THE EFFECT OF A PERSONALIZED GAME CHARACTER ON VISUAL ACUITY AND VISUAL ATTENTION IN ACTION GAMES

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ABSTRACT

Previous work suggested that people who often play action games are better at *visual acuity* tasks; they see more contrasts through the ability to discriminate small changes in shape and colour (Eichenbaum, Bavelier and Green, 2014). Furthermore, it was found that playing action games could improve *visual attention*; the ability to focus on important stimuli, and to ignore irrelevant distractors (Green and Bavelier, 2010). However, the investigated effects were found after a relatively long term experimental trial of ten hours or more, while it remains unclear if the effects will also surface after a relatively short period of action game playing. The current study investigated if this effect will occur after playing action games for twenty minutes.

Furthermore, it is investigated if it is possible to improve these positive effects, gained from playing action games, through character personalization. It is suggested that players feel more involved with their character when they create them by themselves (Izard, 2009). Therefore, it is expected that players will focus more while playing an action game when a fault will result in losing the game with their 'own character'.

An experiment was conducted to test if a personalized game character in action games could improve visual acuity and visual attention after twenty minutes of action game playing.

The results presented that the design indicated no significant effect of character personalization on visual acuity and visual attention. It was found that playtime does influence the effect on visual acuity and visual attention. Besides that, it was found that people became more reckless during the experiment after playing the action game, which is an interesting starting point for future research.

Keywords: Games, action games, personalized games, character adaption, visual acuity, visual attention.

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1. INTRODUCTION

1.1 Effects of gaming on person's abilities and behaviour

Up to today, multiple game developers try to create games to educate, inform, and train people (Michael and Chen, 2006). These kind of games are called serious games. In contrary, entertainment games are designed to amuse the player and to create an optimal game experience. Even though these games are not designed to improve cognitive aspects, it is suggested that it could positively affect the players' abilities. Several scientists investigated the effect of action games on people and found that playing action games, especially the ones in which focus, cognitive flexibility and speed are important, could positively affect visual acuity and visual attention (Green and Bavelier, 2003; Eichenbaum, Bavelier and Green, 2014; Bavelier and Green, 2016). In other words, it is stated that people who often play action games see more contrasts, through the ability to discriminate small changes in shape and colour (visual acuity) (Eichenbaum, Bavelier and Green, 2014). Besides this, it is suggested that playing action games could improve the ability to focus on important stimuli, and to ignore irrelevant distractors (visual attention) (Green and Bavelier, 2010).

1.2 The reinforcing power of personalization

Personalized games are games that utilise player models to tailor the game experience to the individual player (Bakkes, Tan and Pisan, 2012). There are several different aspects in a game which can be personalized. Bakkes, Tan and Pisan (2012) describe eight components which could be implemented to personalize a game, namely space adaption, mission/task adaption, character adaption, game mechanics adaption, narrative adaption, music/sound adaption, player matching and difficulty-scaling. The present study focusses on character adaption.

There are multiple reasons to use personalization in games. One of them is the psychological foundation. This concerns the influence of personalization in games on a player’s knowledge, attitude and actions. Petty, Cacioppo and Schumann (1983) suggested that people are more involved when they are exposed to content which has personal relevance. They state that highly involved individuals have stronger emotional reactions. For this reason, personalization in games can increase emotions and change behaviour. Fischer, Kastenmüller and Greitemeyer (2010) showed in their study that the personalization of an in-game character could lead to elevations in the intensity of the psychological effects of video games. They found that people who played an aggressive game with a personalized character were more violent afterwards than people who played this same game with a non-personalized character. The reason given for this is that gamers with a personalized game character experienced more arousal and self-activation, which lead to a more aggressive response.

1.3 Problem statement and research question

Fischer, Kastenmüller and Greitemeyer (2010) found that in-game character personalization could increase the aggressive response of players after playing an action game for twenty minutes. However, as mentioned earlier, there are also positive influences an action game could have on a person. The current study investigates if personalization could increase positive effects of playing action games, namely improving visual acuity and visual attention. Previous studies investigating improvements of visual acuity and visual attention after playing action games, measured the effect after at least ten hours of action game playing (Eichenbaum, Bavelier and Green, 2014). The investigated effects were found after a relatively long term experimental trial, while it remains unclear if the effects will also surface after playing action games for a relatively short period. The present study investigated if this effect also occurs after twenty minutes of action game playing.

The following research question was asked:

'*What is the effect of a personalized game character in action games on visual acuity and visual attention after a short period of action game playing'*

To answer this question, several sub-questions were asked:

1. What is the effect of playing an action game for a short period on *visual acuity?*
2. What is the effect of playing an action game for a short period on *visual attention*?
3. What is the effect of a personalized game character in action games on *visual acuity* after a short term of action game playing?
4. What is the effect of a personalized game character in action games on *visual attention* after a short term of action game playing?

Eight hypotheses were set, which were all related to one of the sub-questions:

- H1: People who played an action game are better at *visual acuity* tasks than people who played a non-action game. (Sub-question one)
- H2: People who played an action game are better at *visual attentional* tasks than people who played a non-action game. (Sub-question two)
- H3: People who played a game with a personalized character are better at *visual acuity* tasks than people who played the same game with a non-personalized character. (Sub-question three)
- H4: People who played a game with a personalized character are better at *visual attentional* tasks than people who played the same game with a non-personalized character. (Sub-question four)

- H5: People who played an action game with a personalized character are better at *visual acuity* tasks than people who played a non-action game with a personalized character. (Sub-question one)
- H6: People who played an action game with a personalized character are better at *visual acuity* tasks than people who played an action game with a default character. (Sub-question three)
- H7: People who played an action game with a personalized character are better at *visual attentional* tasks than people who played a non-action game with a personalized character. (Sub-question two)
- H8: People who played an action game with a personalized character are better at *visual attentional* tasks than people who played an action game with a default character. (Sub-question four)

By conducting an experiment, the sub-questions were answered and with them the research question was answered.

1.4 Outline

The remainder of this thesis is structured as follows. In the theoretical framework, a description of different types of games is given, and the action game genre is explained in detail. Furthermore, positive effects of playing action games, namely visual acuity and visual attention, are discussed. An overview of previous research is given and critically examined. After this, different types of personalization in games and the effect of it is described. Lastly, the present study is explained.

In the method section, the design of the experiment is discussed. It shows the used variables and the different conditions. Furthermore, the participants and their demographics are given. After that, the materials and procedure are explained. The method ends with a description of the measurements, in which the used tests are clarified.

The data collected during the experiment can be found in the result section. Statistical analyses were performed to find answers to the research question and sub-questions. It is discussed if the hypotheses were confirmed or rejected.

In the discussion section, the strengths and weaknesses of the experiment are discussed. Interesting findings are mentioned and limitations are given.

