Video gaming promotes concussion knowledge acquisition in youth hockey players

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Abstract

While the positive uses for video games in an educational setting have also been established, the educational aim is usually made explicit. The goal of this research was to develop a video game wherein the educational aspect was implicitly embedded in the video game, such that the gaming activity remained interesting and relevant. Following a pilot study to confirm the usability of an in-house developed game, two studies were conducted with 11–17 year old hockey players \( N_1 = 130, N_2 = 39 \). Results demonstrated that participants playing the experimental version of the video game scored significantly higher on a concussion symptoms questionnaire, in a significantly faster time, than participants playing the control version of the game. Most participants indicated that they enjoyed the game and would play it again. These results suggest that educational material can be conveyed successfully and in an appealing manner via video game play.

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Keywords: Video games; Youth; Education; Concussion
Introduction

The majority of recent work regarding computer and video game play has focused primarily on the potential negative impact of this medium, in areas such as aggression (Anderson and Dill, 2000; Gentile, Lynch, Ruh-Linder, & Walsh, 2004; Krahe & Moller, 2004; Uhlmann & Swanson, 2004; Van Schie & Wiegman, 1997), psychological impact (Funk, Bechtoldt-Baldacci, Pasold, & Baumgarder, 2004; Van den Bulck, 2004; Van Mierlo & Van den Bulck, 2004), and social involvement and activity level (Gentile and Walsh, 2002; Hughes, Ebata, & Dollahite, 1999; Kraut et al., 1998; Van Schie & Wiegman, 1997; Vandewater, Shim, & Caplovitz, 2004). Violent video game content has dominated much of this research and several reviews of the topic are available (Anderson, 2004; Anderson & Bushman, 2001; Dill & Dill, 1998). In fact, the editors of a Special Issue of the Journal of Adolescence reported that the Call for Papers predominantly generated papers regarding violent video game exposure and that they “did not receive a single submission reporting research on the potential positive uses of video games” (Anderson, Funk, & Griffiths, 2004, p. 2).

Positive uses of video games have been reported. This medium has been used to study learning (Blumberg, 2000; Blumberg & Sokol, 2004) and selective attention (Blumberg, 1998) in children, to examine memory processes in college students (Shewokis, 1997, 2003), to improve neuropsychological parameters in the elderly (Dustman, Emmerson, Steinhaus, Shearer, & Dustman, 1992), to improve attention span in children with attention deficit/hyperactivity disorder (Pope & Bogart, 1996), and to relieve children undergoing chemotherapy (Kolko & Rickard-Figuero, 1985). However, the primary focus has been science advancement or therapeutic purposes. While some video games have been developed for health promotion and educational purposes (Lieberman, 1997; Lieberman, 2001), such as aiding diabetic children in disease management (Brown et al., 1997), most utilize explicit techniques. That is, the subjects are aware of the purpose and goal of the game. To our knowledge, little research is available whereby educational information is implicit and incorporated in game play strategies.

According to Rieber (1996), this is known as endogenous fantasy; the content is embedded in the game and one cannot be separated from the other. In contrast to exogenous fantasy, which overlays content on top of the fantasy (such as the game Hangman), endogenous fantasy is advantageous in that “if the learner is interested in the fantasy, he or she will consequently be interested in the content.” (p. 50) Intrinsic motivation is necessary for self-regulated learning, and a successful endogenous fantasy provides a basis for intrinsic motivation (Rieber, 1996).

Video games are widely available, widely accessible, and widely utilized as a leisure activity (Gentile et al., 2004; Gentile & Walsh, 2002). Therefore, successfully immersing educational material into a video game without disturbing the inherent features and concepts of game play could transform video games into a channel for information dissemination.

In the field of sports medicine, concussion recognition and diagnosis is primarily based on evident and reported symptomatology. By increasing awareness of concussion symptoms, athletes may be better able to recognize when they are potentially suffering such an injury, which may result in better disclosure to coaches, parents, and medical personnel, and ultimately, increased player safety.

Symptom Shock, a computer game modelled on the popular game Tetris, was developed by the research team to convey information regarding concussion symptomatology. The object of the
The game is to score more goals than the computer opponent. Three icons representing either concussion symptoms (e.g., seeing stars) or symptoms not generally related to a concussion (e.g., sore throat) appeared in a row at the top of the screen and descended towards the bottom at regularly spaced intervals. The game player could move the set of icons up to two columns left or right as the icons descended. In order to score, the player had to make stacks of matching icons, and then correctly determine, by means of a key press, whether or not the icons represented a concussion symptom. A correct response moved the ‘puck’ upwards towards the opponents’ (computer) goal. A wrong response moved the ‘puck’ downwards towards the players goal. In addition, over time the ‘puck’ would drift downwards, eventually resulting in a ‘computer goal’. This was prevented by correctly stacking the icons. Pilot work revealed that children could learn to play Symptom Shock in a relatively short period of time. Post-game conversation with participants indicated that the game was fun to play.

