Computers & Education 63 (2013) 208–217

Contents lists available at SciVerse ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

The influence of an educational course on language expression and treatment of gaming addiction for massive multiplayer online role-playing game (MMORPG) players

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A R T I C L E I N F O

Article history:
Received 22 October 2012
Received in revised form
4 December 2012
Accepted 5 December 2012

Keywords:
Massive multiplayer online role-playing game
Language
Education
Addiction
Event-related potential
P300

A B S T R A C T

Addiction to Massive Multiple Online Role-Playing Games (MMORPGs) among juveniles has become a serious problem in Korea and has led to legislation prohibiting juveniles from playing games after midnight. One key factor in gaming addiction is the so-called narrative, or story, gamers create for themselves while playing. This study investigated how a course in writing and speaking using narrative characteristics and content borrowed from the MMORPG "Dungeon & Fighter (DF)" influenced language expression and gaming addiction. A total of 59 male high school students who were addicted to online gaming voluntarily participated in an experiment involving an educational course aimed at improving their writing and speaking. Participants were randomly divided into two groups, an experimental group of 27 students and a control group of 32 students (the control group participated in a general course addressing topics and various social issues unrelated to gaming). The experiment consisted of a total of 21 sessions lasting 2 h per day over a period of 2 months. The results of a follow-up examination revealed that participants in the experimental group improved their writing and speaking ability far more than those in the control group. In addition, a pilot ERP study suggested that the educational course in the experiment may reflect how gaming activity is processed in the brain, especially in the fronto-central areas, and thereby influence the course of addiction.

1. Introduction

Until recently, research on Massive Multiplayer Online Role-Playing Games (MMORPGs) has mostly focused on their negative effects in the light of game addiction; however, using MMORPG technologies for educational purposes has become a new topic of discussion in recent years (Jang & Ryu, 2011; Susaeta et al., 2010). In South Korea, where game addiction has already become a social problem, a few concrete educational programs are being attempted as the feasible methods resolving it (Kim, Park, & Baek, 2009; Suh, Kim, & Kim, 2010).

The Korean computer gaming industry is an outstanding cultural resource. However, from the perspective of many parents, this industry is behind a social illness that causes their children to become addicted to games. Gaming addiction can be viewed as similar to a chemical addiction that, like alcoholism, causes addicts to lose their ability to control themselves once they start the addictive activity. As a result of their gaming addiction, individuals play games for increasingly longer periods of time, which can even lead to withdrawal symptoms among those who become obsessed with playing games (Kim, 2001, 2010; Korea Game Industry Agent, 2008a, 2008b).

However, unlike drug addiction, gaming addiction is behavioral, and it affects people of many ages, from elementary school students to adults. Juveniles with gaming addiction suffer from various symptoms including social isolation, obsessions and compulsions, paranoia, physical weakness, violent outbursts, excessive competitiveness, and confusion between reality and fantasy (Hsu, Wen, & Wu, 2009; Oggins & Sammis, 2012; Starcevic, Berle, Porter, & Fenech, 2011). In a recent study, the brain of a gaming addict was observed and analyzed via

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0360-1315/$ – see front matter
http://dx.doi.org/10.1016/j.compedu.2012.12.008

functional magnetic resonance imaging while the individual played a game to identify the brain activities associated with gaming addiction (Han, Kim, Lee, Min, & Renshaw, 2010; Ko et al., 2009; Nam & Song, 2010; Thalemann, Wolfling, & Grusser, 2007), in response to previous suggestions that this condition was associated with a brain disorder (Mori, 2003).

In an effort to address gaming addiction, some game companies have begun to charge a game fee, equivalent to about 1% of their annual game sales, to finance initiatives aimed at predicting and treating gaming addiction. Additionally, the Korean government has passed a law that prohibits juveniles from accessing online games after midnight. One of the most serious problems associated with gaming addiction in juveniles is that it decreases the time they spend studying, which can lead not only to poor performance in school but also to conflicts with parents (Prensky, 2006).

However, games can also have a positive influence on users, and some investigators have begun to focus on their potential educational application (Hou, 2012; Prensky, 2008; Sublette & Mullan, 2012). For example, games have been reported to have positive effects on temporal and spatial cognition as well as on strategic thinking (Gonzalez-Gonzalez & Blanco-Izquierdo, 2012; Korea Game Industry Agent, 2007a, 2007b).

The influence of games is related to the stories or narratives constructed by players. Such narrative thinking differs from propositional thinking in that it refers to the internal structure or coherence within a given story. Computer gaming can be a form of creative activity in that many games demand a special type of concentration as well as a sort of interaction in which the gamer helps to create various narratives by directly influencing the plot. In such games, the background narrative of the game is common to all users, but the story is developed differently by individual players. This is why courses in the field of Korean literature, such as “digital storytelling,” devote attention to the narrative structure of games (Lee, 2005, 2010, 2011).