Finally, in the conclusion section, a summary of the findings is given and related to the research question and sub-questions. Furthermore, recommendations for future research are given.

2. THEORETICAL FRAMEWORK

2.1 Video games

The gaming industry has grown since the 1950s into one of the largest entertainment industries. Since the beginning of the 2000s, the gaming industry grew exponentially due to the improving computer processor technology and internet's possibilities (Chikhani, 2015). Games could be played with different devices; PC, game consoles (e.g. Xbox and PlayStation), handheld game consoles (e.g. Nintendo 3DS and PlayStation Vita), and recent years also more on (smart)phones and tablets.

2.2 Serious versus entertainment games

Gaming could be defined as a voluntary activity in an immersive imaginary world, that is or is not related to reality, in which one or multiple players play a game according to predefined rules within a specific time and place (Michael and Chen, 2006). There are different types of games, dividable in serious games and entertainment games.

2.2.1 Serious games

Serious games are games in which the primary goal is to educate, inform, and train, rather than to entertain (Michael and Chen, 2006). However, this would not say that serious games cannot be entertaining. An example of a serious game is *America's Army*, which is a simulator to train soldiers for missions. For soldiers, this game is serious and is used to learn from. However, it could be just an entertainment game for a non-soldier. Since the intention of the game makers was to train soldiers, this game would be considered as a serious game (Michael and Chen, 2006).

2.2.2 Entertainment games

Besides serious games, there are games which are designed to amuse the player and to provide them with a good game experience. These are the so-called entertainment games. These games could be divided in different genres and subgenres, which are used to describe the style of the game. However, the classification of genres is not always consistent. There are multiple opinions about which genres there are and what the definitions are of these genres. Bakkes (2010), combines several definitions and comes with one overlapping categorisation of games, which contains five genres: action games, adventure games, role-playing games, simulation games, and strategy games. During this study, the focus lays on action games. Action games are games in which the players' physical reaction speed and precision are important (Bakkes, 2010). This genre has several sub-genres. The four main sub-genres are according to Bakkes (2010) fighting games, platform games, shooter games, and sport games. During this experiment, a simplified version of a shooter game was used. More about this game will be discussed in the method section.

Even though these entertainment games are not designed to improve cognitive aspects, it is found in multiple studies that they do have a positive effect on the player's abilities (Green and Bavelier, 2003; Green and Bavelier, 2010; Eichenbaum, Bavelier and Green, 2014; Bavelier and Green, 2016). This will be discussed in the following paragraphs.

2.3 Positive effects of action games

Players generally do not master a game from the start, it is a challenge for them. They have to learn how to play the game to become faster and more accurate. Some scientist consider that gamers do not only become better within the game, but that it also positively affects the players' abilities in real-life (Eichenbaum, Bavelier and Green, 2014). Multiple experiments have been done to investigate if action games have a positive effect on a player's abilities. It is suggested that playing action games, especially the ones in which focus, cognitive flexibility and speed are important, improve some cognitive aspects (Bavelier and Green, 2016). In the current study, the focus will lay on the improvement of visual acuity and visual attention, which is extensively explained below.

2.3.1 Visual acuity and visual attention

Green and Bavelier (2003) indicated that video gaming has a positive influence on the perceptual and motor skills of the player. This can be explained by the fact that the visual system of an organism changes when it is exposed to an altered visual environment. Green and Bavelier (2010) describes that playing action games could have a positive effect on visual acuity and on visual attention.

It is stated that people who often play video games see more contrasts, which is a part of visual acuity. Visual acuity can be measured through the ability to discriminate small changes in shape and colour. Eichenbaum, Bavelier and Green (2014) suggested that people who often play action games are able to see small differences in shades of grey. They tested the ability to see these differences with the Pelli Robson contrast sensitivity chart test, in which people have to read letters which are in the beginning dark grey and become lighter and lighter. The results indicated that action video game players are able to read more letters than non-players. Another test which is used to measure visual acuity is the Snellen task. During this task, the participant needs to name letters on a list, starting with large letters which become smaller and smaller. Both tests are extensively explained in the method section.

Visual attention is about the ability to focus on important stimuli, like other cars in traffic, and to ignore irrelevant distractors (Green and Bavelier, 2010). In an experiment, Green and Bavelier (2003) tested if playing action games increases the attentional capacity. The Flanker Compatibility test was used to measure if people could ignore insignificant information. It was predicted that video-game players have a greater attentional capacity than non-players, which was confirmed by their experiment. In other words, gamers are better able to focus on visual details by filtering out the distractions. A reason for this is according to Green and Bavelier (2010) that playing a video game requires strict attention in which multiple items need to be processed simultaneously. Therefore, players need to focus on relevant items and ignore the irrelevant ones. Another often used test which measured the same concept as the Flanker Compatibility task is the Stroop task. Both tests are extensively explained in the method section.

2.3.2 Criticism

As discussed in this chapter, multiple studies investigated the effects of playing action games on people's abilities, which showed often positive results. However, there are some limitations that should be taken into account. First of all, most of the studies, were performed by the same group of researchers using similar samples for multiple papers. Therefore, there is some doubt about the independency of the results. Furthermore, most experiments were done using an experiment with laboratory tasks. Conclusions of those experiments derive often from the results of a specific task, which make it hard to generalize it to real-life situations. Lastly, it could be that people who play a lot of action video games do already have better perceptual and cognitive skills in comparison to non-players. This might be the reason why some people like to play action games better than others. These criticisms need to be taken into account during the present study.

2.4 Personalized gaming

Personalized games are games that utilise player models to tailor the game experience to the individual player (Bakkes, Tan and Pisan, 2012). Zeedzen (2016) designed in his master thesis a model which divides personalization in games in different categories. According to Zeedzen, there are two types of personalization in games. One type allows the player to adapt the game to their own preferences, for example by creating an own character or by choosing how the story in the game will continue. This is called explicit personalization; the gamer makes the choices consciously. The second type is in which the game adapts to the player by choices it makes implicitly. For example, when a player likes the puzzles in a game better than the strategy part, the game will provide more puzzles. Furthermore, a division can be made between significant and insignificant choices. Significant choices have an actual effect on the game, for example, a certain game character that is chosen has a specific power which other characters do not have, which influence the gameplay. Insignificant choices do not change the gameplay, for example the appearance of a game character.

