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Abstract

Although standard psychological treatments have been successful in treating several core features in eating disorders (ED), other characteristics such as emotional regulation or impulsivity appear to be more resistant to change. There is a growing body of evidence to support the efficacy of cognitive remediation for cognitive and emotional difficulties in ED. Playmancer/ Islands is a video game (VG) designed to specifically treat mental disorders, characterized by problems in impulse control. The objective of the game is to increase self- control over emotions, decision making and behaviours. The aim of this study is to describe the results from a consecutive series of nine bulimia nervosa patients who were treated with the VG in addition to cognitive behaviour therapy (CBT). The outcomes included clinical and psychopathological questionnaires, and physiological measures were obtained during the VG. Emotional regulation improved, heart rate variability increased, and respiratory rate and impulsivity measures reduced after the treatment. These findings suggest that VG training may enhance treatment for ED.

Keywords: eating disorders; bulimia nervosa; video game therapy; cognitive stimulation; impulsivity; executive functions; emotional regulation

Introduction

Although standard psychological treatments [i.e. cognitive behav- iour therapy (CBT)] have been successful in treating several core features in eating disorders (ED), in bulimic patients, the levels of abstinence attained are low, and several core characteristics are resistant to change (Aguera et al., 2012; Hay, 2013). For example, executive functioning and emotional regulation (i.e. self-control strategies, tolerance to frustration or impulsivity) are difficult to change and are associated with an adverse outcome (Alvarez-Moya et al., 2007; Fernandez-Aranda et al., 2006; Lejoyeux, Arbaretaz, McLoughlin, & Ades, 2002). On the other hand, the high level of brain plasticity in the prefrontal circuits (Duffau, 2006) associated with these functions suggests that they may be improved by training (Anguera et al., 2013). Training-induced increases in cortical activation are cor- relatedwith improvements in behavioural performance in other forms of disorder (Duffau, 2006; Schweizer, Meisel, & Marschenz, 2013).

Cognitive stimulation in the form of cognitive remediation therapy has been shown to improve cognitive difficulties in ED (Davies et al., 2012; Genders & Tchanturia, 2010; Pretorius et al., 2012; Pitt, Lewis, Morgan, & Woodward, 2010; Tchanturia, Davies, & Campbell, 2007). However, this therapy has been mainly oriented towards cognitive flexibility, set shifting, complex planning and problem solving in patients with anorexia nervosa (Davies & Tchanturia, 2005; Tchanturia et al., 2007). Impulsivity, which is more associated with binge eating, has not yet been taken into consideration in ED, although neuro-feedback and/or biofeedback have been found to increase physiological control and reduce symptomatology in some other disorders (Hallman, Olsson, von Scheele, Melin, & Lyskov, 2011; Vaschillo, Vaschillo, & Lehrer, 2006).

PlayMancer is a video game (VG) designed to specifically treat impulse control disorders (Fernandez-Aranda et al., 2012; Jimenez-Murcia et al., 2009). The objective of the game is to increase emotional self-control skills and reduce general impulsive behaviours by training to reduce arousal and im- prove decision making and planning. This training is thought to produce plastic changes in the brain networks involved in both emotional and cognitive processing (Claes et al., 2012; Duffau, 2006).

The purpose of this study is to examine changes in physiologi- cal reactivity, as a marker of emotional regulation, in response to ecologically relevant mental stress/frustration and cognitive- demanding tasks from this therapeutic VG, in nine bulimia nervosa (BN) patients. The final goal of the study is to analyze the efficiency and effectiveness of using a serious VG, as an addi- tional therapy tool for treating emotional regulation and impul- sive control in ED.

Methods

Participants

The study was conducted between March 2011 and June 2012. Participants enrolled in this study were consecutively admitted to the Eating Disorders Unit at the Department of Psychiatry of the Bellvitge Hospital in Barcelona, Spain. The first nine participants to have finished treatment were included in this series of case prospective study. All of them were female and exhibited a bulimic disorder (binge eating disorder, BN, Eating disorder not otherwise specified of Bulimic type (EDNOS-BN or Subthreshold BN) EDNOS-BN), diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition revised (DSM-IV-TR; APA, 2000) criteria using the Structured Clinical Interview for DSM IV Axis I Disorders (First, Gibbon, Spitzer, & Williams, 1996) conducted by experienced psychologists and psychiatrists.