As the characteristics of traditional single-player games have been incorporated into role-playing games (RPGs), a new genre, MMORPGs, has been created. The MMORPG gamer assumes the role of one specific character and interacts online with many other gamers to achieve a specific goal. Unlike previous genres of games with a concrete and specific ending, MMORPGs enable gamers to continuously create their own stories within the game environment.

One such game that is popular among many different age groups and is associated with long play times is Dungeon & Fighter (DF) by Nexon Co. (Seoul, Korea). In brief, DF involves a world created by gods, and players adopt roles as gladiators, martial arts fighters, gunners, thieves, magicians, and priests, engaging in a variety of interactions including physically attacking huge monsters. Hence, hand movements play a significant part in the narrative, making the game an action-oriented RPG. Each character has unique skills that are developed throughout the game, and each can use different weapons (Fig. 1). All these characteristics make the game a good candidate for studying the possible effects of gaming addiction on not only behavior but also brain activity.

Functional brain imaging techniques, including positron emission tomography and functional magnetic resonance imaging, have recently been used to visualize the brain activity associated with Internet game dependence (Han et al., 2010; Ko et al., 2009). However, few psychophysiological studies have investigated the event-related potentials (ERPs) associated with excessive Internet game playing (Thalemann et al., 2007).

Therefore, in the present study, we investigated the use of DF as an educational tool in a writing and speaking course and examined the MMORPG’s educational value for students addicted to the game. We hypothesized that subjects who were exposed to game-based educational content would show significantly improved language expression. We also conducted a brain imaging study focused on the P300 ERP, which is considered to be a neural correlate of Internet game dependence. The P300 has been of particular interest in research on drug, cigarette, and alcohol use and is associated with attention allocation, intensity of processing, closure of perceptual events, and activation of immediate memory (Kok, 2001; Littel & & Franken, 2001). Furthermore, it is assumed that the enhancement of P300 reflects motivational or emotional engagement, motivated attention, and activation of arousal systems in the brain (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Schupp, 2000).

2. Methods

2.1. Speaking and writing course

2.1.1. Participants

Fifty-nine male students (17.5 ± 0.6 years old), who were addicted to DF were included in the present study. Addiction to DF was defined as playing the game every day for at least 4 h per day. All of them exhibited social phobic and/or lethargic behavior, as well as a dramatic

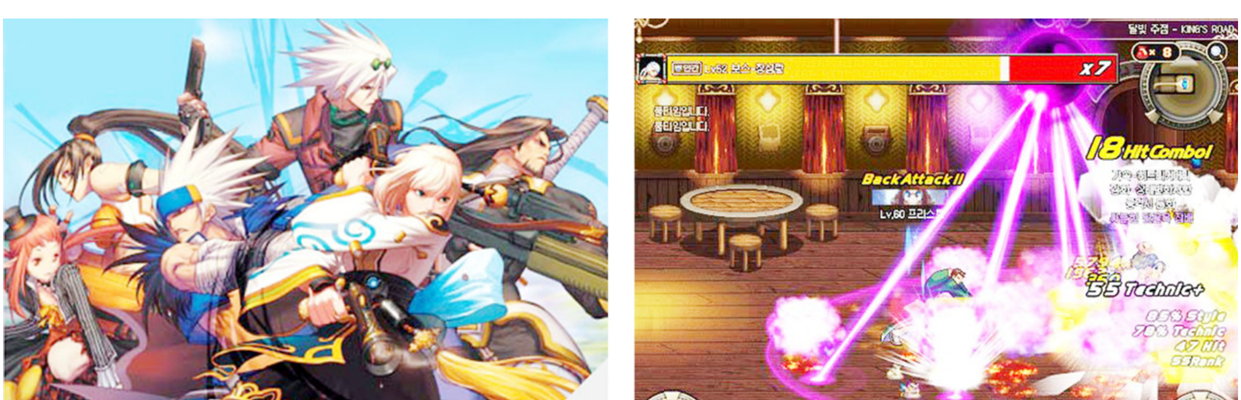

Fig. 1. MMORPG Dungeon & fighter.

drop in academic status. Even their parents and homeroom teachers expressed great concern for their gaming addiction. On average, the students spent an average of 4.983 h per day playing MMORPGs and the majority of them claimed that their dependence on gaming was a result of the academic stress provoked by excessive competition in school.

They were randomly divided into two groups: 27 participants were assigned to the experimental group (17.4 ± 0.6 years old) and attended the game-based course, and 32 participants were assigned to the control group (17.5 ± 0.6 years old) and attended a general course.

2.1.2. Speaking and writing course using MMORPG

The characteristics of the DF-based course are summarized in Table 1. Students received a 3-min briefing and then wrote and spoke about various aspects of the MMORPG, sometimes after watching video clips of the game. During this process, students used meta-cognition (Kim et al., 2009).