2.4.1 Components of personalization

There are several different aspects in a game which could be personalized, to tailor the game experience to the individual player. Bakkes, Tan and Pisan (2012) describe eight components which could be implemented to personalize a game, namely space adaption, mission/task adaption, game mechanics adaption, narrative adaption, music/sound adaption, player matching, difficulty-scaling and character adaption. During the present study, the focus lays on the last component of personalization, character adaption. A character, also called an avatar, is a fictional person in a game that the gamer controls. The avatar has a task in the game that the player has to succeed. For example, in Super Mario Bros, the player's character needs to rescue Princess Toadstool. The player has to complete all levels with the Mario character to accomplish the mission. According to Schell (2008), a special relationship between player and avatar occurs because the player has to control this character. He states that people have the ability to project themselves into things they control, which is a form of empathy. This effect increases when a character is personalized. For example, when your own designed character in a game is hit you will think 'I'm hit' instead of 'my character is hit'.

2.4.2 Why personalization?

There are multiple reasons why to use personalization in games. Bakkes, Tan and Pisan (2012) describe four motivations which could be summarized in game development and the effect on player satisfaction, and the psychological foundation.

2.4.3 Game development and the effect on player satisfaction

The first motivation is about the effect on player satisfaction. Because more and more is technologically possible in the gaming industry, players also expect more from a game (Bakkes, Tan and Pisan, 2012). New methods, artificial intelligence player modelling and content generation, make it possible to create on-demand and just-in-time experiences for the individual player (Riedl, 2010). According to Riedl (2010), it is possible to adapt a game to the individual play style of the player, through knowing what the players' needs, preferences and desires are. It is assumed that personalization in games could lead to more enjoyment, which refers to a better game experience (Fang and Zhao, 2010). There is an underlying psychological foundation for the increasing game experience, which is discussed in the next paragraph.

2.4.4 Psychological foundation

The psychological foundation is about the influence of personalization in games on player's knowledge, attitude and actions. Petty, Cacioppo and Schumann (1983) state that people are more involved when they are exposed to content which has personal relevance. Individuals who are highly involved have stronger emotional reactions and are more willing to perform a certain behaviour (Darley and Lim, 1992). Fischer, Kastenmüller and Greitemeyer (2010) suggested that personalization of in-game characters leads to elevations in the intensity of the psychological effects of video games. An experiment was conducted in which Fischer, Kastenmüller and Greitemeyer (2010) tested if personalization of in-game characters influences the level of aggression of the gamer after playing an action game for twenty minutes. Earlier studies stated that the level of aggression increases on short-term when playing a violent game like an action game (Anderson and Dill, 2000; Anderson et al., 2001). Fischer, Kastenmüller and Greitemeyer (2010) found that people who played the action game with a personalized character were more violent afterwards than people who played the same game with a non-personalized character. This effect is explained by the fact that gamers with a personalized game character experienced more arousal and self-activation, which led to a more aggressive response. The gamers felt more involved with the character when it is personalized than when it is a default character (Fischer, Kastenmüller and Greitemeyer, 2010). Therefore, the observed players had stronger emotions when something happened with their 'own character', which leads to measurable effects on cognition and action (Izard, 2009).

2.5 The present study

2.5.1 Time and the positive effects of action game playing

Previous work suggested that people who often play action games are better at *visual acuity* tasks; they see more contrasts through the ability to discriminate small changes in shape and colour (Eichenbaum, Bavelier and Green, 2014). Furthermore, it was found that playing action games could improve the ability to focus on important stimuli, and to ignore irrelevant distractors (Green and Bavelier, 2010). In other words, playing these games could improve *visual attentional* skills.

Multiple earlier studies measured the effects of gaming on visual acuity and visual attention without a pre-test (Green and Bavelier, 2003; Green and Bavelier, 2010). During these studies, the visual acuity and visual attention of gamers; people who played action games for three to four hours a week for the previous six months, and non-gamers; people who did barely game in the last six months, was compared. However, it is not clear if people who play a lot of action video games do already have better perceptual skills in comparison to non-players or that it is perceived during game play. Therefore, this study chooses to do a pre- and post-test to avoid that already owned skills influence the outcome.

Eichenbaum, Bavelier and Green (2014) did measure a similar concept with pre- and post-test after playing at least ten hours of action or non-action games. However, the investigated effects were found after a relatively long term experimental trial, while it remains unclear if the effects will also surface after a relatively short period of action game playing. The current study investigated if this effect will occur after playing action games for twenty minutes.

2.5.2 The reinforcing power of personalization

As mentioned in section 2.4.4, personalized game characters enlarge the effect of aggressive behaviour after playing an action game, which is a negative effect (Fischer, Kastenmüller and

Greitemeyer, 2010). Instead of increasing a negative influence of playing action games, this study wants to discover if personalization of characters could also improve positive effects, namely visual acuity and visual attention. It is suggested that players feel more involved with their character when they create them by themselves (Izard, 2009). Therefore, it is expected that players will focus more in an action game when a fault will result in losing the game with their 'own character'. It is expected that people who play a game with a personalized character are better at visual attentional and acuity tasks than people who played the same game with a non-personalized character. Furthermore, it is expected that this effect is stronger for action game players than for non-action game players. The following research question is asked: '*What is the effect of a personalized game character in action games on visual acuity and visual attention after a short period of action game playing'*. By conducting an experiment, the hypotheses were tested.

3. METHOD

The main purpose of this study was to determine if personalization of game characters could improve visual acuity and visual attention after playing action games for a short period.

3.1 Design

The study had a 2 (*type of game:* action vs. non-action) x 2 (*type of game character:* personalized vs. default) between-subjects design. Table 1 presents the four used conditions. Two tests were performed to test visual acuity and another two were performed to test visual attention. These tests will extensively be discussed in the measurement section.

Table 1. 2 x 2 design of type of game and personalized game character

	Personalized game character	**Default game character**
Action game	Personalized, action	Default, action
Non-action game	Personalized, non-action	Default, non-action

3.2 Participants

56 participants (33 women and 23 men, ages ranging from 18 to 60; *M* = 25.04, *SD* = 8.00) were involved in this study. Participants were randomly assigned to the different conditions. The participants were recruited via a combination of convenience and network sampling and they participated voluntary. This sampling method was used to provide as many responses as possible within the time limit. The participants consisted of gamers and non-gamers, ranging from 0 to 20 game hours per week (*M* = 3.13, *SD* = 4.73), of which 0 to 15 hours were action games (*M* = 1.33, *SD* = 3.23).

3.3 Material and procedure

During the experiment, the participants were informed by means of a consent form that they participated in a study of personalization in video games, which consisted of a pre-test, task, namely playing a game, and post-test. The consent form can be found in appendix 1. Firstly, some demographic questions and questions about game experience were asked. Then, the participant had to do a pre-test, in which four small tests were included to test visual attention and visual acuity. The tests that were used are well-known vision tasks which are often used for academic research, and are further explained in the measurement section.