Mean age was 30.6 years (SD = 13.6), the mean BMI of patients was 25.2 (SD = 4.9), mean duration of eating disor- der illness was 11 years (SD = 6.98), and mean weekly fre- quency of bingeing and vomiting was 4.33 (SD = 4.1) and 4.89 (SD = 5.7), respectively.

Exclusion criteria at intake were as follows: being male, primary psychiatric or neurological disorders that can interfere with the game performance (e.g. psychotic disorders, bipolar disorders, major depressive disorders and substance abuse-dependence disor- ders), active pharmacological therapy that may influence autonomic functioning or may interfere with the game performance, and current or lifetime diagnosis of behavioural technological addic- tions. All participants were additionally screened for VG and Inter- net addiction. We obtained written informed consent from all participants, and the Ethics Committee of our hospital approved the study.

Instruments and procedure

Questionnaires

Diagnostic questionnaires for video games or Internet addiction according toDSM-IV criteria. Based on a diagnostic questionnaire for Pathological Gambling (PG) according to DSM- IV criteria (Stinchfield, 2003), currently in the process of validation and adaptation to the Spanish population by Jimenez-Murcia et al. (200X), this 19-item questionnaire reflects the DSM-IV diagnostic criteria for PG adapted to VG and Internet addiction.

State-Trait Anxiety Index (Spielberger, Gorsuch, & Lushene, 1970; Staiger, Dawe, & McCarthy, 2000). This consists of 40 items on a 4-point rating scale measuring anxiety state (20 items) and anxiety disposition (20 items). Minimum and maximum scores range from 20 to 80 points.

Symptom Check List-90 items-Revised (Derogatis, 1994). The Symptom Check List-90 items-Revised (SCL-90-R) is a multidimensional self-report assessment measure for a broad range of psychological problems/symptoms. It contains 90 items structured in nine primary symptom dimensions: Somatization, Obsession–Compulsion, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation and Psychoticism. In addition, the questionnaire can produce three global scores: a global severity index (which measures global psychological distress), a positive symptom distress index (a measure of the intensity of symptoms) and a posi- tive symptom total (which reports the total self-reported symptoms). Only the Anxiety subscale was used in this study. This questionnaire has been extensively validated in a Spanish population, obtaining adequate psychometrical values (Martinez- Azumendi, Fernandez-Gomez, & Beitia-Fernandez, 2001). The SCL-90-R is validated in Spanish and has been previously described (Derogatis, 2002).

Eating Disorder Inventory 2 (Garner, 1991). Eating Disorder Inventory 2 (EDI-2) is a reliable and valid 91-item multidimensional self-report questionnaire that assesses different cognitive and behavioural characteristics, which are typical for ED. The EDI-2 retains the 64 items (grouped into eight scales: Drive for Thinness, Bulimia, Body Dissatisfaction, Ineffectiveness, Perfectionism, Inter- personal Distrust, Interoceptive Awareness and Maturity Fears) of the EDI and adds 27 new items into three provisional scales: Asceti- cism, Impulse Regulation and Social Insecurity. All of these scales are answered on a 6-point Likert scale and provide standardized subscale scores. This instrument was validated in a Spanish popula- tion with a mean internal consistency of 0.63 (coefficient alpha) (Garner, 1998).

In addition to the battery of assessment, participants were assessed by a semi-structured face-to-face interview regarding their lifetime and actual time spent playing VG, their favourite VG and other re- lated information; the same interview also assessed sociodemographic data (e.g. education, occupation and marital status) and additional clinical information.

Physiological reactivity measures

The system consisted of a Desktop PC on which the PlayMancer Desktop application was executed. The Desktop application was linked to the sensor system via Bluetooth®. The sen- sors in the sensor system included the following: (i) electrocardio- gram for heart rate and heart rate variability (HRV) measures; (ii) a TMSi resistive respiration belt for respiration rate; and (iii) the Nonin® pulse-oximeter finger-clip sensor for blood flow. This phys- iological stress response involves high levels of sympathetic nervous system activation (Cohen, Janicki-Deverts, & Miller, 2007).