An example of a test subject's written description of a combat field story follows (original writing from KJK):

> *We avoided the whirlwind boss. This boss was emitting strong poison. If we faced toward the wind, then we were poisoned, and if the poison touched us, then we changed into the monster, being attacked by party one. We hid ourselves in the direction in which the wind blew; PHJ attacked the boss several times, but the boss was too strong. PHJ soon died; I was holding the boss for a while when PHJ died. While moving around to avoid the boss, I went in the wrong direction, turning into the monster; KSW pushed me a little for fun. On the bottom, PHJ was attacking the boss. I was attacking the boss too. Boss monster resisted so hard. The boss was turned into the whirlwind, but we avoided this easily. However, I was attacked and died. I used the coin to be revived.*

After each writing task, each student was given feedback in a face-to-face consultation (Fig. 2) that included the presentation of pertinent video game clips. Students were briefed on speaking tasks using images of different game scenes. To avoid bias based on the appearance or voice of the instructor, the instructions and feedback were provided by an instructor who always wore the same uniform and spoke in a similar voice and tone. The preliminary stage of reciting the background story was intended as a simple storytelling task in which the story content would be provided, whereas the hunting-ground story and the combat-field story were used as advanced content requiring more sophisticated speaking strategies involving summarization and description of one's own gaming behaviors.

2.1.3. Experimental protocol

The writing and speaking course was designed by the Korean Broadcasting System (KBS), and tests were conducted on a total of 21 occasions; testing required 2 h per day and was conducted over a period of 2 months. A follow-up examination was subsequently performed. The experimental group participated in the course with the game content, whereas the control group participated in a general course that followed the same procedure but had nothing to do with the game or gaming. Therefore, all participants were taught in the same way, although the content differed.

ERP (P300) tests were conducted with three students in the experimental group and two students who did not take the course and who had never played an MMORPG (Table 2). The study was approved by the institutional review board of the Catholic University of Korea, and informed written consent was obtained from all students or their family members.

Table 1
DF-based speaking and writing course.

Stage	Number of trials	Content	Game story/context
Preliminary	1	Write background story.	Background story
	2	Write feedback.	
	3	Speak about background story.	
Basic	4	Write a description of game scenes described by others.	Hunting ground
	5	Write feedback.	
	6	Speak about the game scenes described by others.	
	7	Write a description of game scenes described by others.	Combat field
	8	Write feedback.	
	9	Speak about the game scenes described by others.	
	10	Write about one's own game behaviors.	Hunting ground
	11	Write feedback.	
	12	Speak about one's own game behaviors.	
	13	Write about one's own game behaviors.	Combat field
	14	Feedback about one's own writing.	
	15	Speak about one's own game behaviors.	
Advanced	16	Write about one's own game behaviors.	Hunting ground
	17	Write feedback.	
	18	Speak about one's own game behaviors.	
	19	Write about game behaviors.	Combat field
	20	Feedback about one's own writing.	
	21	Speak about one's own game behaviors.	

Fig. 2. Briefing about the game.

2.1.4. Estimation of the degree of game addiction

In general, the time spent playing a game is correlated with the degree of addiction to the game. Therefore, we estimated the degree of game addiction based on the time each subject spent playing the game during the month before (pre-test) and after (post-test) the course. Data were expressed in terms of minutes, and the values were transformed into daily averages and compared.

2.1.5. Evaluation of speech and writing ability

The KBS speech performance and writing test assesses two aspects of communication, composition and expression, each of which has five sub-categories. In the speech assessment, the following categories were scored to measure composition: "impressive introduction," "understandable explanation," "emphasis of the important point," "organized content," and "effective summary." The following categories were scored to measure expressive ability: "appropriateness of semi-verbal language," "adequacy of selection of words and grammar," "fluency," "proper use of non-verbal language," and "effective time arrangement." Scores were assigned on a scale from 1 to 5 (with higher scores representing better performance) by trained personnel from KBS who were not aware of the experimental protocols. The experimental procedure involved the use of a computer-based testing method (Fig. 3). Speech performance was recorded, reviewed, and given a score with feedback.

In the writing assessment, the following were scored to measure composition: "impressive introduction," "ability to understand and analyze the protagonist," "clear and well-grounded opinions," "coherent content," and "effective conclusion." The following were scored to measure expressive ability: "appropriateness of language expression," "adequacy of selection of words and grammar," "writing skill" (sentence composition), "creative expression," and "adjusting the narrative." The evaluation was based on a paper-based test (PBT) in which subjects were required to write 1200 words. The speaking and writing post-tests were also administered by KBS and had nothing to do with the game.

2.1.6. Data analysis

The demographic characteristics of the two groups were compared using an independent *t*-test. The effects of the course were statistically analyzed by comparing the pre- and post-test scores of the groups with repeated-measures analysis of variance (ANOVA). Cohen's effect-size evaluation was performed to reveal increases in the mean. Further analysis of each category involved comparisons with repeated-measures ANOVAs. Values are presented as means $\pm$ standard deviations. A *P*-value below 0.05 was considered to indicate statistical significance.

2.2. ERP study

2.2.1. Preparation of audio-visual stimuli

Ten video clips related to the goals of the game (e.g., defending or killing a monster) were presented with their associated music as target stimuli, and 10 pictures of plain landscapes of the game were presented with background music as standard (non-target) stimuli (Fig. 4).

