

Group Environments and Visuospatial Attention in Patients with TBI

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ABSTRACT

Maintaining the attention and focus of patients with Traumatic Brain Injury (TBI) is a concern of many rehabilitation clinics that work with this population. The novel use of interactive video games to combat the problem of requiring attention to improve attention was utilized in the present study. It has been noted in several studies that video games can have a positive effect on one's focus and attention. The use of games such as Rockband™ and Guitar Hero™ have been observed to maintain the focus and attention of patients with TBI for prolonged periods of time. Additionally group environments have been observed to enhance the performance and focus of patients with TBI. Positive group environments are used often in clinics as a means of improving cognitive functioning. Patients with TBI and a control group (undergraduates of SUNY Plattsburgh) engaged in two one-hour sessions one month apart. During these sessions participants performed the task of playing Guitar Hero™ and completing the Trail Making Test (TMT), Symbols Digit Modalities Test (SDMT), and Paced Auditory Serial Assessment Test (PASAT). Each participant completed one session in the presence of a positive social environment and one control session (only an experimenter was present). A positive social environment was induced by utilizing positive feedback from trained confederates. Results provide evidence disfavoring the use of interactive video as a means of attention therapy. In contrast there is evidence to suggest that a positive social environment is a significant form of attention therapy.

Keywords: TBI, video Games, attention, positive environment

INTRODUCTION

According to the Center for Disease Control and Prevention 1.4 million Americans incur a Traumatic Brain Injury (TBI) each year. TBI can affect one or more parts of the brain and often results in great neuropsychological consequences including deficits in attention (Malojic, Mubrin, Coric, Susnic & Spilich, 2008). It has also been noted that people with Traumatic Brain Injury experience greater subjective fatigue because of the need to devote more of their cognitive energy to executive functioning (Ziino & Ponsford, 2006). Specifically, studies have also shown that orienting and executive components of visuospatial attention are most susceptible to neural changes following TBI (Haltermann et al., 2006). Consequently, many clinicians require the expertise of trained rehabilitation professionals who can help redirect people with brain injury in order to help them stay on task and persevere. The problem of requiring attention to increase attention is often challenging for the rehabilitation professional whose goal is to help ameliorate the cognitive deficits that interfere with functioning. This can be especially problematic for clinics that do not operate on a large budget or are understaffed. A new, innovative, and effective intervention method to improve attention is needed by smaller clinics that train and teach independent living skills to people as patients with TBI recover from brain injury.

Improving attention and concentration for people with TBI is critically important. There are three independent problems that are associated with attention rehabilitation in people with TBI. First, although attention has been shown to increase through neuropsychological training (Galbiati et al., 2009), the technology needed for such intervention is costly. A second problem that develops following brain injury is fatigue, which impairs attention (Ziino & Ponsford, 2006). This can present problems to researchers and clinicians attempting to involve consumers in rehabilitation interventions that are mundane or not interesting. A third concern that can cause problems for researchers and clinicians is that the patient's overall vigilance has been shown to decrease as the complexity of the task increases (Loken, Thornton, Otto & Long, 1995). Therefore, it can be increasingly difficult to maintain the attention of a patient with a TBI if the task is far too complex. These three problems offer challenges to the process and efficacy of cognitive rehabilitation interventions.

Researchers are just beginning to reveal the efficacy of video games to enhance one area of cognition: visuospatial attention. This fact is supported by the evidence that frequent video game players have better visuospatial attention than non-video game players (Green & Bavelier, 2006). Specifically action or interactive video games have revealed the ability to generate more efficient visuospatial attention than non-action video games (Green & Bavelier, 2006). Studies have also effectively noted the use of video games as a novel approach towards the rehabilitation of patients with TBI and mental retardation. Virtual reality use has been shown to increase enthusiasm, balance and self-confidence in patients with TBI (Thornton et al., 2005). Patients with mental retardation experienced an increase in attention immediately after the use of computer games (Rezaiyan, Mohammadi & Fallah, 2007). The engaging effects of novel stimuli warrant strong attention from the player. Stepping into a virtual video game environment would elicit more neural activity associated with attention; this in turn would make the activity of a video game appear as an exercise in attention.