The video game intervention

The Island VG is being used as an additional therapeutic tool (combined with standard psychological approaches), with consec- utively referred outpatients. A detailed description of the Island VG is available in Fernandez-Aranda et al. (2012) and Jimenez- Murcia et al. (2009). Each session consists of exposure to the aforementioned VG, where the performance of patients is being collected during 20minutes. Relaxing music is played for 3mi- nutes before and after each VG. Each session was carried out once a week, on the day of patients' usual CBT therapy.

The VG consists of three mini-games: (i) The Face of Cronos— The player has to climb up a cliff in which obstacles appear depending on the player's arousal (based on biofeedback). This mini-game trains planning and decision making; (ii) Treasures of the Sea—A swimming game in which the player has to gather differ- ent artifacts and fish and at the same time conserve their oxygen supply. This trains visuospatial abilities, visual working memory and decision making. High arousal makes the task more difficult (e.g. it is harder to catch fish and the oxygen runs out faster); (iii) Sign of the Magupta—A relaxation game in which the player con- nects a constellation of stars through breathing control. Slow deep breathing allows the connections between stars to form (see video demonstration under the supporting information online).

Statistical analysis

Statistical analysis was carried out with SPSS 20 (SPSS System; SPSS, Chicago, IL, USA) for Windows. First, t-test for paired samples explored the pre–post changes for binges and vomiting, State-trait Anger Expression Inventory (STAXI) , EDI-2 and SCL-90-R scores; confidence intervals (CI) for the effect sizes of the different pre–post changes were measured. Next, the comparison between games of the trajectories of physiological measures during the session's game was undertaken based on a mixed analysis of variance (ANOVA), which defined the session measure as intra-factor and the game as inter-factor, and polynomial contrasts valued trends.

Results

Evolution of physiological variables during the sessions of game

The training tasks [Treasures of the Sea (Diving) and Face of Cronos] were compared with the relaxation tasks [Sign of the Magupta (Relax)]. Table 1 shows heart rate, HRV and respiration rate, registered during each session for each type of game depicted on Figure 1.

The results of the mixed ANOVA comparing the trajectories be- tween game types showed no significant session× game interaction. Because of the lack of interaction of intra * inter factors, main effects measuring linear trends were estimated and interpreted. A significant linear trend was found for the heart rate variability measure ($p = .002$): mean scores tended to crease along the sessions of game (session 1–9) (Supplementary Figure 1). The respiration rate measure also achieved a quasi significant linear trend ($p = .085$) but in the opposite direction (means tended to decrease along sessions).

Pre–post changes of binges and vomits

The number of binges and vomiting episodes over the combined treatment (between T1 and T2) decreased from 4.33 to 0.11 [p= .016, 95% CI for mean difference (MD): 1.03 to 7.41] and from 4.89 to 0.03 (p= .034, 95% CI for MD: 0.48 to 9.25) between T0 and T3, respectively. There was also a reduction in binges during the time when PlayMancer was instigated (sessions 3–12 (between T1 and T2); Figure 2) (from 3.43 to 0.29; p = .027; 95% CI for MD: 0.50 to 5.78); the reduction in vomiting did not reach formal significance (from 1 to 0; p= .086). At the end of PlayMancer treatment (T2), 89% of the patients were abstinent from bingeing and 100% from vomiting, and these gains were maintained at the end of CBT treatment (T3).

Pre–post changes of psychometrical scores

Table 2 shows the results of the pre–post changes for STAXI, EDI- 2 and SCL-90-R scores. As a whole, mean results registered for the post were lower than those at the baseline. Some EDI-2 subscales (namely bulimia and ascetism) and SCL-90-R-anxiety mean scores achieved statistical significance.