**Study 1**

The first study was planned to determine if game content had an effect on knowledge acquisition.

**Method**

**Participants**

One hundred and thirty minor (youth) hockey players from the Kamloops Minor Hockey Association (interior of British Columbia, Canada) participated in the study. The athletes came from four Pee Wee teams (11–12 years, n = 44), three Bantam teams (13–14 years, n = 38) and four Midget teams (15–17 years, n = 48) whose coaches agreed to facilitate testing. Informed consent and ethical procedures conformed with guidelines of the University Research Ethics Board.

**Materials**

**Computer game.** An experimental (symptoms and non-symptoms) and control version of Symptom Shock were used. The control version used icons of either animals or faces. Participants played either the control game or the experimental version of Symptom Shock in this study.

**Concussion symptoms questionnaire.** A computerized 36-item checklist questionnaire was administered to all participants following completion of the game protocol to assess the effect of game content on recognition of concussion symptoms. The stem for all items was ‘Please check off if this symptom might be present when a person gets a concussion.’ Each item was listed with ‘Yes’ or ‘No’ checkboxes. Questionnaire content consisted of 12 symptoms, 12 non-symptoms, and 12 fillers. All 24 of the symptoms and non-symptoms were presented by iconic representation during game play to participants in the experimental group. The control group saw no symptoms or non-symptoms during game play. Fillers were not included in any game content. Time to complete the questionnaire was also recorded by the computer program.
Feedback questionnaire.  A computerized feedback questionnaire was administered following the concussion symptoms questionnaire. Information regarding concussion history, years involved in hockey, and video gaming habits and preferences was requested. In addition, participants were asked to rate specific game attributes, such as difficulty, clarity of instructions, and level of enjoyment. Answers were given on a seven-point scale ranging from 1 (very strongly disagree) to 7 (very strongly agree).

Procedure

Testing sessions were scheduled before a team practice. The first 10 players (with consent) to arrive at the practice were escorted to the testing location, which was a dressing room or a meeting room in the practice arena. Ten similar notebook computers were set up in advance of the session with five computers on each of two tables in staggered positions. Computers were randomly assigned to control and experimental settings and participants then sat as desired. A brief introduction to the game was provided by a member of the research team, and participants were informed that their team was competing against other teams of the same age division for a prize, based on success in playing the game. The prize was an incentive for players to pay close attention to the game rules and strategies. Then participants were asked to put on the supplied headphones. Basic demographic information was collected and the research team then checked each computer to ensure the subject was at the correct screen to start the instructions. Subjects were informed that clicking the “Instructions” button would start the game. They would then be able to follow the onscreen directions until the end of the procedure. Subjects were asked to attend to only his or her computer monitor, and not to talk to the other subjects during the procedure.

All participants listened to the instructions, which were accompanied by a worked example (video demonstration) to illustrate the rules and strategies of the game. A practice game (three 1-min periods) followed the instructions. No concussion content was available in this portion of the protocol. The program then moved into two games (three 1-min periods each) of the same version of Symptom Shock and seamlessly into the Questionnaire. When each participant had completed the test session, they were provided a sport beverage as a token of appreciation from the researcher, and then joined their other teammates preparing for practice. When all 10 participants finished the protocol, the remaining participants were escorted to the testing location and completed the same testing procedure.

Results

The age divisions imposed by the hockey association resulted in mean ages of 11.75 (s.d. = 0.58), 13.55 (s.d. = 0.56), and 15.58 (s.d. = 1.07) in the pee wee, bantam, and midget age divisions, respectively. Within each age division, control and experimental groups were well matched (maximum difference less than one month).

Game usability

Results of the game usability analysis revealed that most participants made appropriate combinations, even though not all resulted in goals. Total wins (70) outnumbered losses (45), which was consistent across the three age groups. There was no significant difference in game outcome (won versus loss) in the control versus experimental versions. Only three participants
failed to make any combinations (one control, two experimental), while only two made just a single combination (experimental).

### Concussion symptoms questionnaire

**Questionnaire score.** Scores on the symptoms portion of the questionnaire were analysed with a 3 (age divisions: pee wee, bantam, midget) × 2 (game types: control, experimental) ANOVA. Significant main effects were found for age division, $F(2,124) = 8.34$, $p < 0.001$, and game type $F(1,124) = 3.98$, $p < 0.05$. No interaction effects were revealed. These results, displayed in Table 1, suggest that exposure to concussion content via the computer game improved identification of concussion symptoms.