The effects of a positive support group on visuospatial attention have also been noted in research. Studies have shown the effectiveness of motivation to enhance exogenous spatial attention (Malojic et al., 2008). Although the literature on the use of group motivation to enhance attention in a clinical setting is sparse, it has been reported that group intervention is effective at cutting down disruptive behavior in children with attention disorders (Houck, King, Tomlinson, Vrabel & Wecks, 2002). Other motivationally based interventions such as Pivotal Response Training (PRT) have been shown to be effective in increasing the cooperation and interaction of children with Autism Spectrum disorders (ASD) using groups and individuals (Baker-Ericzen, Stahmer & Burns, 2007; Harper, Symon & Frea, 2007). Using structured motivational strategies outlined in a PRT manual (Koegel et. al., 1989, as cited in Sherer & Schreibman, 2005) children as young as eight years old were able to effectively increase the attention span and cooperation of children diagnosed with ASDs. One explanation for the ability of a structured positive environment to enhance attention in a clinical population is the possibility of an increase in self-esteem. The encouragement and support of a positive environment provides a sense of support and comfort. Thus, it is proposed that being in a supportive environment may increase faith in one's abilities, in turn increasing one's focus.

This study utilized the novel stimulus of the interactive video game Guitar Hero™ and a positive, supportive environment to attempt to enhance visuospatial attention in patients with TBI.

The study began with three key hypotheses: 1) Patients with TBI will respond with improved attention scores after becoming familiar with the novelty of an interactive video game experience; 2) Patients with TBI will respond more dramatically to a positive environment than controls due to the saliency of their own physical and cognitive abilities; and, 3) Patients with TBI will experience a greater overall improvement in attention scores than controls. Because subjective fatigue is almost universal in TBI patients (Ponsford & Ziino, 2009), it was expected that the overall effects of video games would have a more dramatic effect on the improvement of attention in patients with TBI than in controls.

METHODS

Participants

Nine clients of the North Country Regional TBI Center and twelve matriculating students of the Plattsburgh State University of New York participated in this study. Control participants were recruited from an introductory psychology course and were asked to fill out an informed consent form prior to the beginning of the study. Due to the fact that this study utilized confederates as well as an induced positive social environment, it was necessary to keep the participants naïve to the hypothesis. Prior to the start of the study, permission by the Committee for the Protection of Human Subjects was secured. Participants were immediately debriefed after the study was completed.

Materials

For this study the interactive music game Guitar Hero™ for Playstation 2™ was used. The game consists of a simulated plastic guitar that mimics the design of an actual electric guitar. The important difference between an actual guitar and the simulated guitar in the present study is that the simulated guitar contains five sequentially placed buttons where a guitarist would normally “fret” the strings of an actual guitar. The game requires the user to match corresponding notes that are seen on the television screen with the notes on the guitar. A correct response is made if the player matches the stimuli on the screen with the correct corresponding button on the guitar in correct rhythm with the song. There are five levels of difficulty: beginner, easy, medium, hard, and expert. At the end of each song the total percentage of correct responses and the longest streak of correct responses are displayed.

Procedure

Participants underwent a battery of pre-intervention attention tests. The first test was the Symbol Digit Modalities Test (SDMT; Smith, 1991). This test consists of 110 trials and requires the participant to code a series of numbers based on a key of symbols. The second test was the Paced Auditory Serial Addition Test (PASAT; Gronwell, 1977). This test consists of 61 items and requires the participant to consecutively add pairs of numbers in such a way that each number is added to the one that immediately preceded it. Thus the preceding number must always be kept in mind when completing the addition. The third test was the Trail Making Test (TMT; Reitan, 1955). This test consists of two path-making trials. The first trial is a measure of the participant’s ability to

draw a sequential path connecting numbers from 1 to 25. The second path measures the participant's ability to switch between numbers and letters progressively up to 13.

After the tests were completed all participants engaged in a diagnostic phase where Guitar Hero™ was played until it was determined what difficulty the participant felt comfortable playing on. This difficulty was increased appropriately in order to avoid a ceiling effect. For instance, if the participant achieved a near perfect score on "Hard Mode" the difficulty was placed at "Expert Mode." This was based on the percentage of notes hit. The upper limit was 90% and the lower limit was a failing score (65% or below). Thus a score of between 65 and 90 percent on the diagnostic song indicated the participant's difficulty level.