Discussion

This study set out to examine the efficacy of using a serious VG (PlayMancer/ Islands) as a tool to enhancing emotional regulation and self-control in ED. The intervention targeted training on the physiological markers of sympathetic/para-sympathetic autonomic function, which are associated with anxiety and emotional regula- tion capacity (Carney, Freedland, & Stein, 2000; Chevalier & Sinatra, 2011; Licht et al., 2008). The results suggest that training to reduce arousal may improve control over eating disorder symptom and that the changes are mediated by improvements in the physiological markers [Heart Rate Variability (HRV) and Respiration Rate]. Although emotional regulation has been previously studied in ED (Kanakam, Krug, Raoult, Collier, & Treasure, 2013; Oldershaw et al., 2012; Abbate-Daga et al., 2012), this is, to the best of our knowledge, the first time that a VG therapy has been employed as a therapeutic intervention in BN patients.

Anxiety was reduced, which suggests enhanced emotional regu- lation and is in agreement with studies showing that anxiety is associated with the inability to control emotional responses (Giuliani, Drabant, Bhatnagar, & Gross, 2011; Zeidan, Martucci, Kraft, McHaffie, & Coghill, 2013). Neuroimaging studies also support this hypothesis, and it has been postulated that larger decreases in anxiety are related to increased ventromedial prefron- tal cortex activity, a cerebral region involved in downregulating negative emotions and improving executive control (i.e. impulsiv- ity control) (Hermann et al., 2009; Kompus, Hugdahl, Ohman, Marklund, & Nyberg, 2009; Lane et al., 2009). Furthermore, higher levels of anxiety have been associated with reduced activity in prefrontal and anterior cingulated regions, both areas associated with emotional regulation and impulsivity control, corroborating the links between anxiety and emotional deregulation (Bishop, 2009; Harrison et al., 2008).

As explained earlier, the final objective of this VG therapy is to achieve more efficient brain functioning with appropriate emotional and executive processing, which finally will translate into improved satisfactory real-world behaviours. This was expected to be reached by modulating the task-related brain networks, by means of contin- uous training. Insights from neuroscience suggest that affective pro- cessing is based on similar frontoparietal cerebral network, including the dorsolateral prefrontal cortex and the anterior cingulated cortex (Banich et al., 2009), which is involved in executive function (Brass, Derrfuss, & von Cramon, 2005; Owen, 2004) (Figure 3).

Such findings led to the hypothesis that cognitive brain training programmes, planned to increment the activation of this frontoparietal network, have the potential to produce transferable improvement into emotional control. Our results support this transfer hypothesis and suggest that regular executive training, performed in an emotional context, might potentially enhance the emotional regulation probably by incrementing the effective- ness of these common cerebral circuits

The changes found in our study, and associated with the brain training, might be explained by neural plasticity. Neural plasticity implies that we never use the same brain twice, and is an innate characteristic of the mammalian brain (Kempermann, van Praag, & Gage, 2000). Specifically, brain plasticity refers to variations on the cerebral networks because of modifications in environmental and personal experiences (Duffau, 2006). These cerebral-induced modifications usually comprise visible changes in the neural substrate, which are finally translated into observable behavioural changes (Duffau, 2006). Cognitive and emotional changes, as obtained in our study, are derived from task repetition, producing a positive reinforcement of one task-related cerebral network while restraining others (Robertson & Murre, 1999).

Another justification for these observed changes, associated with the VG therapy, is the intensity of the training. It has been demonstrated that for obtaining significant brain changes, tasks should be well defined, with an adequate difficulty level, and should be conducted for sufficient periods (Ungerleider, Doyon, & Karni, 2002). The explanation for this theory is that learning has two main phases (Kulak & Sobaniec, 2004; Vinogradov, Fisher, & de Villers-Sidani, 2012). The first phase implicates quick performance improvement after a single or initial session, proba- bly because of the construction of a broad task representation relying on the prefrontal cortex (Ahissar & Hochstein, 2004). The plasticity changes during this phase do not usually persist after the training (Classen, Liepert, Wise, Hallett, & Cohen, 1998; Laubach, Wessberg, & Nicolelis, 2000). The second phase, however, produces modest enhancement in performance that continuously improves across the training sessions (Karni et al., 1998) associated with synaptogenesis changes in the cortex and reorganization of the cerebral-related circuits (Kleim et al., 2004). Although our results point to changes after nine VG sessions, future studies in ED with a follow-up design should be conducted, in order to confirm this hypothesis.