**Questionnaire completion time.** Time to complete the questionnaire was also analysed with a 3 (age divisions: pee wee, bantam, midget) × 2 (game types: control, experimental) ANOVA. Significant main effects were found for age division, $F(2,124) = 10.21$, $p < 0.001$, and game type $F(1,124) = 5.09$, $p < 0.05$. No interaction effects were revealed. These results, displayed in Table 1, suggest that exposure to concussion content via the computer game can increase the speed of recognizing concussion symptoms.

**Feedback questionnaire.** Feedback was requested regarding specific game attributes from those participating in the experimental version of the game. Interest in the game appeared inversely proportional to age, with over 90% at the pee wee level agreeing that the game held their interest, almost 75% at the bantam level, and just over 60% at the midget level. Fewer than one-third of

<table>
<thead>
<tr>
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<th>Age division</th>
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<tr>
<td></td>
<td>Pee Wee</td>
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<tr>
<td><strong>Control group</strong></td>
<td></td>
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<tr>
<td>Symptom score</td>
<td>9.6 (3.0)</td>
</tr>
<tr>
<td>Completion time</td>
<td>175.8 (46.8)</td>
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<tr>
<td><strong>Experimental group</strong></td>
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<tr>
<td>Symptom score</td>
<td>10.2 (2.9)</td>
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<tr>
<td>Completion time</td>
<td>156.6 (27.0)</td>
</tr>
<tr>
<td><strong>Combined</strong></td>
<td></td>
</tr>
<tr>
<td>Symptom score</td>
<td>9.9 (2.9)</td>
</tr>
<tr>
<td>Completion time</td>
<td>166.0 (39.0)</td>
</tr>
</tbody>
</table>

*Note:* Symptoms score represents total on knowledge questionnaire, out of 12.
Test time represents time spent completing the questionnaire, in seconds.
Significant main effects for score were found for age division, $F(2,124) = 8.34$, $p < 0.001$, and game type $F(1,124) = 3.98$, $p < 0.05$.
Significant main effects for time was found for age division, $F(2,124) = 10.21$, $p < 0.001$, and game type $F(1,124) = 5.09$, $p < 0.05$. 
participants agreed that Symptom Shock was difficult to play. Of these, 10% agreed strongly or very strongly, indicating that the current game difficulty is appropriate for short, single exposure testing sessions. Over 70% of participants disagreed with the statement that game play was frustrating, and half to three-quarters found the instructions easy to understand. Over half of the experimental group agreed that iconic representation was not completely clear.

Discussion

The goal of the study was to determine if a video/computer game could be an effective and enjoyable medium to educate youth, and the results appear to be positive. The participants found the game experience interesting. The game design appears well balanced—it seemed to have enough difficulty to maintain interest, but not so much as to lead to frustration. Even though there was an apparent ‘ceiling effect,’ with both groups scoring highly on the concussion symptoms questionnaire, the experimental group did score significantly better than the control group while completing the knowledge questionnaire in a significantly shorter time period. Therefore, it seems reasonable to conclude that video/computer games successfully conveyed positive information, in the domain of short-term recall at the very least. In addition, interest in the game ranged from 60% to 90% and frustration was ranked low, indicating that the underlying informative content of the game did not automatically render it boring or unpleasant to youth.

Study 2

In order to simplify administration of the test and further assess the ability of the game to convey information about concussion symptoms, the game instructions were changed to an interactive tutorial. This alteration to the game was assessed in Study 2.

Method

Participants

Thirty-nine minor hockey players participating in a Richmond Minor Hockey Association (RMHA) Bantam ‘C’ Tournament were included in the study. The athletes came from seven teams whose managers agreed to facilitate testing. Informed consent and ethical procedures conformed with guidelines of the Simon Fraser University Research Ethics Board.

Materials

Computer game. The Symptom Shock instructions were modified from a worked example with audio overlay to an interactive tutorial with audio overlay. The protocol was the same as Study 1.

Concussion symptoms questionnaire. The checklist questionnaire content was the same as used in Study 1, with a slight modification. The movement between questionnaire items was automated in order to reduce variability in time required to answer each question.

Feedback questionnaire. The feedback questionnaire was the same as used in Study 1.
Procedure

Test sessions were scheduled at the team’s convenience, however all team managers chose to have athletes tested within 1 h of finishing a tournament game.

Team players with completed consent forms were escorted to the testing location, a covered outdoor site for four sessions and an arena lobby for the final two sessions. Ten similar notebook computers were set up in advance of the sessions with seven computers on one table and three on a second for the first four sessions, and ten computers on a single table for the final two. The computers were set up in staggered positions and were randomly assigned to control and experimental settings. Participants then sat as desired.

The testing procedure was the same as in Study 1. When each participant had completed the test session, they were provided a sport beverage as a token of appreciation from the researcher.

