Computer Gaming and Driving Education

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Abstract: This study investigates the learning effects of playing racing, action, and sports computer games. In particular we focus on traffic school students' driving behavior. A survey conducted at three driving schools, questioned driving students about their gaming habits. The driving instructors evaluated their students' driving skills and traffic safety attitudes. The results indicate that experience in computer games can have a positive effect on driving performance. Experienced gamers were ranked significantly higher by their instructors regarding their overall driving skills compared to students with low experience in computer games. However, no evidence was found to indicate that experienced gamers have a worse attitude towards fellow road-users or traffic safety.
Experiments conducted in a driving simulator, using a game developed purposely to enhance certain traffic safety variables, reveals that it is possible to provide an entertaining game with serious content. Preliminary results, however, indicate that the version of the game where the explicit game goals are hidden was found to be the most entertaining one.
The results of the investigation warrant further review into the development and utilization of computer games for traffic safety and education purposes.

Keywords: Serious games, computer game effects, learning from games, traffic safety, traffic education, driver attitude, driving behavior, driving skill

Introduction and Background

There is an increasing interest in the positive and negative effects of computer games on human beings as well as on various aspects of society. A brief review of reports of such effects indicates an increasing interest for computer games in a number of areas outside the entertainment industry [13]. We also found that there are effects from playing computer games outside the actual scope of the games such as the indirect effects on various everyday life situations. Several of the mentioned aspects are addressed within the field of *serious gaming*. Zyda [23, p. 26] defines:

> "Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives."

Hence, the idea is to use advanced computer gaming technology to provide new ways for people to learn, analyze, and explore [12, 17, 18]. Indeed, there are reports on how gamers develop their thinking strategies towards more analogical thinking rather than trial-and-error thinking [11]. This document reports the results of the survey regarding the effects of gaming habits on driving behavior. We investigated the effect(s) of commercial games used for entertainment purposes as well as of a game designed with an educational goal in mind. We acknowledge that some applications of three-dimensional visualization and simulation in car driving education, e.g. (http://www.roadquiz.com), and (http://www.bonnierstrafikskola.se) exist. However, none of these applications can be characterized as games. Blackman [2] describes the *3D Driving Academy*

(http://www.3d-fahrschule.de) as being more gamelike. We consider this program primarily an educational tool, as opposed to a game which is the focus of our attention. The remainder of the document is organized as follows: Section 1 represents reports from various areas concerning the effects of computer games on human and social behavior. Section 2 describes the societal impact of games. In Section 3 we present a study of the effects of playing computer games on driving behavior. In Section 4 we present preliminary results from experiments using a driving game developed to promote sensible driving behavior. The results are then summarized and consideration for further investigation is discussed.

1. Effects on Human and Social Behavior

The effects of computer games have been studied from various perspectives. Michael and Chen [13] report effects of playing computer games on skills such as ability to multitask, team work and target prioritization.

Enochsson et al. [6] report on a positive correlation between experience in computer games and performance in endoscopic simulation by medical students. The better performance of gamers is attributed to their three-dimensional perception experience from computer gaming. Similarly, in architecture and design, computer games can be used as a means of developing student confidence and abilities in spatial modeling, design composition, and form creation [3, 16]. Guy et al. [10] suggest playing with three-dimensional models as a means for enhancing town planning. Moreover, De Lisi and Wolford [4] report on how spatial abilities, more precisely, the capacity for mental rotation can be improved by playing games such as Tetris.

There are also reports in the area of educational sciences and psychology of positive consequences from playing computer games. Experiments, where the test group used specially designed software for attention training, showed that even nonsystematic experience with computer games improved attention behavior of children [14]. Furthermore, game elements such as competitive scoring, increasingly difficult levels, and role playing have proven useful in corporate training [22]. Further examples of similar applications are the *World Hunger Food Force* (http://www.socialimpactgames.com) from the UN World Food Programme and *America's Army* (http://www.americasarmy.com) sponsored by the U.S. Army. Even though America's Army is a traditional *first person shooter* game in many aspects, it has proven to be a major source of information and knowledge for its target audience. According to a study made by the Army, 30% of Americans between the ages 16 to 24 claim to have learned some of what they know about the Army from this game [9].