Table 2
Participants in the ERP study (all male).

Initials	Age	Characteristics	Average spent time playing game (h)
KJK	18	Experimental group	4.5
KSW	18		5
PHJ	18		5
PKY	18	Non-gamers	0
PJK	18		

Fig. 3. Computer-based speaking test designed by KBS.

2.2.2. Procedures

All subjects participated in two sessions. In each session, 20 target (20%) and 80 standard (80%) stimuli were presented for 3 s. All target stimuli were presented in a random order, and a 5-min break was inserted between sessions. In total, 200 audio-visual stimuli were presented; the inter-stimulus interval was 1000 ms.

For the brain-activity tests, subjects wore earphones and sat in a reclining chair at an eye distance of 50 cm from a 38-cm computer monitor. All subjects were asked to focus on the center of the monitor and to try to avoid blinking during the electroencephalography (EEG) session.

2.2.3. EEG recording

EEG activity was recorded with a NeuroScan SynAmps amplifier (Compumedics USA, TX, USA) and 62 AG-AgCl electrodes mounted in a Quick Cap. EEG data were recorded at a sampling rate of 1000 Hz. Trials were rejected if they contained significant physiological artifacts (amplitudes exceeding $\pm 75\ \mu V$) at the electrode sites. Data were band-pass filtered at 1–30 Hz and then epoched to 100 ms pre-stimulus and 800 ms post-stimulus. After artifact removal, baseline correction was performed by subtracting the mean value for the 100 ms before stimulus onset from the post-stimulus data for each trial.

2.2.4. Source localization of P300 activity using sLORETA

Current source analysis of the P300 component was conducted using sLORETA software (Pascal-Marqui, 2002), which calculates a particular solution of the nonunique EEG inverse problem based on the assumption of maximum synchronization between neighboring voxels. sLORETA images were obtained by estimating the current source density distribution on a dense grid of 6239 voxels with a 5-mm intervoxel distance located in the cortical gray matter and hippocampus to which the solution space was restricted. sLORETA images for each ERP were calculated for infrequent target tones in the timeframe of 300–500 ms post-stimulus. The current source density of the ERP waveform was computed for each subject as well as for the average of the experimental group.

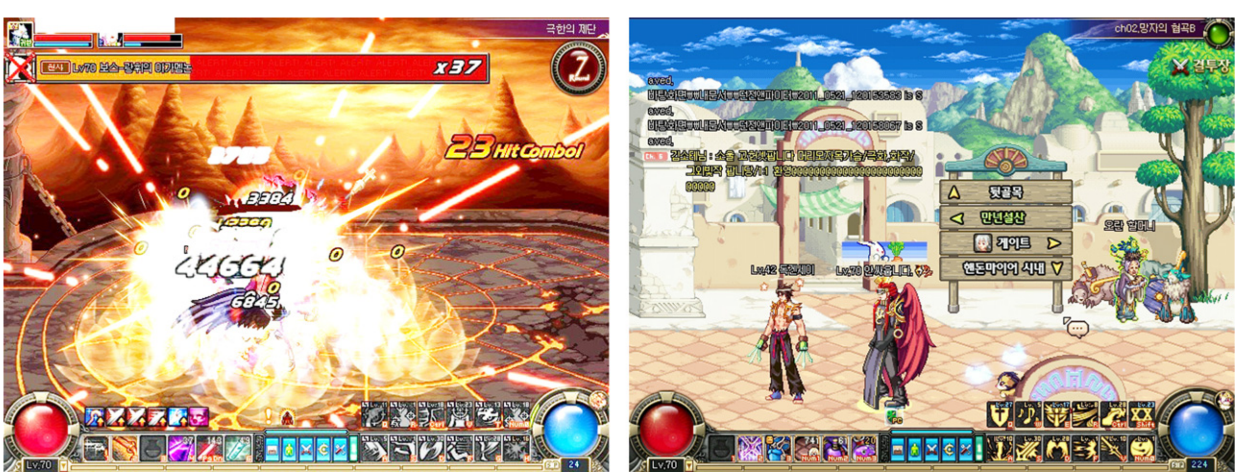

Fig. 4. Target versus standard (non-target) stimuli.

Table 3
Comparison of game-playing duration before and after the experiment.

Variable	Test	Experimental group ($n = 27$)	Controls group ($n = 32$)	Source	F	p-Value
		Mean (SD)	Mean (SD)			
Time spent playing DF	Pre-test	151.111 (37.193)	148.125 (38.431)	Group	1.287	.261
	Post-test	126.666 (46.945)	150.468 (34.811)	Time	5.654	.021*
				Group × time	8.306	.006**

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; *SD*, standard deviation.

3. Results

3.1. Changes in time spent playing DF

As previously described, the participants' degree of game addiction was evaluated on the basis of the time they spent playing DF during the month before and the month after the course. Before the course, members of the experimental (151.111 ± 37.193 s) and control (148.125 + 38.431 s, $P = 0.764$) groups did not differ in this regard.