Afterwards, participants had to play a video game for twenty minutes on the Nintendo Wii. Participants in the action game condition had to play Wii Play's Shooting Range. This is a game in which the player has to shoot moving objects. There are multiple levels with different shooting tasks. This game was chosen because speed, focus and cognitive flexibility are important, which are aspects of an action game. Participants in the non-action game condition had to play Wii Sport's Golf. This is a slow game in which the participant has to aim the ball into the hole without a time limit. Table 2 represent the differences of the two games based on the requirements of an action game; focus, cognitive flexibility and speed.

Table 2. Differences of the chosen games.

	Wii Play's Shooting Range	**Wii Sport's Golf**
Focus	Fast moving aims, requires to focus to see them on time.	Focus on the distance to the hole and the amount of wind.
Cognitive flexibility	Multiple levels with different tasks. Furthermore, players have to decide if they have to shoot or not on the given targets, since some of them result in negative points.	Multiple levels with always the same task.
Speed	Fast moving aims, requires speed to hit them.	No time limit.

These games were chosen because their designs are similar to each other, which minimized the influence of game differences. Furthermore, it is easy to learn how to play the game, since players only need to use a few buttons and motions for both games. 48 of the 56 participants had played the Nintendo Wii before, and 33 of them already played the game used during the experiment once before. Even non-gamers, who never played the Nintendo Wii before, were able to play the game. In the current study, the focus lays on one specific component of personalisation, namely character adaption. Participants in the non-personalized condition played the game with a default character, which did not relate to the personal appearance of the player. The participants in the personalized condition had to create an own character using Nintendo Wii's Mii feature before playing the game. They got five minutes to create a Mii character. This allowed the player to model the appearance of their character from hair colour to the form of eyes and mouth. This is an explicit form of character adaption, since the participant makes the choices consciously. Eventually, they played the game with their own personalized character. The type of character had no significant influence on the game itself.

Lastly, the participants were asked to do a post-test, which included the same tests which were used during the pre-test. The results were filled in on a form, which can be found in appendix 2. Afterwards, the participants were thanked for participating and were asked if they were interested in receiving the results.

3.4 Measurement

During the pre-test and post-test, participants had to do four different tasks. Two tests to measure visual attention and two tests to measure visual acuity. The used tasks are represented in table 3 and explained extensively below.

Table 3. Used tests during pre- and post-test.

Visual acuity	**Visual Attention**
Pelli Robson task	Flanker task
Snellen task	Stroop task

3.4.1 Visual acuity

The visual acuity of the participant was measured using two different tasks. Firstly, the Pelli Robson contrast sensitivity chart was used to measure the ability to see contrast. During this test, the participant was shown a list with letters on a laptop with different grey values, differing from dark to light grey. The participants had to stand two meter from the computer screen and name the letters on the list until they could not read further. The list contained 30 letters in total. The last correctly named letter was written down as a number as a result of the test. For example, if the 20th letter in the list was named wrong, 19 was written down. The higher the number, the better the participant could see grey-contrasts. To maintain that every situation was the same, every participant had to stand exactly two meters in front the screen. The screen was always the same size and had the same brightness. Every test was done in a room with artificial light.

Secondly, the Snellen chart was used to measure visual acuity. In this task, the participant was again shown a list of letters on a laptop, this time differing from large to small. There were 72 letters in total. Again, the participant had to stand exactly two meter in front of the computer screen and name the letters until they could not read any furhter. The last correctly named letter was written down as a number as result of the test. The higher the number, the smaller the last correctly named letter was, the better the participant could discriminate small changes in shape. Also during this test, every participant had to read from the same computer screen with the same size and brightness in a room with artificial light.

3.4.2 Visual attention

To measure visual attention, two tasks were used. During both of these tasks, the participant was asked to respond as fast as possible to a stimulus, which is surrounded by irrelevant stimuli. Firstly, they had to do the Flanker Compatibility task. This is a standard experimental paradigm used in attentional studies to measure attention. During this task, the participant had to name the direction of an arrow which was in the middle of a set of five arrows. Some sets were congruent to the centre arrow (↑↑↑↑↑) and some were incongruent (↑↑→↑↑). The test resulted in the time a participant needed to answer the congruent sets right and the time a participant needed to answer the incongruent sets right. It is assumed that when the arrows around the centre arrow are incongruent, the task is harder than when all arrows direct in the same direction (Eriksen and Eriksen, 1974). Therefore, the processing of an incongruent task takes more time than a congruent task. The difference in reaction-time between a congruent and incongruent task is called the Flanker-effect. A positive number indicates that it took the participant more time to do the incongruent tasks, zero suggests no difference, and a negative number shows that it took the participant more time to do the congruent tasks.

The second task was the Stroop task. During the Stroop task, the participant was asked to name the colour of a certain word that was given. The words that were used were names of colours. Some words were congruent with the colours (the word YELLOW coloured yellow) and some incongruent (the word YELLOW coloured green). The Stroop test measures selective attention; participants needed to respond to the physical appearance of the words while ignoring the meaning of the words. When the task is congruent, it is generally easier to respond than when the task is incongruent (MacLeod, 1991). The difference in reaction-time between a congruent and incongruent task is called the Stroop-effect. A positive number indicates that it took the participant more time to do the incongruent tasks, zero suggests no difference, and a negative number shows that it took the participant more time to do the congruent tasks.

4. RESULTS

In order to answer the research question, *what is the effect of a personalized game character in action games on visual acuity and visual attention after a short period of action game playing,* statistical analyses were needed. During the experiment, four different tests were conducted (Pelli Robson test, Snellen test, Flanker Compatibility test, and Stroop test,) at two different moments (pre-test and post-test). The participants were divided into four equal groups. Each group had a different condition; action personalization, non-action personalization, action default or non-action default. The variance of the different groups was the same. Therefore, the assumption of homogeneity was met. Visual acuity was measured through the numbers of letters the participant answered right before it made a fault during the Pelli Robson task and the Snellen task. The higher the number, the better the visual acuity. To measure visual attention, the observed Flanker-effect and Stroop-effect was used, which indicated the difference in time in milliseconds between answering a congruent and answering an incongruent task. The closer the number to zero, the better the visual attention and the less the participant was distracted by other factors. When the number was positive, the participant was more distracted by incongruent tasks. While it was negative, the participant was more distracted by congruent tasks. Multiple mixed factorial ANOVAs were conducted to compare the main effect and interaction of type of game character and the type of game. Type of game character included two levels (personalized, default), as well as type of game (action, non-action). The results will be discussed per hypothesis below.