Squire and Steinkuehler [19] report that playing on-line community games actually is a matter of creating knowledge together, being an activity which fosters various types of information literacy as well as developing information-seeking habits. These activities are examples of required knowledge in order to find information in any library or on the Internet. In summary, computer games have been used for various kinds of interactive training and information efforts. We also note that there are some positive effects of gaming which are not associated with any specific training or information objectives.

Negative effects of gaming, such as increased aggressiveness, are still under debate. Baldaro et al. [1] evaluated short term effect on physiological (arterial pressure and heart rate) and psychological (anxiety and aggressiveness) factors of playing video-games. The study was conducted on expert players and the results indicate short term effects on physiological factors from playing violent games as opposed to non-violent games. However, the results showed no effect on hostility measurements. We find these results ambiguous thus indicating a need for more investigation. To a large extent the debate

concerning negative effects of (violent) computer games resembles the debate on effects of video violence. However, according to a survey by Durkin and Barber [5] there is no evidence of effects on measures of aggressiveness. On the contrary, some experiments actually indicated reductions in aggression.

Table 1 summarizes the literature review. The categories are relevant to traffic safety research [15].

Table 1: Overview of reported effects.

	Motor skill/ spatial	**Educational/ informational**	**Social**	**Physiological**
Enochsson et al. [6]	*			
Guy et al. [10]	*			
Radford [16]	*			
De Lisi and Wolford [4]	*	*		
Navarro et al. [14]		*		
Grossmann [9]		*	*	
Squire and Steinkuehler [19]		*	*	
Baldaro et al. [1]			*	*
Durkin and Barber [5]			*	
Hong and Liu [11]		*		

We note that the literature review did not reveal any studies on the effects of computer games on driving skills.

2. Societal Impact

Although computer games have existed for decades the established attitude towards games are still based on old stereotypes. Statistics from the Entertainment Software Association [7] show an increasing diversity in gaming. The typical gamer is no longer a teenage boy, in fact 43% of all gamers are female and women over 18 represent a larger portion of the game-player population than do boys from 6 to 17. In total 43% of the computer games consumers are in the ages 18-49 years. Regardless of this, most games on the market target boys and young men [8]. Gorriz and Medina [8] report that a seemingly low participation of girls in computer games is not due to a lack of interest but rather a lack of engaging and compelling content for girls. The new statistics from ESA [7] may hence indicate a slight change in the matter of gender diversity. These trends entail new potential areas for using games as well as for taking advantage of the positive (indirect) effects of playing any type of computer game.

These effects may be further utilized if we can identify the correct content and accurately exploit the user's experience as a driving force for developing serious games. Swartout and van Lent [20] identify the areas of experience-based systems and experience-based education as potentially benefiting from such a game-based approach. The general idea is to influence users by exposing them to some type of experience. However, there are reports of the shortcomings of serious games stating that education, science and healthcare do not provide exciting entertainment as real-world simulators [21]. There are good games helping society but without good public relations people will never know about them [21]. Even though gaming is not a replacement for simulation it may well serve as a compliment in some regards [18].

To summarize, we note that there is still much to do in terms of identifying suitable areas for serious games as well as improving the utilization of positive side-effects of commercial computer games. We also note that there are reports indicating positive effects of playing computer games on other, non-game aspects of human performance. These observations in combination with reports of increased diversity in gaming lead us to explore new societal areas such as driving behavior and traffic safety since large groups in society are affected. What are the potential effects of computer games in driving education?

3. Traffic School Survey

The research concerning effects of computer gaming on driving behavior was conducted at three local driving schools during December 2005 and January 2006. In the study, students at the three driving schools rated their experience in racing, action and sport games (*RAS-games*) in a questionnaire. We choose RAS-games since we wanted to capture the aspects of motor and coordination skills. Furthermore, such games are often perceived as violent and destructive [1]. A total of 64 students participated and 56 of these were matched with instructor evaluations. We asked the instructors to evaluate their students compared to their perception of an average student. In one case the instructor misinterpreted the rating scale, which is the explanation for the reduction from the original 64 to 56 evaluations actually analyzed. The 56 subjects were in the ages 18−31 ($\chi = 19.98$, $\sigma = 3.18$) divided on 35 women (60%) and 21 men (40%). The number of participants from each of the driving schools was 14 (25%), 31 (55%) and 11 (20%), respectively. The instructors rated their students' ability regarding a set of driving behavior variables which we identified from relevant traffic safety research, e.g. [15]. We divided the variables in two, skill and attitude. Skill variables describe the capacity for divided attention, quick decision making, and risk assessment. Attitude variables describe the attitude towards driving with safety margins, keeping speed limits, and considerateness towards fellow road-users.