We found a statistically significant difference between the within-subjects effect of mean time spent playing the game and the interactions between the time and group of effects ($F = 5.654$, $P = 0.021$ and $F = 8.306$, $P = 0.006$), but the between-subjects effects were not significant ($F = 1.287$, $P = 0.261$) (Table 3). Cohen's effect sizes for the difference between the experimental and control groups were 0.079 for the pre-test and −0.576 for the post-test, indicating a one-fold decrease. The mean treatment effect size was −0.498.

3.2. Changes in speaking ability after the course

The two groups did not differ with respect to their baseline speaking ability (Table 4).

However, we found statistically significant differences in the within-subject effects of four variables (important point, adequacy of selection of words and grammar, fluency, and proper use of non-verbal language) (Table 5). Moreover, significant differences were observed in the interactions among the between-subjects effects for three variables (organized content, effective summary, and fluency); organized content was the most effective category ($F = 0.041$, $P = 0.000$). These results show that members of the experimental group improved significantly in terms of composition but not expression.

3.3. Changes in writing ability after the course

The two groups did not differ in their baseline writing abilities (Table 6). However, we observed statistically significant differences in the within-subject effects of all 10 variables (Table 7) and in the interactions among the between-subject effects of two variables (ability to understand and analyze the protagonist and coherent content); coherent content had the strongest effect ($F = 20.803$, $P = 0.000$). After the course, the experimental group showed the most improvement in this category ($F = 20.803$, $p = 0.000$). As in the results for the speaking part of the course, participants in the experimental group demonstrated great improvement in both composition and expression in the writing assessment.

3.4. Results of ERP evaluation

3.4.1. P300 amplitude analysis

The P300 amplitudes of the target block were much higher than were those of the standard block in the three students in the experimental group. However, these were markedly lower after the course (Pz: 2.87 → 0.57 μV; Cz: 3.87 → 2.67 μV). Their latency, however, did not change between the pre- and post-test (data not shown).

3.4.2. sLORETA images of game-addicted students

sLORETA analysis revealed that the mean P300 responses to game-related stimuli were significantly stronger in both fronto-central areas before the course (Fig. 5, upper) compared to after the course (Fig. 5, lower). Additionally, the mean differential current density of the three

Table 4
Baseline speaking ability of the experimental and control groups.

Evaluation focus	Experimental group ($n = 27$)	Control group ($n = 32$)	t	p-Value
	Mean (SD)	Mean (SD)		
1. Impressive introduction	3.152 (0.383)	3.026 (0.176)	1.606	0.117
2. Understandable explanation	3.434 (0.432)	3.257 (0.469)	1.491	0.141
3. Emphasis of the important point	3.056 (0.351)	3.045 (0.383)	0.111	0.912
4. Organized content	3.258 (0.409)	3.368 (0.299)	−1.192	0.238
5. Effective summary	2.555 (0.616)	2.752 (0.588)	−1.257	0.214
6. Appropriateness of semi-verbal language expression	3.548 (0.642)	3.341 (0.529)	1.356	0.180
7. Adequacy of selection of words and grammar	3.303 (0.457)	3.266 (0.383)	0.333	0.741
8. Fluency	3.169 (0.662)	2.999 (0.611)	1.026	0.309
9. Proper use of non-verbal language	2.970 (0.771)	2.745 (0.726)	1.152	0.254
10. Effective arrangement of time	3.311 (0.621)	3.054 (0.715)	1.461	0.149

SD: standard deviation.

Table 5
Comparison of post-test speaking.

Variable	Test	Experimental group ($n = 27$)	Control group ($n = 32$)	Source	F	*p-value*
		Mean (SD)	Mean (SD)			
1. Impressive introduction	Pretest	3.152 (0.393)	3.026 (0.176)	Group	2.812	.099
	Post-test	3.137 (0.273)	3.041 (0.191)	Time	.006	.938
				Group × time	1.103	.298
2. Understandable explanation	Pretest	3.434 (0.432)	3.257 (0.469)	Group	3.766	.057
	Post-test	3.531 (0.407)	3.271 (0.477)	Time	2.682	.107
				Group × time	1.539	.220
3. Emphasis of the important point	Pretest	3.056 (0.351)	3.045 (0.383)	Group	.147	.703
	Post-test	3.138 (0.318)	3.079 (0.370)	Time	10.156	.002**
				Group × time	1.840	.180
4. Organized content	Pretest	3.258 (0.409)	3.368 (0.299)	Group	1.538	.220
	Post-test	3.297 (0.369)	3.403 (0.283)	Time	5.637	.090
				Group × time	.013	.000***
5. Effective summary	Pretest	2.555 (0.616)	2.752 (0.588)	Group	1.780	.187
	Post-test	2.650 (0.513)	2.834 (0.522)	Time	7.699	.119
				Group × time	.041	.001**
6. Appropriateness of semi-verbal language expression	Pretest	3.548 (0.642)	3.341 (0.529)	Group	3.850	.055
	Post-test	3.690 (0.487)	3.392 (0.410)	Time	4.864	.079
				Group × time	1.075	.019*
7. Adequacy of selection of words and grammar	Pretest	3.303 (0.457)	3.266 (0.383)	Group	.003	.954
	Post-test	3.345 (0.418)	3.370 (0.331)	Time	8.687	.005**
				Group × time	1.534	.221
8. Fluency	Pretest	3.169 (0.662)	2.999 (0.611)	Group	3.686	.060
	Post-test	3.425 (0.453)	3.052 (0.530)	Time	10.881	.002**
				Group × time	4.697	.034*
9. Proper use of non-verbal language	Pretest	2.970 (0.771)	2.745 (0.726)	Group	4.902	.031*
	Post-test	3.394 (0.458)	2.934 (0.579)	Time	20.401	.000***
				Group × time	3.014	.088
10. Effective arrangement of time	Pretest	3.311 (0.621)	3.054 (0.715)	Group	2.615	.111
	Post-test	3.393 (0.507)	3.153 (0.534)	Time	6.820	.012**
				Group × time	.066	.799

