.

Finally, psychophysiological measurement provides a method for understanding the mind/body effects of games and can therefore help in game modification and development. For instance while a person is being measured physiologically their reactions to different aspects of the game are recorded. These can be relaxing or stressed reactions or they can be excitement. Depending on the goal of the game a programmer could increase or decrease the amount of a certain variable (i.e. music, visuals etc.) to increase or decrease the effect. A game that is physiologically tailored to meet individual specific human needs seems plausible in the near future.

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