4.1 Hypothesis one

The first hypothesis was as follows: *people who played an action game are better at visual acuity tasks than people who played a non-action game*. Using a mixed factorial ANOVA, it was tested if type of game has an influence on visual acuity. The analysis revealed no significant effect of game type on visual acuity during the Snellen task: *F* (1,54) = .81, *p* = .371 (Action: Pre-test: *M* = 29.96, *SD* = 9.39, Post-test: M = 30.54, *SD* = 8.38, Non-Action: Pre-test: *M* = 30.96, *SD* = 6.78, Post-test: *M* = 31.54, *SD* = 7.52). There were some outliers, which did not significantly affect the results. It was remarkable that both groups, action and non-action, scored on average exactly 0.58 better in the post-test in comparison to the pre-test. There was also no significant effect found of game type on visual acuity during the Pelli Robson task: *F* (1,54) = .97, *p* = .329 (Action: Pre-test: *M* = 23.54, *SD* = 3.89, Post-test: M = 24.50, *SD* = 3.55, Non-Action: Pre-test: *M* = 23.71, *SD* = 3.25, Post-test: *M* = 23.54, *SD* = 3.57). There were no outliers. The action condition scored 0.96 better during the post-test in comparison to the pre-test, whereas the non-action conditions scored 0.17 worse. The observed values of the Pelli Robson task suggested that there is a difference which match the hypothesis. However, since the results were not significant, the first hypothesis was rejected.

4.2 Hypothesis two

Secondly, it was tested using a factorial mixed ANOVA if type of game has an influence on visual attention. The second hypothesis was as follows: *people who played an action game are better at visual attentional tasks than people who played a non-action game.* The analysis revealed no significant effect of game type on visual attention during the Flanker task: *F* (1,54) = .02, *p* = .879 (Action: Pre-test: *M* = 24.00, *SD* = 44.56, Post-test: M = 17.04, *SD* = 43.83, Non-Action: Pre-test: *M* = 23.32, *SD* = 48.46, Post-test: *M* = 27.36, *SD* = 56.70). One outlier was found, which did not significantly affect the results. There was a significant effect found by a *p*-value of .067 of game type on visual attention during the Stroop task: *F* (1,54) = 3.49, *p* = .067 (Action: Pre-test: *M* = 91.96, *SD* = 97.68, Post-test: M = 126.46, *SD* = 88.03, Non-Action: Pre-test: *M* = 97.29, *SD* = 90.03, Post-test: *M* = 128.57, *SD* = 135.95). There were no outliers. It was expected that people who played an action game are better at visual attentional tasks than people who played a non-action game. Apparently, according to the data, both conditions became worse at the Stroop task after playing the game. Besides this, a larger difference between pre- and post-test was found for the action condition in comparison to the non-action condition. Therefore, the second hypothesis was rejected.

4.3 Hypothesis three

The third hypothesis was: *People who played a game with a personalized character are better at visual acuity tasks than people who played the same game with a non-personalized character*. A mixed factorial ANOVA was used to investigate if type of game character has an influence on visual acuity. The analysis revealed no significant effect of game type character on visual acuity during the Snellen task: F (1,54) = .84, p = .364 (Personalized: Pre-test: M = 32.25, SD = 7.19, Post-test: M = 32.04, SD = 7.18, Default: Pre-test: M = 28.68, SD = 8.74, Post-test: M = 30.04, SD = 8.58). There were some outliers, which did not significantly affect the results. The observed values indicated a difference that did not met with the hypothesis. People in the personalized condition became 0.21 worse on average in the post-test in comparison to the pre-test, whereas the default condition became 1.36 better. However, since it is not significant, no conclusions can be made. There was also no significant effect found of game type character on visual acuity during the Pelli Robson task: F (1,54) = .94, p = .338 (Personalized: Pre-test: M = 24.25, SD = 3.25, Post-test: M = 24.57, SD = 3.30, Default: Pre-test: M = 23.00, SD = 3.79, Post-test: M = 23.46, SD = 3.80). There were no outliers. Also in this task, the default condition scores increased on average more, namely 0.46, than the scores of the personalized condition, which increased with 0.32. However, since the results were not significant, the hypothesis was rejected.

4.4 Hypothesis four

Next, it was tested if type of game character has an influence on visual attention. The fourth hypothesis was as following: *People who played a game with a personalized character are better at visual attentional tasks than people who played the same game with a non-personalized character.* The analysis revealed no significant effect of type of character on visual attention during the Flanker task: F (1,54) = .02, p = .878 (Personalized: Pre-test: M = 29.93, SD = 51.13, Post-test: M = 18.04, SD = 44.06, Default: Pre-test: M = 17.39, SD = 40.48, Post-test: M = 26.36, SD = 56.69). There were two outliers found, which did not significantly affect the results. Even though it was not significant, it is remarkable that the personalized condition became 11.89 better in the post-test in comparison to the pre-test, whereas the default condition became 8.97 worse, which matches the hypothesis. There was a significant effect found by a p-value of .067 of type of character on visual attention during the Stroop task: F (1,54) = 3.49, p = .067 (Personalized: Pre-test: M = 92.18, SD = 104.70, Post-test: M = 127.18, SD = 117.05, Default: Pre-test: M = 97.07, SD = 93.11, Post-test: M = 127.86, SD = 111.94). There was one outlier, which did not significantly influence the results. It was expected that people who played with a personized game character are better at visual attentional tasks than people who played with a default character. Apparently, according to the data, both conditions became worse at the Stroop task after playing the game. Besides this, a larger difference between pre- and post-test was found for the personalized condition in comparison to the default condition. Therefore, this hypothesis was rejected.

4.5 Hypotheses five and six

After this, the observable effect of type of game and type of game character interacting was investigated for the visual acuity tasks. Table 4 presents the descriptive statistics of visual acuity, divided into the Snellen task and the Pelli Robson task. It gives the mean scores and standard deviations per condition per measurement. Furthermore, it gives the z-scores for skewness and kurtosis, which indicate if the results were normally distributed. Table 4 shows that all scores were normally distributed, except for the action default condition during the post-test of the Snellen task, where positive kurtosis was found. This could be explained by the small sample size. During both tests, the participants performed better during the post-test than during the pre-test, except for the action personalization condition in the Snellen task and the non-action condition during the Pelli Robson task. The results of the Snellen test had some outliers, which did not significantly influence the results. The results of the Pelli Robson test showed no outliers.

Table 4. Descriptive statistics of visual acuity

	Review type	**Pre/post**	***M***	***SD***	**z-score skewness**	**z-score kurtosis**
Snellen	AP	Pre	33.38	8.96	-1.14	1.82
		Post	32.08	9.06	-1.22	.54
	AD	Pre	27.21	9.30	-1.61	0.31
		Post	29.57	7.97	-1.68	***3.19***
	NP	Pre	31.79	5.16	1.04	1.12
		Post	32.57	5.11	.72	.63
	ND	Pre	30.14	8.21	-.93	.02
		Post	30.50	9.44	-1.01	-.62
Pelli Robson	AP	Pre	24.69	3.40	-1.42	-.24
		Post	25.15	2.97	-.76	-.16
	AD	Pre	22.71	4.21	-.12	-1.18
		Post	24.00	4.15	-1.54	-.032

NP	Pre	24.14	3.11	-.50	-1.26
	Post	24.14	3.70	-.85	-1.41
ND	Pre	23.29	3.45	-.23	-1.59
	Post	22.93	3.47	-.21	-1.44

Note. A = action game, N = non-action game, P = personalized character, D = default character.

