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# VIDEO-GAMES: A VIRTUAL TRAINING GROUND FOR VISUAL SKILLS - APPLICATIONS IN MEDICINE AND AVIATION

Łukasz MALANOWSKI
University of Warsaw, Faculty of Psychology, Department of Cognitive Psychology, Poland

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**Author's address:** Ł. Malanowski, University of Warsaw, Faculty of Psychology, Department of Cognitive Psychology, Stawki 5/7 r. 206, 00-183 Warszawa, email: lmalanowski@psych.uw.edu.pl

**Background:** The main goal of this article is to present a broad range of cognitive skills, vision-related skills in particular that become improved by playing video games as well as to describe classical methods used in the assessment of such improvements. The publication also presents a brief description of the emergence of video games as a powerful medium and a part of our lives. Choice of studies used in this article was based on their usefulness to occupational training and safety, particularly in the fields of medicine and aviation. Article presents several examples of current and future video game applications. Simulators are presented as a milestone of what was already achieved using video game-based training and as a limit that can be pushed even further, using different approaches.

**Keywords:** cognition, occupational training, pilots, simulators, surgeons, video games, visual skills

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## INTRODUCTION

Video games came a long way over the years, evolving from text-based interactive stories and MUD's, through simple graphic arcade games, to photorealistic masterpieces they are today. Graphics, although very important, are not the only thing that has changed over the years. Games matured as a medium, grew in complexity, advanced interfaces and, most importantly, realism and emulation of physical dynamics. At the same time, they became available to billions of people around the world. They also became very diverse, dividing into multiple game genres and game-like creations, thus it is hard to settle for one simple definition of a video game. For the purpose of this publication I will be referring to games as interactive virtual environments. This proposed definition is an attempt to capture the full spectrum of what we call games, not only products created for pure entertainment, including simulators designed to train a fixed set of skills or serious games focused on education, science, planning and management in different fields.

Serious games are basically games developed for other purposes than entertainment. As such, they include teaching, learning and training in various fields, usually pertaining to aviation, military, space and surgery [28]. Simulators in particular are designed to train a very narrow set of skills, often practicing scenarios that would prove risky, costly and very demanding under real-life conditions. Simulators are also very different from regular games in several aspects - in most cases they require special hardware and need to perfectly emulate physics of the real world (aviation) and human biology (surgery).

Whether intentional or by chance, modern video games have also proven as excellent cognition-enhancing and learning tools. Scope of cognitive improvement ranges from visual information processing-related abilities [1,14,18,19,29], vision-movement coordination skills [15,22] and various attention skills [5,7,10,16,20], through working memory [7,25,27], mental rotation [8] and processing speed [9], to modification of perceptual templates [4]. More importantly, enhancements observed in game environments extend well beyond their boundaries [17]. These improvements may differ based on the type of game and are highly dependent on general quality of the game. Successful video games incorporate many design elements that support learning, such as: accessible learning curve, environment that encourages investing considerable amounts of time in gaming and regular reinforcement [11]. Substantial amount of video game-related research comes from action video games characterized by detailed, stimuli-rich 3D environments, fast pace of gameplay, rapid task-switching demands and need to make quick and accurate actions [17].

Even though simulator training has been deeply incorporated into modern learning modalities in aviation and surgery, there are several studies showing that common entertainment-focused video games may improve those field-specific skills to even greater extent [21,30,32] or might potentially serve as surrogate training path [26].

In the subsequent parts of this article I will focus on presenting a broad spectrum of visual skills that can be trained using video games by reviewing exemplary or (whenever possible) outstanding studies on cognition enhancement induced by video games. Final section will consist of proposed future directions of research and potential applications for video games with particular emphasis on surgery and aviation.

## ENHANCEMENT ASSESSMENT METHODS

There are multiple available paradigms used in video game-induced visual processing enhancement studies, some in common use, such as Useful Field of View (UFOV), Attentional Blink (AB) or Motion Object Tracking (MOT) task variations [27,29], others more exotic, such as proposed use of an actual video game (Space Fortress) as a design base for creating interactive information processing tasks [31]. Some of the practical skills assessment methods (e.g. flight simulators) are video games themselves [28].

## VISION AND ATTENTION

Vision-related cognitive skills improved by video game training include spatial and temporal resolution of vision, capacity, distribution and dynamics of visual attention and contrast sensitivity function [1].

In their studies on spatial resolution of vision Green and Bavelier utilized an effect known as crowding. They measured the minimum distance between distractor and key stimulus that does not compromise identification of the key stimulus using a simple stimulus-recognition task. Results show significant differences in the crowding effect between video game players and non-video game players in favor of VGPs. Similar differences were observed in the group of NVGPs, tested before and after 30 hours of training in Unreal Tour-

nament 2004 (action-video game test group) and Tetris (non-action-video game control group), with greater improvement observed in the test group. This proves a causative relationship between playing video games and reduction of the crowding effect. Improvements were consistent across all tested eccentricities, including regions well beyond zone trained in the video game [1,18].