Following this diagnostic phase, participants entered into an experimenter-only phase where four Guitar Hero™ songs were played with only the experimenter as an observer. During this phase the experimenter was required to not provide any feedback. The experimenter-only phase was followed by the participants returning for a second "group" session. The second session occurred one month later in order to avoid a practice effect on the attention measures. During the group phase, two confederates observed and provided structured support to the player. The structured support included colloquial phrases (see Appendix 1) to provide motivation to the player.

To induce a positive environment confederates were used in the study. Confederates were introduced as undergraduate students interested in conducting research next semester. The experimenters secured participant permission for the confederates to join the session. The two confederates followed a protocol in order to convey a standard positive supportive environment. This included conveying agreeableness, openness and providing positive feedback in the form of compliments during game play. Each confederate and the experimenter gave five supportive utterances for each song the participant played. In order to measure if the group settings were "positive," a control measure was introduced at the end of the experiment. The control measure was included at the end of the subjective mood analysis for the group session. The participants were asked to rate the group environment on a scale from -5 (negative) to 5 (positive) after the positive group session. This scale is available on Appendix 2.

The effect of order was controlled by having some of the participants engage in each phase in the reverse order. This meant that one-half of the TBI participants and one-half of the controls engaged in the group phase first, followed by the experimenter-only phase. Participants were given a specific "set list" of songs to play in order to avoid having data confounded by the player's song preference.

Prior to each phase of the experiment, participants completed a short survey. The survey consisted of four questions that determined the participants' feelings towards Guitar Hero™ and enjoyment of their overall experience (see Appendix 2). The questions were answered on a 7-point Likert scale from -3 to 3. Participants were also asked whether playing individually or with a group was preferred. The purpose of the survey was to assess the mood of the participant towards the activity (Guitar Hero™) on that particular day. Exclusion criteria included significant discrepancies between a participant's moods for the two sessions.

Finally participants completed the same battery of tests (PASAT, SDMT, TMT) immediately after the second phase was complete. These tests served as comparative data to test the overall effectiveness of Guitar Hero™ on attention.

RESULTS

A reliable change analysis was conducted prior to a test of statistical significance. Reliable change is a test to determine if a treatment using the same test twice is exhibiting greater change above a practice effect. A reliable change analysis did not reveal any reliable change for any of the instruments used in the experiment. This suggests that the significance of the results of this experiment may be explained by a practice effect of the attention measure rather than an effect of video games or the positive social environments.

TMT time scores were standardized based on the *Revised Comprehensive Norms for an Expanded Halstead-Reitan Battery*. T-test analysis of the SDMT revealed a significant increase from pretest to posttest scores for the control group ($p < .05$), but not for the clinical group ($p > .05$, ns). A PASAT t-test analysis revealed no statistical difference for either group ($p > .05$, ns). Finally TMT t-test analysis showed a significant decrease in standard scores from pretest to posttest for the clinical group ($p < .001$) and a significant increase in standard scores for the control group ($p < .001$). T-test scores comparing the improvement of both control and TBI group show a stronger improvement in attention scores for the control group on each test; these results fail to reject the null hypothesis that the clinical group would achieve greater improvement than the control group (See Table 1).

A statistical analysis of the clinical group and control group was conducted to determine the significance of the positive environment. Because of the imbalance of TBI and control participants in the study six participants were randomly chosen from the TBI group and six participants were chosen from the control group for analysis. This allowed the researchers to compare three participants from every order. Within each set of six, three participants experienced the positive group during the first session and three experienced the positive group during the second session. Finally, the statistical analysis scores during the session that included the positive environment were subtracted from the experimenter only phase in order to obtain comparison results for each participant.

Results revealing the efficacy of the positive social environment are shown in Table 2. SDMT scores reveal a strong statistical difference between the TBI and control groups ($p < .05$; See figure 2). TBI patients on average scored 3 points higher during the positive environment phase than during the experimenter only phase. Contrastingly controls scored 3.167 points lower during the positive environment phase than during the experimenter only phase. However, results indicating a greater overall improvement by the TBI group compared to the control group were not seen on the PASAT ($p < .439$, ns). Finally Trail B of the TMT also revealed no statistical difference between the two groups regarding the effects of the positive environment ($p > .05$, ns).