The instructors were also asked to judge the overall driving skill and overall attitude in terms of their students' mental state involving beliefs, feelings, values, and dispositions to act in certain ways. Both skill and attitude variables were measured as absolute values, i.e. the instructors' judgment of current skills and attitudes. In addition, the instructors rated their students' relative development, i.e. how the students have evolved during their driving training. The students were categorized into one of two distinct groups depending on their experience in RAS-games. Subjects whose maximum rate was 1-2 (of 5) were classified as "non-gamers" (27 students). Whereas those with a maximum rate of 4-5 were classified as "gamers" (12 students). Effects of gaming experience on driving behavior were analyzed using group belonging and driving behavior variables as independent variables and instructors' ratings (using a 7-graded Likert scale) as the dependent variable. The differences between each of the driving variables for the two groups were tested with Student's t-tests.

Gamers were ranked higher than non-gamers for all four skill variables (Table 2) and three of them, capacity for divided attention, handling situations requiring quick decisions and overall driving skill, were statistically significant. Concerning attitude variables the results are less clear. However, there was a statistically significant difference between non-gamers and gamers in their attitude towards driving with safety margins. Gamers were more aware of the necessity of driving with safety margins.

Table 2: Average ratings for skill and attitude (significant differences in bold).

Skill	**Non-gamers**	**Gamers**	**P (t-test)**
Capacity for divided attention	**3.1**	**4.3**	.001
Handling situations requiring quick decisions	**3.0**	**4.8**	.000
Risk assessment in critical situations	3.9	4.4	.146
Driving skill, overall	**3.9**	**4.9**	.016
Attitude towards			
Driving with safety margins	**3.7**	**4.5**	.047
Speed limits	4.9	4.9	.491
Fellow road-users	4.9	4.8	.399
Attitude, overall	5.4	5.3	.422

The results from the evaluation of the students' skill and attitude development are summarized in Table 3.

Table 3: Average ratings for change in skill and attitude (significant differences in bold).

Skill	**Non-gamers**	**Gamers**	**P (t-test)**
Capacity for divided attention	**4.8**	**5.7**	.002
Handling situations requiring quick decisions	**4.6**	**5.9**	.000
Risk assessment in critical situations	5.3	5.8	.053
Driving skill, overall	**5.4**	**6.1**	.009
Attitude towards			
Driving with safety margins	**5.3**	**6.0**	.020
Speed limits	5.9	5.9	.433
Fellow road-users	5.7	5.8	.386
Attitude, overall	5.9	6.2	.195

Table 3 shows the same pattern for skill and attitude development as does Table 2 concerning the absolute judgments. Gamers were ranked higher for all skill variables, three of them statistically significant. Similarly, the only statistically significant difference concerning attitude variables was found on the attitude towards driving with safety margins.

We also tested whether any of the differences may be attributed to gender. However, we only found one systematic correlation with respect to the skill in handling situations requiring quick decisions.

4. A Serious Driving Game

In ongoing research we have conducted experiments with a selection of the driving school students participating in the survey. A driving game has been developed with an explicit goal to promote sensible traffic behavior. The objective is to investigate how the positive effects of computer games, reported above, can be more intentionally exploited in traffic

education. In these experiments we use an advanced gaming environment where the player sits in a real car, using its original controls, with front, side, and rear views of the game (Figure 1). The environment, which strongly enhances the gaming experience, is built using off the shelf hardware components.

Figure 1: The gaming environment used in the ongoing experiments.

The game itself has been developed in collaboration with traffic safety expertise and a major Swedish insurance company. In the game, the player is driving a car on a five-lane motorway. The goal is to follow an ambulance heading for a hospital. The mission fails if the driver looses the ambulance out of sight or violates traffic rules with respect to speed, lane-changing and distance to vehicles in-front. When a mission is completed the player receives a grade and advances to a higher level unless the grade is a "fail". The levels differ in traffic intensity, fellow road-user behavior and weather conditions.