A mixed factorial ANOVA was conducted to investigate the fifth hypothesis; *people who played an action game with a personalized character are better at visual acuity tasks than people who played a non-action game with a personalized character*, and sixth hypothesis; *people who played an action game with a personalized character are better at visual acuity tasks than people who played an action game with a default character.* The analysis revealed no significant effect of condition on visual acuity during the Snellen task: F (1,52) = .847, p = .362, and during the Pelli Robson task: F (1,52) = .942, p = .336. Therefore, both hypotheses were rejected.

However, there were some interesting findings. People who played an *action* game with a *personalized* character scored worse in the Snellen task during the post-test in comparison to the pre-test than the people who played a *non-action* game with a *personalized* character. In contradiction, people who played an *action* game with a *personalized* character performed better during the post-test in comparison to the pre-test at the Pelli Robson task than the people who played the *non-action* game with a *personalized* character. In other words, the results of both tests contradict to each other.

Furthermore, it was hypothesized that people who played an *action* game with a *personalized* character are better at visual acuity tasks than people who played an *action* game with a *default* character. However, the scores of both tests showed the other way around. The default condition resulted in better scores when pre- and post-tests were compared.

4.6 Hypotheses seven and eight

After this, the observable effect of type of game and type of game character interacting was investigated for the visual attentional tasks. Table 5 presents the descriptive statistics of visual attention. It gives the mean score and standard deviation per condition per measurement. Furthermore, it gives the z-scores for skewness and kurtosis, which indicate if the results were normally distributed. There was some skewness and kurtosis found, which are represented in bold in table 5. This can be explained by the small sample size. During the Flanker task, the participants performed better during the pre-test than during the post-test, except for the non-action default condition. This could be explained by one extreme outlier in this condition. However, this outlier did not significantly affect the results. Remarkable is that all conditions scored worse during the post-test of the Stroop task in comparison to the pre-test. This means that the participants were more distracted by irrelevant information during this task after playing the game. There were also a few outliers found for the Stroop task, which did not significantly affect the results.

Table 5. Descriptive statistics of visual attention

	Review type	**Pre/post**	***M***	***SD***	**z-score skewness**	**z-score kurtosis**
Flanker	AP	Pre	29.23	46.16	.20	.86
		Post	26.77	50.60	-.53	1.03
	AD	Pre	21.50	45.16	-1.78	***2.38***
		Post	11.07	36.77	-1.28	.86
	NP	Pre	33.36	57.72	***2.37***	1.95
		Post	13.07	37.63	***2.14***	***2.69***
	ND	Pre	<u>13.29</u>	36.44	-.47	-.99
		Post	<u>41.64</u>	69.43	***-2.68***	***2.40***

Stroop	AP	Pre	92.77	106.17	***-2.71***	***2.77***
		Post	159.31	102.52	.86	.39
	AD	Pre	86.50	95.10	.02	-1.28
		Post	95.07	65.10	-.78	-1.16
	NP	Pre	86.93	109.55	.75	-.54
		Post	96.50	129.21	***-2.04***	***1.99***
	ND	Pre	107.64	67.83	-.22	-.54
		Post	160.64	139.55	1.03	.13

Note. A = action game, N = non-action game, P = personalized character, D = default character.

A mixed factorial ANOVA's was conducted to investigate the seventh hypothesis; *people who played an action game with a personalized character are better at visual attentional tasks than people who played a non-action game with a personalized character*, and eighth hypothesis; *people who played an action game with a personalized character are better at visual attentional tasks than people who played an action game with a default character.* The analysis revealed no significant effect of condition on visual attention during the Flanker task: *F* (1,52) = .024, *p* = .878. However, there was a significant effect found by a *p*-value of .067 of condition on visual attention during the Stroop task: *F* (1,52) = 3.476, *p* = .068. As already mentioned, all conditions performed worse during the post-test in comparison to the pre-test during the Stroop task. Furthermore, the difference between pre- and post-test was larger for the action personalization condition and the non-action default condition in comparison to the action default and non-action personalization condition. As displayed in figure 1, the lines of the action personalization condition and the non-action default condition increase relatively with a greater amount than the lines of the action default and non-action personalization condition, when pre- and post-test are compared. This is a remarkable outcome, since it did not match with the founded theory.