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, SD: Standard deviation.

students in the experimental group was markedly lower at the midline paracentral lobule and precuneus (Brodmann areas 4 and 7) after the course (Fig. 6).

4. Discussion

It is has been established that practice improves both written and oral linguistic expression. The main idea behind the educational course focused on speaking and writing suggested in this study is that "game-addicted" students can use their "gaming behavior" as a method of treatment. Indeed, we were able to exploit the students' gaming habits by using these familiar phenomena for educational purposes. In other words, the underlying causal mechanism for the improvement of language expression involved the motivation to learn derived from familiar content. However, a more detailed analysis of the results of the KBS educational course presents a somewhat different picture. We found improved speaking ability with respect to organized content ($F = 0.013$, $p = 0.000$) and effective summary ($F = 0.041$, $p = 0.001$) for composition and with respect to fluency of expression ($F = 4.697$, $p = 0.034$). In other words, the speaking part of the course, which used gaming as a learning tool, had a more significant impact on composition than on expression in general. This is because speaking ability can be increased via feedback from instructors when speakers talk about familiar content (Daly, McCroskey, & Ayres, 2009; Pull, 2012).

Similarly, writing ability improved with respect to ability to understand and analyze the protagonist ($F = 8.353$, $p = 0.005$) and coherent content ($F = 20.803$, $p = 0.000$) for composition, whereas no significant effect was found for any category of expression. In other words, the game-based writing part of the course also had a greater effect on composition than on expression. This was because writing strategies were acquired through a process in which students used words to express familiar material, enabling this process to serve as a prototype for

Table 6
Pre-test homogeneity in the writing test.

Evaluation area	Experimental group ($n = 27$)	Control group ($n = 32$)	t	p-Value
	Mean (SD)	Mean (SD)		
1. Impressive introduction	3.152 (0.383)	3.026 (0.176)	1.606	0.117
2. Ability to understand and analyze the protagonist	3.434 (0.432)	3.257 (0.469)	1.491	0.141
3. Clear and well-grounded opinions	3.056 (0.351)	3.045 (0.383)	0.111	0.912
4. Coherent content	3.258 (0.409)	3.368 (0.299)	−1.192	0.238
5. Effective conclusion	2.555 (0.616)	2.752 (0.588)	−1.257	0.214
6. Appropriateness of language expression	3.548 (0.642)	3.341 (0.529)	1.356	0.180
7. Proper use of words and grammar	3.303 (0.457)	3.266 (0.383)	0.333	0.741
8. Writing skill (sentence composition)	3.169 (0.662)	2.999 (0.611)	1.026	0.309
9. Creative expression	2.970 (0.771)	2.745 (0.726)	1.152	0.254
10. Adjusting the narrative	3.311 (0.621)	3.054 (0.715)	1.461	0.149

SD: standard deviation.

Table 7
Post-test comparison of writing.