A statistical analysis of errors made on the Trail Making Test was performed. Both sequencing and sequential errors were analyzed. A sequencing error is defined as failure to connect sequential stimuli within a set. A set error is defined as a failure to switch between two sets on Trail B of the TMT.

Statistical analysis of sequencing errors and set errors revealed no significant difference between the number of errors made during the pretests compared to the posttests for either the control or clinical group ($p > .05$).

DISCUSSION

The results of this experiment reveal differences not only between two different populations, but also between different neuropsychological instruments. If we consider the collapsed effect of Guitar Hero™ we see that the hypothesis did not hold true for the TBI patients; there was no significant improvement in the scores of the TBI patients. Greater improvement in the scores of the control group in response to the interactive video game were revealed. There are several explanations that could account for this trend.

First, it may be possible that video games were able to enhance the TBI group's attention during game play, but not during test taking. This could mean that the focus gained during game play did not transfer to a less entertaining task. The contrast in entertainment value of the two tasks (video games versus test-taking) could also possibly account for the lack of improvement in the TBI patients (although the control group was able to transcend this). Ultimately, this may mean that patients with TBI have a more difficult time transferring their focus between novel stimuli and mundane tasks. Similarly, it may mean that a fully functioning person would not have as much difficulty transferring their focus between novel and mundane tasks.

A second explanation of the findings in this study may be that video games did not actually increase focus for patients with TBI. Although there have been publications reviewing the effects of video games on non-clinical populations (Green & Bavelier, 2006; Rezaiyan, Mohammadi, and Fallah, 2007; Thornton et al., 2005), the research on the effects of interactive video games on patients with TBI is sparse. There are few publications to support that video games can actually improve the attention of a patient with TBI. It is possible that video games such as Guitar Hero™ may be able to conquer the effects of subjective fatigue in patients with TBI, but that it does not actually garner a change in attention scores. Also, it is possible that video games actually induce fatigue as a result of attention demand.

A final explanation may be that the effects of video games help some patients with TBI, while others are more resistant to change. This could explain the high standard deviation on the PASAT (16.394) although the SDMT and TMT Trail B yielded lower standard deviations (3.43 and 0 respectively). This experiment also used TBI patients with widely varying brain lesions. Because of this there is a range of cognitive distortion that could explain the results in this experiment. There is no telling whether or not the results were the result of a singular or several cognitive deficits.

Despite the scores indicating that the TBI group did not achieve significance on various measures, we can see evidence that video games can improve attention scores in a non-clinical group. The SDMT and TMT Trail B both indicate a significant increase in attention scores for the control group in this experiment. Although there was certainly improvement by many participants, there was a wide range of differences between scores. The standard deviation for each test is noteworthy (SDMT - 7.97; PASAT - 2.54; TMT Trail B - 8.06).

The results regarding the effects of a positive environment are mixed. Although the experiment yielded significant statistics for the SDMT, the TMT Trail B and PASAT did not indicate a noteworthy change. Still it is possible that the positive environment yielded a stronger effect on patients with TBI than the control group since the control group yielded no statistical significance on any test.

The validity of the "positive environment" can be argued. However a measure of the general atmosphere of the group was taken on a scale from -5 (extremely negative) to 5 (extremely positive) immediately preceding the experiment. The average rating of the environment by

participants was very high for both groups (4.89 for TBI group and 3.17 for control group). The fact that patients with TBI rated the experience as more positive than the control group may indicate that patients with TBI are more sensitive to emotional support or to the activities that are engaged. This could explain the improved attention scores on the SDMT as a result of the positive environment.

In review there were several strengths to this study. It included the use of widely used neuropsychological instruments to track attention change. Although these measures often gave different results, each is useful in their own respect. This experiment allowed the researchers to validate the production of a positive environment. Indeed there was virtually no negative anecdotal feedback from any of the participants in the study. However, this study only included two short sessions of an interactive video game. It is possible that the effects found in this study may be amplified if more time was allotted for the participants to play. Also there was only one month between sessions in this experiment. It is very possible that some of the results in this study were the result of a practice effect. Further research is required to see if interactive video games such as Guitar Hero™ are actually a valid therapy for attention in patients with TBI. Additionally it is possible that the effect of playing video games could have interacted with the effect of experiencing a positive social environment. Further research is required to see if these two effects possibly interact.