Li and colleagues [24] conducted studies on temporal resolution of vision using backward masking paradigm. A group of gamers and non-gamers were asked to decide whether a key stimulus (Gabor patch) was presented in one of two intervals. Key stimulus was accompanied by orthogonal or collinear mask or was presented in isolation. Gamers proved to be more resilient to both types of masking than non-gamers. The experiment was followed by a training study, in which non-gamers were assigned to either 50 hours of Call of Duty 2 (action video game) or Sims 2 (non-action video game) training. Results showed significant improvement in resilience to masking only in the action video game training group. This supports the concept of different types of games being able to train certain sets of skills while not affecting other skills. Experiments using simultaneous and forward masking were also conducted, but showed little to no differences between non-gamers vs. gamers or untrained vs. trained non-gamers [1,24]. Proposed explanation for such augmentation is that gaming leads to increase in sensory information integration efficiency, whether by noise exclusion or signal amplification remains unclear [1].

Li and colleagues [23] also studied effects of playing video games on contrast sensitivity function using simple CSF procedure, in which participants were trying to detect key stimuli (low-contrast Gabor patch) in one of two intervals. To ensure everyday eyesight conditions, participants were allowed to use glasses matching their current eyeglass prescriptions. Methodology was similar to previous studies on temporal resolution of vision: comparison and training studies were conducted. The training study consisted of action video game (Unreal Tournament 2004 and Call of Duty 2) and non-action video game (Sims 2) training groups. Improvement in contrast sensitivity and respective integration time were observed in both VGPs and NVGP trainees (stronger effect in the action video game training group). It was the first report of the effects of training on CSF in adults at the time [23].

In order to examine how playing video games affects visual attention, Green and Bavelier [16-19] performed a series of tests consisting of flanker compatibility task, enumeration task, useful field of view task and attentional blink task. Substantial differences in attentional capacity between VGPs and NVGPs were observed in flanker compatibility task and enumeration task, with VGPs having residual attentional resources "spilling over" distractors after apprehending target stimuli across all task difficulties. VGPs were also able to apprehend more target stimuli in general. VGPs performed better than NVGPs in the UFOV task across all eccentricities, inside the trained zone, on the border and outside the trained zone, presenting superior attention distribution skills and their transfer beyond regions trained during gaming. In order to examine the differences with regard to task-switching and temporal dynamics of attention between VGPs and NVGPs, AB task was used, in which participants were asked to apprehend two consecutive stimuli by identifying the first and detecting the second one. VGP performance was better across all five lags with the biggest difference observed in early lag and decreasing over subsequent intervals. Training study was also conducted with similar differences being observed in NVGP trainees tested before and after 10 days of action video game and non-action video game training. The following video games used in training: Medal of Honor: Allied Assault (action video game) and Tetris (non-action video game) [16].

## VISION - MOVEMENT COORDINATION

Even though video game-induced cognition and vision improvements are well-documented, research regarding vision-movement coordination in video game players is relatively new and focused mostly on brain plasticity [22], with little attention paid to performance and skill acquisition [15,22].

Work by Lee and colleagues [22] is an example of such research. They studied how different training strategies in Space Fortress game affect brain function with regard to several visuomotor tasks. Training groups were split into three different groups: Full Emphasis Training, Variable Priority Training and Control Group. Visuomotor tasks that followed required precisely coordinated wrist, finger and hand movements with a joystick or a keypad in response to material presented on the screen. Participants also took part in MRI examinations, both before and after training. Results show that brain processes connected to performing visuomotor tasks are subject to change by training, most important being a decrease in brain activation in regions responsible for visuomotor process-

ing, which is consistent with improvements in task performance. This is explained by reduction in the costs of cognitive resources engaged in task performance [22].

In their studies on manual movement tracking Gozli, Bavelier and Pratt [14] used two different tracking tasks: one with repetitive movement pattern and one with changing movement pattern, both split into several trials. Participating VGPs and NVGPs were tested in both tasks. Results show no significant differences in initial results under repetitive movement pattern conditions. Instead, VGPs showed significantly faster skill acquisition between trials, outperforming NVGPs greatly in final trials. Differences with respect to performance in changing movement pattern conditions were not observed. Authors conclude that, while not directly affecting visuomotor skills, playing video games improves sensorimotor learning [15].

## PRACTICAL APPLICATIONS:

In response to an increasing number of reports that playing video games (especially action video games) can augment human visual processing skills and cognitive skills in general, several potential applications were proposed and studied. Those include rehabilitation - fighting cognitive decline in the elderly [5,11] along with reducing the risk of Alzheimer's disease [11], retraining people with amblyopia (lazy eye disorder) [11,17,23], and improving job-related skills in several fields. Recently, particular interest in video game training can be observed in fields of aviation and medicine. Even though both fields have already incorporated simulator training as official learning path for pilots and surgeons respectively, there are studies suggesting that regular engagement in playing video games can improve occupational skills of pilots and surgeons beyond what can be achieved using current learning paths, including simulator training [13,14,21,30,32,33].