An important goal with the game has been to maintain a high entertainment value in combination with serious traffic safety aspects. To test the entertainment-value of the original game, a second version of the application has been developed, a "non-game", where the game task has been removed. In the "non-game" players are not instructed to follow the ambulance and they are not given grades. The "non-game" and the game are identical apart from these differences.

In the experiments 12 driving school students were instructed to play the game and 12 students to use the "non-game". In both cases students were instructed to freely explore the application using all the time they wanted. When a student had finished the free driving, the experiment session continued with a number of evaluative tests and a questionnaire.

By letting the students themselves decide how much time to spend and how to interact with the application we have been able to evaluate the effectiveness of the game task. It is believed that voluntarily spending more time implies that the application is more interesting and entertaining. Preliminary results from the experiments indicate that students who played the game spent slightly more time than those using the "non-game". In the questionnaire, students were generally positive towards the entertainment value of the applications. Surprisingly, "non-game" students were significantly more positive compared to players of the game. Concerning the statement "it was fun to drive" the "non-game" users had an

average of *4.8* on a 5-graded Likert scale (where 1=fully disagree and 5=fully agree), whereas the players of the game had an average of 4.1. It is apparent that game task had a negative impact on the entertainment value of the game. A possible explanation is that the removal of constraints, i.e. to follow the ambulance, made the application more interesting to explore. Some student-remarks also indicate that they invented their own game objectives while driving.

The effect on traffic safety behavior seems to be the same for both versions of the application, based on preliminary analysis. As an example, the amount of correct lane changes is significantly higher in the end compared to the beginning of the experiment session. This implies that game design elements that were introduced to increase the entertainment value had little or negative effect on the outcome of the experiments.

5. Conclusion

Our results indicate a positive correlation between gaming and some skill oriented aspects of driving and that gaming seems to have no negative effects on attitude oriented variables, rather the opposite. Furthermore, the positive effects of gaming on driving behavior seem to concern absolute skill levels as well as their progression. The effect on driving skill corresponds well with results from other, but related, research areas and may be attributed to motor and coordination training. Moreover, the lack of negative effects regarding attitude, contrary to the common opinion in mass media, is in line with some other research. However, the issue is still under debate and hence our result may contribute to a more diversified understanding of this phenomenon. Since we find such clear relations between gaming habits and traffic behavior we expect that games can be further utilized in terms of enhancing driving skills as well as in developing an improved traffic safety culture, thus being of great value for society. The paper reports on a pilot study in a novel area. Further work is needed to fully understand the underlying mechanisms in order to utilize their positive effects.

Preliminary results from experiments with a serious driving game indicate that it is possible to develop entertaining driving games that promote sensible traffic behavior. Two versions of the application were developed. The one without an explicit game task was considered to be more entertaining than the one where the player was given a task. It appears that the principle “less is more” may be applicable to the field of serious games. In some aspects a free game design may be preferable over missions targeted on educational goals. This is an important experience as it suggests that serious game designers may relax constraints and still achieve the educational goals.

An increased diversity in gaming will require more diversity in products. One such line of development is in serious gaming where there is a need both for targeting a new audience as well as for finding interesting applications for existing groups of users. Our results show no or very little difference with respect to gender. We find this interesting for two reasons: firstly, it indicates that it actually is gaming habits which has an effect; secondly, in our future work we want to target an audience of both genders and hence need to start exploring how games of such type that has an effect on car driving can attract diverse groups of users represented in driving education.

What is the potential for using games in a traffic safety context? Firstly, since it seems that gaming in general has a positive effect on some aspects of car driving we envision the possibility of using commercial racing, as well as action and sport, games for training certain capabilities, e.g. reaction time and capacity for divided attention, for some target groups. Secondly, we intend to explore the area of serious games as a means for influencing

traffic safety culture. Thirdly, we see the potential for developing more advanced gaming environments resembling simulators. These may then be used for simulation-based training. Hence, it is an issue of selecting/combining the right type of experiences for a specific target group. In relation to this, there is a need to further develop pedagogical aspects of using computer games as well as conventional simulators in traffic education.