Variable	Test	Experimental group ($n = 27$)	Control group ($n = 32$)	Source	F	p-Value
		Mean (SD)	Mean (SD)			
1. Impressive introduction	Pre-test	3.295 (0.456)	3.312 (0.514)	Group	0.040	0.842
	Post-test	3.431 (0.513)	3.364 (0.510)	Time	8.611	0.005**
				Group × time	1.698	0.198
2. Ability to understand and analyze the protagonist	Pre-test	3.321 (0.834)	3.386 (0.610)	Group	0.921	0.341
	Post-test	3.802 (0.541)	3.448 (0.551)	Time	14.093	0.000***
				Group × time	8.353	0.005**
3. Clear and well-grounded opinions	Pre-test	2.962 (0.775)	3.213 (0.552)	Group	1.849	0.179
	Post-test	3.147 (0.587)	3.307 (0.521)	Time	7.392	0.009**
				Group × time	0.799	0.375
4. Coherent content	Pre-test	3.198 (0.780)	3.478 (0.546)	Group	0.180	0.673
	Post-test	3.901 (0.389)	3.509 (0.546)	Time	24.852	0.000***
				Group × time	20.803	0.000***
5. Effective conclusion	Pre-test	2.764 (0.919)	2.915 (0.904)	Group	0.837	0.364
	Post-test	2.949 (0.760)	3.155 (0.548)	Time	9.467	0.003**
				Group × time	0.156	0.695
6. Appropriateness of language expression	Pre-test	3.666 (0.612)	3.672 (0.617)	Group	0.000	0.990
	Post-test	3.778 (0.521)	3.776 (0.517)	Time	6.838	0.011*
				Group × time	0.008	0.929
7. Proper use of words and grammar	Pre-test	3.382 (0.749)	3.552 (0.548)	Group	0.496	0.484
	Post-test	3.579 (0.596)	3.620 (0.525)	Time	6.490	0.014*
				Group × time	1.549	0.218
8. Writing skill (sentence composition)	Pre-test	3.086 (0.845)	3.322 (0.605)	Group	1.848	0.179
	Post-test	3.234 (0.815)	3.468 (0.483)	Time	7.838	0.007**
				Group × time	0.001	0.981
9. Creative expression	Pre-test	3.173 (1.043)	3.331 (0.461)	Group	0.023	0.880
	Post-test	3.568 (0.783)	3.462 (0.553)	Time	13.700	0.000***
				Group × time	3.456	0.068
10. Adjusting the narrative	Pre-test	2.802 (1.117)	3.151 (0.981)	Group	1.272	0.264
	Post-test	3.197 (0.921)	3.385 (0.829)	Time	15.217	0.000**
				Group × time	0.993	0.323

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

writing about other topics. Although none of the aspects of expression improved to a statistically significant degree, it may be that improvements in composition positively influence more general writing ability (Flower, 1993; Quible, 1997).

We also found evidence that the game-based teaching strategy employed in the present study may be effective for treating game addiction. That is, the use of gaming behaviors as purpose-oriented language activities during the educational course may have changed the

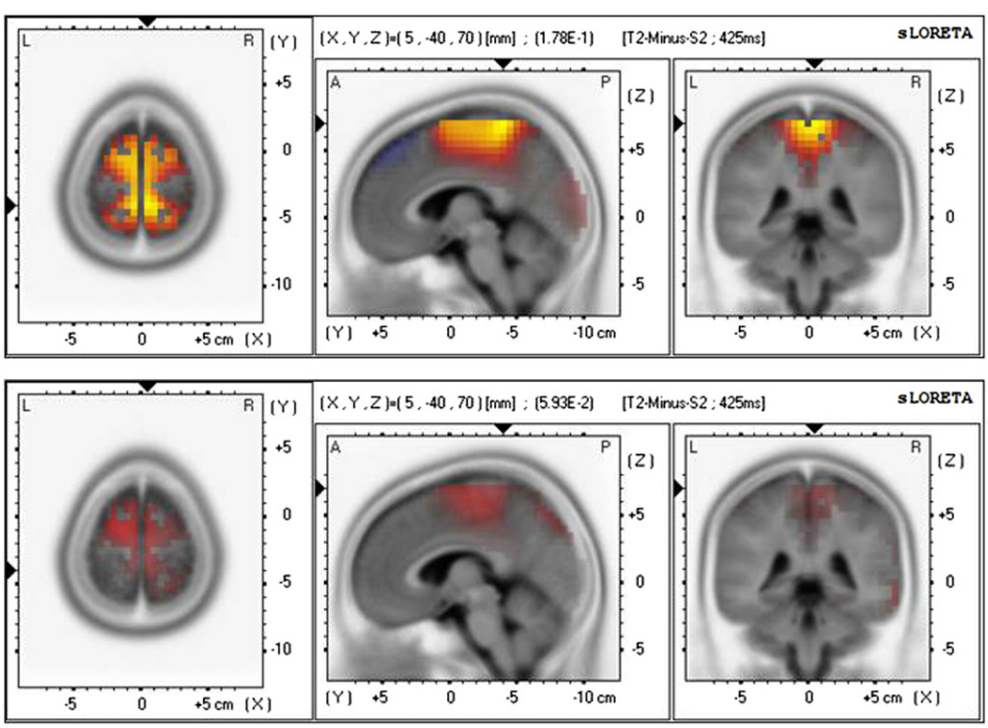

Fig. 5. sLORETA images of average P300 current density, which peaked 425 ms after target stimuli before (upper) and after (lower) the course in three students in the experimental group.