Rosser and colleagues conducted a study on the effects of game playing on laparoscopic skills by comparing a group of surgeons with past gaming experience, present gaming experience and no gaming experience using several methods. Questionnaires were used to assess surgical experience, gaming experience, hand dominance and gather basic demographic data. Top Gun Program tasks and drills were used to assess surgical skills and three video games were used to assess gaming skills. Results showed that surgeons with previous video game experience and current video game experience make fewer errors, are faster and achieve better scores then their non-video game-playing colleagues. Study also showed high correlation between laparoscopic skills and gaming skills [33].

Video games can also be used as short-term performance booster for surgeons, as demonstrated in studies on video game warm-up by Rosser and colleagues [32,33]. Top Gun Program tasks and drills were used to compare laparoscopic skills of surgeons using such a warm-up with the control group. Warm-up involved playing Super Monkey Ball 2, Star Wars Racer Revenge and Silent Scope. Surgeons using video game warm-up (lasting up to 20 minutes) scored higher in Top Gun, performing faster and with fewer errors overall [32].

In their research on skill transfer from video game to flight Gopher, Weil and Bareket [13] used modified Space Fortress game tuned for two game training scenarios, one being a normal gameplay and the other stripped down to seven partial tasks. One control group and two test groups were created, one trained with both scenarios and one using only general enhancement scenario. All participants were flight cadets in Israeli Air Force. Flight performance was evaluated using jet trainer, while general vocational skills were assessed using air force selection test battery. Results show no differences in flight skills between the two test groups, even though their in-game scores differed greatly in favor of the group trained with both scenarios. The control group scored substantially poorer in their flights then the test groups. Modified Space Fortress game has been incorporated in preliminary pilot training in the Israeli Air Force since then.

In response to raising demands for MQ-1 and MQ-9 drone operators and shortage of available pilots, McKinley and colleagues suggested use of video game players as potential operator candidates [26]. They used several methods to test whether gaming skills transfer to unmanned aerial system (UAS) flight skills. A computer-based test consisting of eight tasks was used to assess participants' cognitive skills. Tasks ranged from simple cognitive tests (delayed matching to sample, spatial recognition memory), through complete test batteries (MAT-B, G-PASS) to UAS simulator scenarios. Participants consisted of three groups of experienced pilots, video game players and a control group without previous gaming or pilot experience. Results showed little to no difference in UAS operating performance between players and pilots, with the control group performing significantly worse. Video game players also proved to be superior in identifying, finding and tracking visual targets. Thee results demonstrate players' suitability to become surrogate UAS operators [26].

## GAMING CRITICISM

Studies presented in this article this far may create an impression that using video games as a training method is a perfect solution. While in terms of human cognition alone this may be the case, there are several studies showing potential downsides of gaming in other areas, most important being: increased aggression in FPS/combat gamers [2,3] and increased propensity to risk-taking in racing gamers [6,12].

In their studies on aggressive behavior Bartholow and Anderson compared two groups of students in a simple provocation/retaliation task after 10-minute video game training. Participants were allocated to a violent game group (Mortal Kombat 1) and a nonviolent game group (PGA Tournament Gold). Results of provocation/retaliation task show higher aggression levels in the violent game group with a stronger effect observed in men then women [3].

Anderson and Bushman made meta-analysis of research related to violent media exposure, explaining how violent video games affect players. They isolated several key factors, such as: decrease in prosocial behavior, increase in aggressive thoughts, increase in physiological arousal and increase in anger / hostility. All effects used in the meta-analysis were temporary due to lack of available longitudinal studies [2].

Research conducted by Beullens and colleagues on gaming and risk-taking was a longitudinal panel survey focused mostly on racing video games and real-life driving. They found out that being exposed to racing video games in adolescence could be a predictor of competitive and risky driving in adulthood. Their data also support the proposed theory that such relationship might be explained by game content, not gaming activity as a whole [6].

By conducting a series of experiments Fischer and colleagues tried to further explain the relationship between gaming and risk-taking. Games used in their research included both racing games (Need for Speed, Burnout) and neutral games (Tak, Tetris). Experiments consisted of multiple stages: playing or observing a video game, assessment of game attractiveness, assessment of excitement the game provided and Schuhfried WRBTV risk-taking test. Consecutive experiments also added assessments of self-perception as a reckless driver (second experiment), additional racing game (F1), which unlike other titles does not promote careless driving (third experiment), and assessment of self-involvement (fourth experiment). Results from these experiments show that key factors of gaming-induced risk-taking include positive feedback to reckless driving, increased self-perception as reckless driver and content that promotes traffic rules violation [12].

## CONCLUSIONS

Numerous reports of video games being able to change and improve human cognition provide a clear picture of games, possessing the potential to become ultimate learning and training tools. In aviation and medical applications the greatest promise is held by action video games, which particularly affect vision-related skills.

Potential side effects of gaming that are highly undesirable include augmentation of aggressive behavior, excessive risk-taking and attenuated prosocial behaviors. These effects, however, are rooted in specific content rather then gaming itself, thus their elimination or mitigation at the least is possible.

Last but not least is the fact that as a mainstream medium video games are already a part of people's lives. The question is not "if" but "how" we can use them? In order to fully exploit the power of games for greater good, further research must be focused not only on human cognitive system and behavior, but also on games themselves, which will require great degree of collaboration between scientists and gaming industry.

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