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RESULTS

Table 1

T-Test Analysis of the Efficacy of Guitar Hero™ on Attention Scores by Instrument

SDMT Scores	STDEV	Average Difference	T-Test
TBI	3.432	+1.440	0.121
Control	7.971	+3.750	0.053*
PASAT Scores	STDEV	Average Difference	T-Test
TBI	16.394	+1.440	0.399
Control	2.539	+0.580	0.221
TMT Scores	STDEV	Average Difference	T-Test
TBI	4.475	-2.556	0.001***
Control	8.062	+10.000	0.001***

Note. *p < .05, ***p < .001

Table 2

Between Groups T – Test Analysis of the Efficacy of a Positive Social Environment by Instrument

SDMT Scores	Standard Deviation	Average Difference	T – Test
TBI	1.897	+3.0	0.026*
Control	6.178	-2.8	
PASAT Scores	Standard Deviation	Average Difference	T – Test
TBI	20.659	0.0	0.4393
Control	2.805	+1.3	
TMT Scores	Standard Deviation	Average Difference	T – Test
TBI	4.719	+1.3	0.4047
Control	12.313	0.0	

Note. *p < .05.

APPENDIX 1

Positive Environment Checklist

The following are a list of standard utterances that can be provided as support during the song:

- Nice
- Good Job
- Alright
- Keep it up
- Wow
- Nice job
- Fantastic
- Awesome
- Nice Streak
- Not bad
- Amazing
- You're on a roll
- Cool
- You're doing fine
- Looks good
- Yay (name)
- There you go
- Hey!
- Great
- Good
- Impressive
- Rock on

These don't have to be said verbatim, but must be conveyed in your support (for instance "that's **GREAT**" and "you're doing a **Nice Job.**")

Each confederate will produce exactly 5 utterances during each song for 4 songs (for 20 utterances). The participant's name can be included in any of these sayings.

After the participant's ability has been determined and the first song is ready to be played the experimenter will bring in the 2 other confederates and explain that they are interested in doing research and want to ask if they can sit in on a session. If the participant is comfortable with the conditions the confederates will introduce themselves and the experimenter will continue with the experiment with the confederates acting as a positive supportive environment.

The confederates will politely leave after the fourth song is done as prompted by the experimenter.

APPENDIX 2

Subjective Mood Analysis

Name _____ Date _____

Pre-test or Post-Test Individual or Group

How do you feel about your guitar hero performance?					Expressed Indifference	
-3	-2	-1	0	1	2	3
The Worst	Terrible	Bad	Okay	Good	Great	The Best

How long would you feel about continuing guitar hero next week?						
-3	-2	-1	0	1	2	3
Not at all	Only if Forced	Pessimistic	Indifferent	Maybe	Most Probably	Definitely

Did you have fun while playing?				Expressed Indifference		
-3	-2	-1	0	1	2	3
Hated it	Str. Dislike	Dislike	Indifference	Enjoyed	Str. Enjoy	Loved

Would you rather play in a group or individually?				Expressed Indifference		
Group			Individually			
How was the experience (i.e. Positive, Negative, beneficial)? _____						

How would you rate the group experience session?											
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	
Positive				Neutral				Positive			

APPENDIX 3

Please complete the following information below:

Birth date: ___/___/___

Age: _____

Circle all that apply:

Gender: Male

Female

College Level:

Freshman

Sophomore

Junior

Senior

Other _____

Ethnic Group:

African American

Hispanic

Asian

Caucasian

Other _____

How often do you play video games?

0 – 1 hours/week

1- 3 hours/week

3 – 5 hours /week

5- 10 hours/week

10 + hours/week

Have you ever played Guitar Hero™ before? _____

Please check off any of the following that apply to you:

___ ADD or ADHD

___ Learning Disabled

___ Language Disability

___ Traumatic Brain Injury

___ Concussion at least 2 times in your life

___ English is your second language