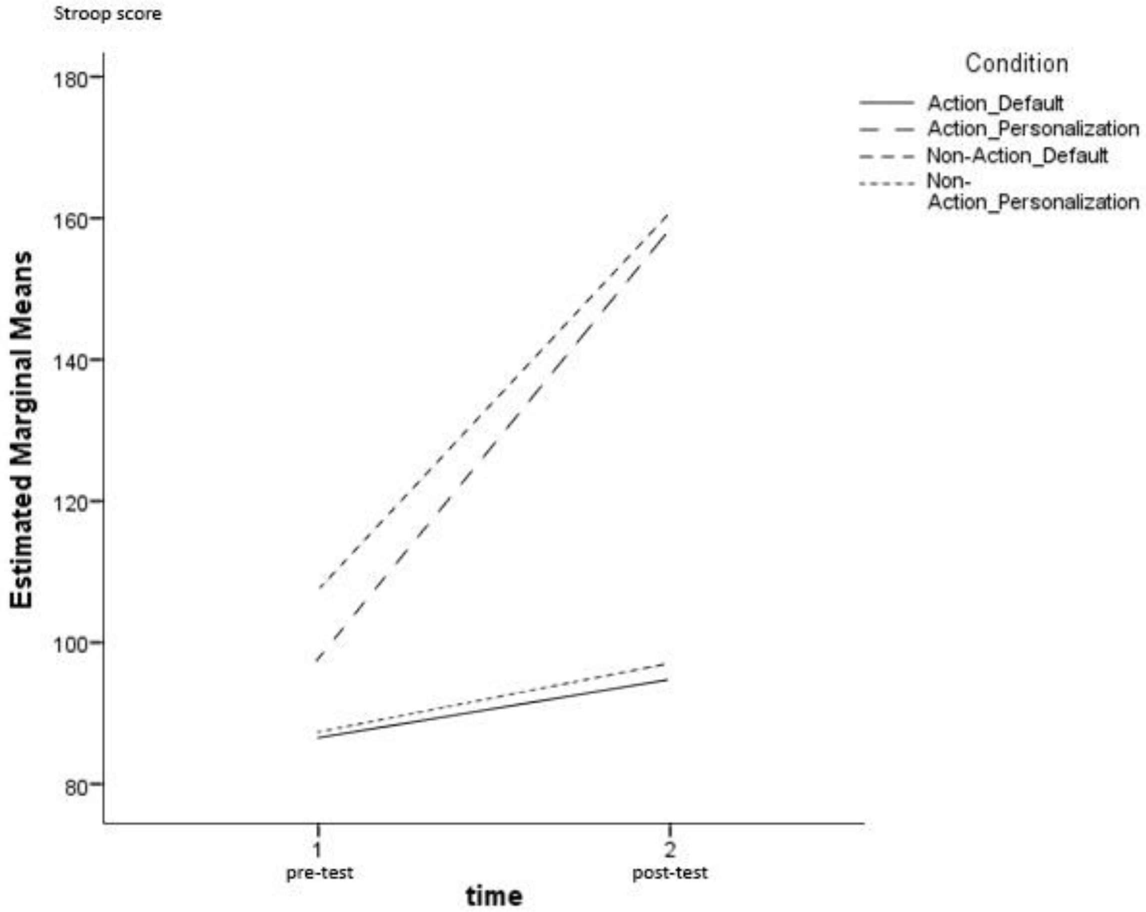

Figure 1. Estimated marginal means of Stroop task.

Besides this, it is remarkable that the *action personalization* condition performed worse than the *non-action personalization* condition in both tests when pre- and post-test scores are compared, which is the opposite of what was expected in the seventh hypothesis. Also when the scores of the *action personalization* condition are compared to the scores of the *action default* conditions in both tests, it was found that the action default condition performed better during the post-test in comparison to the pre-test. This is again different than was expected in the eighth hypothesis. Therefore, the seventh and eight hypotheses were rejected.

5. DISCUSSION

A previous study found that personalization of game characters in games could enlarge the effect of aggressive behaviour on short-term after playing an action game, which is a *negative* effect (Fischer, Kastenmüller and Greitemeyer, 2010). This study tested if personalization of game characters could also improve *positive* effects, which are found after playing action games on short-term, namely the improvement of visual acuity and visual attention (Green and Bavelier 2003; Green and Bavelier, 2010; Eichenbaum, Bavelier and Green, 2014).

5.1 Visual acuity

It was expected that people who played the action game were better at visual acuity tasks on short-term than people who played the non-action game. Furthermore, it was predicted that people who played the game with a personalized character were better at visual acuity tasks than people who played the game with a default character. However, the experiment showed no significant results for visual acuity. Therefore, these hypotheses were rejected.

Nevertheless, something remarkable occurred during the experiment. Participants who had to play the action game became more reckless after playing the game when they had to name the letters during the Snellen task and the Pelli Robson task. They named the letters faster during the post-test in comparison to the pre-test. Therefore, they made more mistakes, which were often directly corrected by themselves. This effect could be explained by the fact that the action game encouraged to take risks. People had to shoot as fast as possible to hit the aims during the game, it did not matter if they missed. People were likely to copy this behaviour to the visual acuity tasks. Unfortunately, there was no measurable data to prove this effect. Therefore, additional research is needed.

5.2 Visual attention

It was expected that people who played the action game were better at visual attentional tasks on short-term than people who played the non-action game. Furthermore, it was predicted that people who played the game with a personalized character were better at visual attentional tasks than people who played the game with a default character. The experiment showed also no significant results for visual attention (p>.005) Therefore, these hypotheses were rejected.

However, there were some interesting findings. The results of the Stroop task showed that all conditions performed better during the pre-test in comparison to the post-test. In other words, the participants needed more time for the incongruent tasks than for the congruent tasks during the post-test in comparison to the pre-test, which is an unexpected outcome since it cannot be explained by the theory. Furthermore, it did not match with the outcomes of the Flanker task, which had to measure a similar effect. This difference could be explained by the buttons that were used during the Stroop task. Multiple participants mentioned that they found it hard to find the right button on the keyboard during the Stroop task and said that it was easier the second time they had to do the test. This could be a reason why the time difference between congruent and incongruent tasks was larger the second time, since they knew better where the buttons were. Therefore, the Stroop-effect was better visible during the post-test. However, there was no measurable data to prove this effect. Since there is doubt about the reliability of the Stroop task, because of the buttons, and because the results did not match with the Flanker task which should measure a similar effect, the results should be critically interpreted.

5.3 Playtime

The current study found no significant effects of playing an action game on visual acuity and visual attention (p > .05). This could be explained by the fact that the participants had to play the game for only twenty minutes. During previous studies, which did find effects, participants played an action or non-action game for at least ten hours (Eichenbaum, Bavelier and Green, 2014). The difference in playtime could explain why this study did not find similar effects. It would be interesting to test how many hours a person needs to play action games to find an effect on visual acuity and visual attention. Besides this, it could be that character personalization in games does have an effect on visual acuity and visual attention after ten hours of game play. Further research is required to test this hypothesis.

6. CONCLUSION AND FUTURE WORK

The aim of the present study was to investigate whether type of game (action or non-action) and type of game character (personalized or default) influences visual acuity and visual attention on short-term. The following research question was asked: '*What is the effect of a personalized game character in action games on visual acuity and visual attention after a short period of action game playing'*. To answer this research question, four sub-questions were asked, which are discussed below.

6.1 Sub-question 1

Sub-question one was as follows: *What is the effect of playing an action game for a short period on visual acuity?* It was expected that *people who played an action game are better at visual acuity tasks than people who played a non-action game* (hypothesis 1). The current study found no significant difference of action game playing on visual acuity. The observed values of the Pelli Robson task suggested that there is a difference which match the hypothesis. However, since the results were not significant, the first hypothesis was rejected.

Furthermore, it was expected that *people who played an action game with a personalized character are better at visual acuity tasks than people wo played a non-action game with a personalized character* (hypothesis 5). However, there was also no significant difference between the different conditions found. It can be concluded that there was no effect of playing an action game for a short period on visual acuity.

6.2 Sub-question 2

Sub-question two was as follows: *What is the effect of playing an action game for a short period on visual attention?* It was expected that *people who played an action game are better at visual attentional tasks than people who played a non-action game* (hypothesis 2). The present study found no significant difference of action game playing on visual attention during the Flanker task. The Stroop task showed a significant effect by a *p*-value of .067 of game type on visual attention. However, the results did not match with the hypothesis. Both action game players and non-action game players became worse after playing the game for twenty minutes. Furthermore, there was a larger difference between pre- and post-test found for the action condition in comparison to the non-action condition. Therefore, this hypothesis was rejected.