One characteristic of the VG therapy is that patients like it and are keen to continue to use it. Additionally, PlayMancer sessions are suitably challenging, and the difficulty is continuously increas- ing depending on patient performance. These characteristics might be influencing our results, as previous studies suggested that learning-induced plasticity is decisively associated with the motivational state (Schweizer et al., 2013). It has been suggested that long-term neural modifications are only produced when a task is personally attended, that is, if we are motivated to perform it (Adcock, Thangavel, Whitfield-Gabrieli, Knutson, & Gabrieli, 2006). This hypothesis implies that training must be carefully planned, and subjects should focus on every task, and tasks should be designed with both a suitably rewarding programme and an adequately challenging level so that the participant maintains motivation. As explained earlier, PlayMancer has all of these char- acteristics, which helps not only in the effectiveness of the therapy but also in the adherence to the treatment.

This study has several important strengths, primarily the novelty of the therapeutic approach. VG therapies, as applied in the present study, might be a practical tool for the treatment of cognitive and emotional alterations in psychiatric disorders. However, the results of this study should be interpreted in the context of some limitations. First, no control group was included, although a longitudinal design was employed and pre–post mea- sures of each patient were considered. Second, the sample size was small, and only women were included. Thus, future studies, considering larger samples and including males, should be conducted. Finally, considering that impulsivity is a complex executive function, future studies assessing different aspects of impulsivity are desirable, in order to shed more light on this multifaceted cognitive construct.

In summary, our results provide novel information regarding the treatment of emotional regulation and impulsivity control in BN patients. This study is particularly timely given the prevalence of impulsivity in psychiatric disorders and the important public-health impact of ED. The linkage found in our study between an improve- ment in physiological variables, emotional regulation and impulsivity control, and serious VG training opens a great field of innovative clinical treatment for cognitive and emotional restoration and improvement of quality of life in ED patients.