Results

During the testing procedure, one participant was identified by the researcher as not taking part appropriately and his data was excluded from analysis a priori. A preliminary examination of symptom score, questionnaire completion time, and responses to the feedback questionnaire, which was carried out blind to condition (experimental or control) resulted in the exclusion of a further five subjects due to highly anomalous (outlier) scores (2 S.D. from mean). All participants were Bantam age hockey players ($M = 13.48$ years, $S.D. = 0.619$), and random assignment to control and experimental groups resulted in no observable age difference between groups.

Game usability

Based on the win/loss/tie record of the participants, they appeared to understand game play with all but three of the participants (one control, two experimental) made at least four combinations. When considered with respect to the bantam group in Study 1, participants in this study won more (72.7%), lost less (21.2%), tied less (6.1%). In over 78% of the games played, participants scored at least one goal.

Concussion symptoms questionnaire

Questionnaire score. Group means and standard deviations are shown in Table 2. Scores on the symptoms portion of the questionnaire were analysed with a one-way (game types: control,

<table>
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<th>Table 2</th>
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<tr>
<td>Means (and standard deviations) for age, score on the symptoms questionnaire, and test completion time by game type</td>
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<td></td>
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<tr>
<td>Age</td>
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<td>Symptoms score</td>
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<td>Test time</td>
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Note: Age represents age in years. Symptoms score represents total on knowledge questionnaire, out of 12. Test time represents time spent completing the questionnaire, in seconds. *Significantly different from control game, $p < 0.05$. 
ANOVA. The difference between control and experimental groups just failed to reach statistical significance, $F(1,33) = 3.96, p = 0.055$, with the experimental group tending to score higher than controls.

**Questionnaire completion time.** Group means and standard deviations are shown in Table 2. Time to complete the questionnaire was analysed with a one-tailed independent $t$-test. There was a significant difference between control and experimental groups, $F(1,33) = 6.54, p = 0.015$, with the experimental group completing the test more quickly than controls.

**Feedback questionnaire**

While cross-experimental comparisons must be treated with caution, there appeared to be some differences in the response distribution for statements concerning difficulty and instruction when the data was compared to the Bantam group in Study 1. Fewer participants (12%) agreed that Symptom Shock was difficult to play, and more (76%) disagreed. Agreement that the instructions were easy to understand increased from just over half to 65%. These variations could possibly be attributed to improvements in the instructions. Overall, responses regarding frustration changed little; however, more participants in Study 2 very strongly disagreed with the statement “I got frustrated while playing”. While agreement that the game maintained interest was lower (53%), disagreement with the statement was also slightly lower, as a much larger proportion of Study 2 participants chose the response “Not Sure.” A similar trend was observed for the statement with reference to icon clarity.

**Discussion**

The results from Study 2 essentially replicated those of Study 1. The experimental group performed significantly better than the control group on the symptoms questionnaire, in a significantly shorter time span. The control group, whose symptoms score was significantly lower, still scored very well, again revealing a ‘ceiling effect.’ Following replacement of the worked example with an interactive tutorial, statements regarding game difficulty, instructions, and frustration all changed in the desired manner; more participants disagreed that Symptom Shock was difficult to play and that they were frustrated while playing the game, and more participants agreed that instructions were easy to understand. In addition, the group in Study 2 exhibited greater success with respect to winning/losing Symptom Shock, which may also be attributed to improved instructional technique. While more participants in this group responded ‘not sure’ to the statement regarding interest in the game, the atmosphere of the testing procedure may be the underlying factor. Since testing was conducted at an official hockey tournament, the testing procedure was most likely a considerably lower priority than any matters directly related to tournament performance.

**General discussion**

In both Study 1 and 2, we demonstrated a positive use for video/computer games in a population of hockey players, with respect to an injury prevalent in the sport. Information can be
successfully conveyed by playing a computer game, and without obviating the inherent purpose of the game. It should be noted, however, that we only examined short-term retention of the information. Follow-up data over an elapsed time would have clearly strengthened our arguments. In the context of endogenous fantasy in Symptom Shock, goals cannot be scored (and the game consequently won) without correct identification of concussion symptoms, but without the purpose of scoring goals, there would be no incentive to identify the symptoms. Based on our results and this model, we feel Symptom Shock can be used to teach hockey players about concussion symptoms.

In light of the high scores on the symptoms portion of the questionnaire posted by both the bantam and midget aged controls, future efforts using Symptom Shock will be targeted at pee wee and atom aged hockey players. The 11 and 12 year olds in Study 1 scored well, but there is still room for improvement. The current knowledge of Atom players, aged 9 and 10, has yet to be established, but we expect it to be lower than that of the pee wee group, and therefore these youth may benefit from playing Symptom Shock.

However, perhaps of more tangible significance is that video gaming has the potential to be a method of providing information regarding matters of importance. This could extend to issues beyond concussion in the sport of ice hockey (bodychecking, for instance), and clearly beyond the sport of hockey and its athletes.

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References