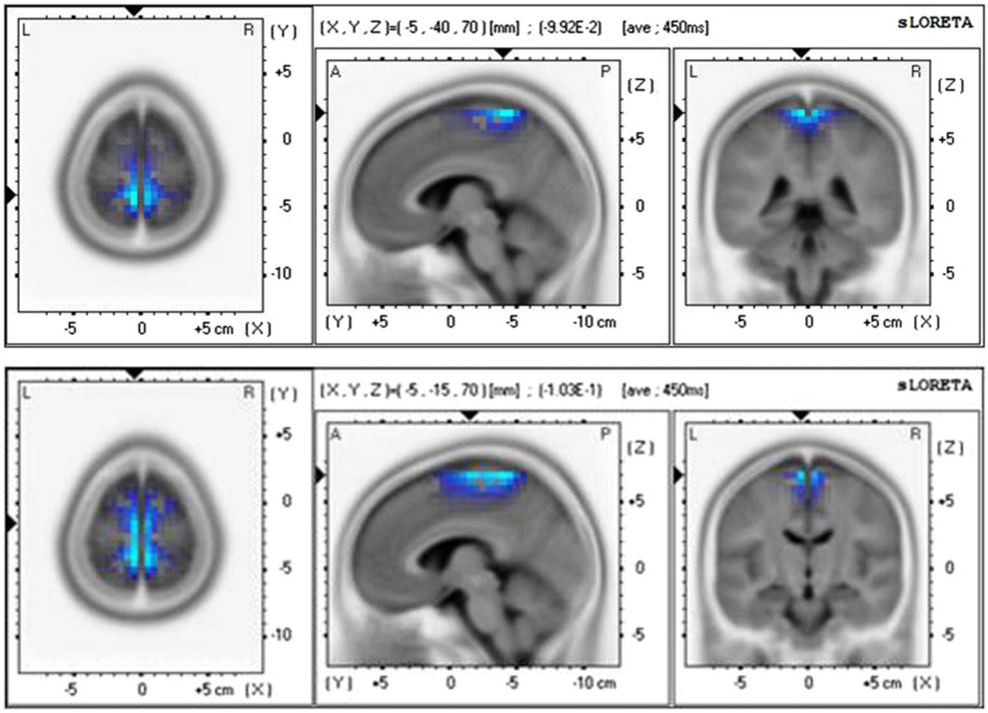

Fig. 6. Fronto-central regions (maximized in vertical area) showing a significant decrease in P300 current density in the three experimental group participants after the course.

mental processing used for the task itself, as suggested by the results of the brain-activity study. For example, P300 activity in response to game-related cues was greater before the course than after it. This may imply that game-addicted subjects have a processing bias that is similar to that observed in smokers (Littel & Franken, 2007; McDonough & Warren, 2001; Warren & McDonough, 1999) and other addicts (Franken et al., 2003, 2004; Herrmann, Weijers, Wiesbeck, Boning, & Fallgatter, 2001; Ko, Hwang, & Yoon, 2008; Lubman, Allen, Peters, & Deakin, 2007; Namkoong, Lee, Lee, Lee, & An, 2004; van de Laar, Licht, Franken, & Hendriks, 2004; Wolfling, Flor, & Grusser, 2008). Additionally, previous studies have shown that ERP waves (i.e., enhanced P300 and slow positive wave amplitudes) are significantly correlated with subjective drug cravings (Franken, Hulstijn, Stam, Hendriks, & van den Brink, 2004; Namkoong et al., 2004). In the present study, the higher P300 activity observed before the course may have been induced by gamers' allocation of attention to information related to their gaming addiction; that is, they may have entered an incentive-motivational state (Warren & McDonough, 1999).

Nevertheless, we should not draw any premature conclusions about the potential therapeutic effects of this game-based course on the cue-induced cortical reactivity measured by P300 because we measured ERP activity in only two normal subjects (i.e., subjects without gaming addiction), which precluded a group comparison. Further ERP studies including many more participants, a better stimulation paradigm, and validated clinical measures are warranted.

This study has several limitations. First, the number of participants was small, and all subjects were male. Even though the prevalence of gaming addiction is higher among male students than among female students, female students should also be included in such studies. Furthermore, all participants in this study were high school students. Hence, our results must be supplemented by follow-up studies that include both sexes as well as a wider range of ages. This will make it possible to offer draw generalizations. Additionally, we included only moderately addicted students (those who play about 4 h per day) and considered only one gaming genre. Therefore, it is necessary to conduct a follow-up study of gamers with severe addiction that considers various gaming genres.

Second, the specific mechanisms by which the game had an educational effect on speaking and writing were not identified. Because the 21 areas of feedback and results included in this study may be insufficient, more specific and detailed information about how much feedback is required to achieve an educational effect is necessary.

Finally, this study could not determine whether and how long the effects of the course will last. We hope that future research can overcome these limitations by studying the long-term follow-up data with MMORPG.

In conclusion, our computer game-based speaking and writing course for game-addicted students may be effective for treating gaming addiction and for improving the functional aspects of language expression. As the strategy utilizes gaming behaviors in the service of purpose-oriented language expression, it may change how gaming activity is processed in the brain, especially in the fronto-central areas, and thereby influence the course of the addiction.

Disclosure

The authors have no conflicts of interest to disclose.

Acknowledgments

This study was supported by the Songeui Research Grant funded by the Catholic University of Korea. We confirm that we have read the journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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