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Figure 1

Figure 2

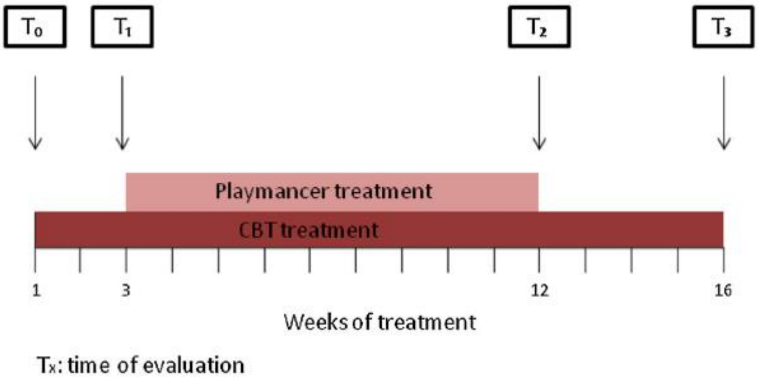

Figure 3

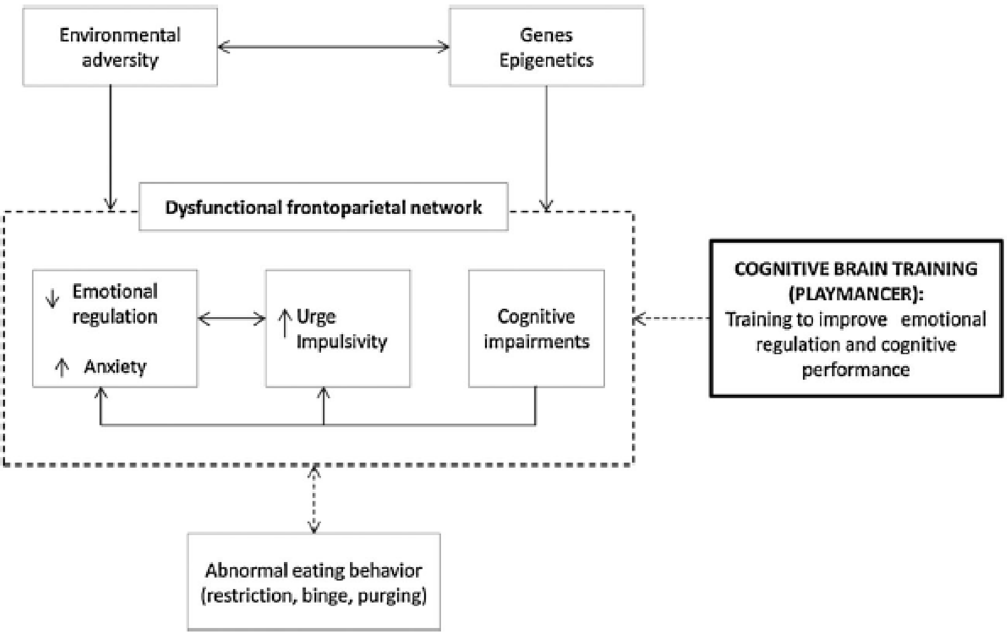

Table 1

	Task	Means for each session									Inter.*	Session:
		Ses.01	Ses.02	Ses.03	Ses.04	Ses.05	Ses.06	Ses.07	Ses.08	Ses.09	S * G	LT[†]
HR	Training	70.2	71.7	71.8	72.9	70.3	72.9	69.3	69.5	66.8	.750	.409
	Relax	72.2	69.7	72.3	73.1	70.6	72.0	70.3	69.2	68.1		
HRV	Training	3.95	4.36	4.06	3.56	3.87	3.93	3.94	4.41	6.09	.094	**.002**
	Relax	5.61	6.45	6.06	6.29	5.40	5.09	6.25	7.38	9.19		
R.RATE	Training	16.6	16.2	15.0	17.1	16.2	15.1	15.7	15.1	14.9	.646	.085
	Relax	11.4	9.95	10.6	9.38	10.6	10.2	10.2	9.58	9.12		

Table 2

	Mean (standard deviation)		*t*-test		
	Pre	Post	*p*	MD	(95% CI)
STAXI State Anger	22.4; (12.2)	22.3; (11.0)	.620	0.83	(−3.23; 4.89)
STAXI Trait Anger	25.1; (8.77)	22.4; (7.79)	.087	3.67	(−0.77; 8.10)
STAXI Anger Expression and Anger Control	34.9; (10.6)	29.0; (11.2)	.065	6.14	(−0.51; 12.8)
EDI: Drive for Thinness	15.2; (5.76)	11.3; (6.45)	.163	3.43	(−1.85; 8.71)
EDI: Body Dissatisfaction	19.3; (8.09)	15.3; (6.32)	.302	2.00	(−2.34; 6.34)
EDI: Interoceptive Awareness	12.8; (7.85)	9.00; (8.72)	.131	3.43	(−1.37; 8.23)
EDI: Bulimia	11.4; (6.11)	3.43; (2.57)	.015	**7.14**	**(1.98; 12.3)**
EDI: Interpersonal Distrust	5.56; (6.00)	4.14; (3.24)	.824	−0.29	(−3.29; 2.72)
EDI: Ineffectiveness	11.2; (8.24)	7.71; (8.36)	.416	1.71	(−3.08; 6.51)
EDI: Maturity Fears	7.89; (5.69)	6.71; (6.26)	.334	0.71	(−0.95; 2.38)
EDI: Perfectionism	7.11; (5.58)	5.71; (3.73)	.622	0.71	(−2.65; 4.08)
EDI: Impulse Regulation	7.78; (8.03)	5.29; (6.21)	.076	3.14	(−0.46; 6.74)
EDI: Asceticism	8.67; (4.42)	3.43; (2.15)	.019	**4.14**	**(0.96; 7.32)**
EDI: Social Insecurity	8.44; (5.10)	6.71; (6.47)	.728	0.71	(−4.08; 5.51)
EDI-2 Total	116.2; (54.4)	78.7; (51.3)	.058	26.9	(−1.29; 55.0)
SCL-90-R Anxiety	2.10; (1.22)	1.24; (1.16)	.050	**0.69**	**(0.00; 1.37)**
SCL-90-R Global Severity Index	1.93; (1.13)	1.34; (1.06)	.125	0.34	(−0.13; 0.82)
SCL-90-R Positive Symptom Total	66.2; (23.9)	53.1; (25.2)	.088	8.43	(−1.69; 18.5)