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References

[1] Baldaro, B., Tuozzi, G., Codispoti, M., Montebarocci, O., Barbagli, F., Trombini, E., and Rossi, N. 2004. Aggressive and non-violent videogames: short-term psychological and cardiovascular effects on habitual players. *Stress and Health* 20, 4, 203–208.

[2] Blackman, S. 2005. Serious games...and less! *SIGGRAPH Computer Graphics* 39, 1, 12–16.

[3] Coyne, R. 2003. Mindless repetition: learning from computer games. *Design Studies* 24, 3, 199–212.

[4] De Lisi, R., and Wolford, J. L. 2002. Improving children's mental rotation accuracy with computer game playing. *Journal of Genetic Psychology* 163, 3, 172–182.

[5] Durkin, K., and Barber, B. 2002. Not so doomed: computer game play and positive adolescent development. *Journal of Applied Developmental Psychology* 23, 4, 373–392.

[6] Enochsson, L., Isaksson, B., Tour, R., Kjellin, A., Hedman, L., Wredmark, T., and Tsai-Fellander, L. 2004. Visuospatial skills and computer game experience influence the performance of virtual endoscopy. *Journal of Gastrointestinal Surgery* 8, 7, 874–880.

[7] ESA, 2005. Game player data. Retrieved 2005-04-13, from http://www.theesa.com/facts/gamer data.php.

[8] Gorriz, C. M., and Medina, C. 2000. Engaging girls with computers through software games. *Communication of the ACM* 43, 1, 42–49.

[9] Grossman, L. 2005. The army's killer app. *Time* 165, 9, 43–44.

[10] Guy, B., Bidwell, N. J., and Musumeci, P. 2005. Gameplan: Serious gaming for place making. In IE2005: Proceedings of the second Australasian conference on Interactive entertainment, *Creativity & Cognition Studios Press*, Sydney, Australia , 252.

[11] Hong, J.-C., and Liu, M.-C. 2003. A study on thinking strategy between experts and novices of computer games. *Computers in Human Behavior* 19, 2, 245–258.

[12] Lopiccolo, P. 2004. Serious games. *Computer Graphics World* 27, 2.

[13] Michael, D., and Chen, S. 2006. Serious games: Games that educate, train, and inform. *Thomson Course Technology*.

[14] Navarro, J. I., Marchena, E., Alcalde, C., Ruiz, G., Llorens, I., and Aguilar, M. 2003. Improving attention behaviour in primary and secondary school children with a computer assisted instruction procedure. *International Journal of Psychology* 38, 6, 359–365.

[15] Nyberg, A., Henriksson, P., Nolén, S., and Engström, I., 2002. Körbeteenden som mäts med instrumenterade bilar i verklig trafik. (In Swedish, Driver behavior measurements in instrumented cars in real traffic). *VTI notat* 53-2002, Swedish Road and Transport Research Institute (VTI), Linköping, Sweden.

[16] Radford, A. 2000. Games and learning about form in architecture. *Automation in Construction* 9, 4, 379–385.

[17] Sawyer, B., 2002. Serious games: Improving public policy through game-based learning and simulation. *Foresight and Governance Project Woodrow Wilson International Center for Scholars*. Retrieved 2005-04-13, from http://wwics.si.edu/subsites/game/index.htm.

[18] Sawyer, B. 2004. The serious games summit: emergent use of interactive games for solving problems is serious effort. *Computers in Entertainment* 2, 1, 5.

[19] Squire, K., and Steinkuehler, C. 2005. Meet the gamers. *Library Journal* 130, 7, 38–42.

[20] Swartout, W., and Van Lent, M. 2003. Making a game of system design. *Communication of the ACM* 46, 7, 32–39.

[21] Terdiman, D., 2006. What's wrong with serious games? Retrieved 2006-04-10, from http://news.com.com/2100-1043 3-6052346.html.

[22] Totty, M., 2005. Better training through gaming. *Wall Street Journal - Eastern Edition* 245, 80, R6-0.

[23] Zyda, M. 2005. From visual simulation to virtual reality to games. *Computer* 38, 9, 25–32.