Besides this, it was expected that *people who played an action game with a personalized character are better at visual attentional tasks than people who played a non-action game with a personalized character* (hypothesis 7). The Flanker task indicated no significant difference between the conditions on visual attention. The Stroop task showed a significant effect by a *p*-value of .067 of condition on visual attention. However, it did not match with what was hypothesized. All conditions became worse, and there was a larger difference between pre- and post- test found for the action personalization condition and non-action default condition. As already mentioned in the discussion, there is some doubt about the reliability of the Stroop task. For this reason, and because the results of the Flanker task and Stroop task did not match with each other, it can be carefully concluded that there was no effect found of playing an action game on visual attention.

6.3 Sub-question 3

The third sub-question was: *What is the effect of a personalized game character in action games on visual acuity after a short term of action game playing?* It was expected that *people who played a game with a personalized character are better at visual acuity tasks than people who played the same game with a non-personalized character* (hypothesis 3). The present study found no significant difference of a personalized game character on visual acuity after playing an action or non-action game for a short period. The observed values of the Snellen task indicated a difference that did not met with the hypothesis. People in the personalized condition became worse in the post-test in comparison with the pre-test, whereas the default condition became better. However, since the results were not significant, the third hypothesis was rejected.

Furthermore, it was expected that *people who played an action game with a personalized character are better at visual acuity tasks than people who played an action game with a default character* (hypothesis 6). There was also no significant difference between the different conditions found. It can be concluded that there was no effect of playing an action game with a personalized character for a short period on visual acuity.

6.4 Sub-question 4

The fourth sub-question was: *What is the effect of a personalized game character in action games on visual attention after a short term of action game playing?* It was expected that *people who played a game with a personalized character are better at visual attentional tasks than people who played the same game with a non-personalized character* (hypothesis 4). The present study found no significant difference of type of game character on visual attention during the Flanker task. The Stroop task showed a significant effect by a *p*-value of .067 of type of game character on visual attention. However, the results did not match with the hypothesis.

Both conditions, who played with a personalized character and who played with a default character, became worse after playing the game for twenty minutes. Furthermore, there was a larger difference between pre- and post-test found for the default condition in comparison to the personalized condition. Therefore, the hypothesis was rejected.

Besides this, it was expected that *people who played an action game with a personalized character are better at visual attentional tasks than people who played an action game with a default character* (hypothesis 8). The Flanker task indicated also no significant difference between the conditions and visual attention. The Stroop task showed a significant effect by a *p*-value of .067 of condition on visual attention. However, it did not match with what was hypothesized. All conditions became worse, and there was a larger difference between pre- and post-test found for the action personalization condition and non-action default condition. As already mentioned in the discussion, there is some doubt about the reliability of the Stroop task results. For this reason, and because the results of the Flanker task and Stroop task did not match with each other, it can be carefully concluded that there was no effect found of playing an action game with a personalized character on visual attention.

6.5 Main conclusion

The main conclusion of the present investigation is that the hypotheses, which states that type of game and game character influences visual acuity and visual attention, were not supported by the design. There were no significant results found during the Snellen, Pelli Robson and Flanker test. Possible reasons for this could be the small sample size or the short period of game playing. The Stroop task showed some significant results by a *p*-value of .067. However, since there is doubt about the reliability of the Stroop task and because the results did not match with the Flanker task which should measure a similar effect, the results should be critically interpreted. To answer the research question, it could be said that there was no significant effect found of a personalized game character in action games on visual acuity and visual attention after a short period of action game playing.

6.6 Future work

The current study resulted in some interesting suggestions for future research. Firstly, it is interesting to investigate after how many hours of playing action games the positive effects of visual acuity and visual attention will occur. The present study found that twenty minutes is too short, but maybe there are some effect after one hour.

Furthermore, it was found during this study that twenty minutes of action game playing did not result in significant differences between the type of game character on visual acuity and visual attention. However, it could be that there is a difference after playing action games for ten hours for instance. This could be an interesting topic for future research.

Lastly, it was remarkable that people who played the action game were likely to copy their play-behaviour to the visual acuity tasks. They became faster and more reckless. It would be interesting to investigate the positive effect of visual acuity which occurred after playing an action game and compare this with the negative effect of recklessness and how both effects influence each other.

Despite the limitations and suggestions given, the goal of this study on investigating the effect of type of game and type of game character on visual acuity and visual attention on short period of game playing has been reached. The results presented that the design indicated no significant effect between the variables ($p > .05$). It is an interesting finding that the amount of playtime does influence the effect on visual acuity and visual attention. Also the recklessness which occurred during the visual acuity tasks are an interesting starting point for future research.

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Appendices

Appendix 1: Consent form

Consent form

You are being asked to take part in a research study about personalized gaming. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

Purpose of experiment: The purpose of this study is to investigate the influence of (personalized action) video games on visual acuity and visual attention.

What we will ask you to do: If you agree to be in this study, you will participate in an experiment. The experiment will include a pre-test and post-test containing four small tasks measuring visual acuity and visual attention. Between these two tests, you are asked to play a video game on the Nintendo Wii for approximately 20-25 minutes. Furthermore, a few demographic questions will be asked.

Consent for participation in experiment
I volunteer to participate in a research project conducted by Myrthe Sanders from Tilburg University. I understand that the experiment is designed to gather information for academic purposes.

1. My participation in this project is voluntary. I understand that I will not be paid for my participation. I may withdraw and discontinue participation at any time without penalty.
2. I understand that if I feel uncomfortable in any way during the experiment, I have the right to decline to participate to tasks.
3. Participation involves a pre-test, playing a Wii game, a post-test, and some demographic questions. The experiment will last approximately 40-50 minutes. Notes will be made during the experiment. No audio tape or video will be made during the experiment.
4. I understand that the researcher will not identify me by name in any reports using information obtained from this experiment, and that my confidentiality as a participant in this study will remain secure.
5. I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.
6. I have been given a copy of this consent form.

____________________________ ____________________________

My signature Date

____________________________ ____________________________

My full name Signature of the investigator

For further information, please contact:

Myrthe Sanders
Tel:
E-mail:

Appendix 2: Result form

Participant number ______________________
Gender _________________________________ (M/W)
Age ____________________________________
Condition ______________________________ (action personalisation/non-action personalisation/action default/non-action default)

Questions about games
Hours of playing games per week? ________________ (full or half hours)
Hours action games per week? _____________(full or half hours)
Game systems? _______________(computer, console, handheld console, phone+, other)
Have you played Nintendo Wii games before? _________ (yes/no)
Have you played Wii play/Wii sports before? ________ (depending on which game they have to play. yes/no)

Pre-test	**Post-test**
Acuity: (circle last correct named letter) 0.1: NXV 0.2: MCTH 0.3: AFDZE 0.4: BGLYCKI 0.5: HDFZVXT 0.6: DLVBNCMF 0.7: FNOPHDVLX 0.8: AGDUZBMFK 0.9: CHNFLDTUPZ 1: IBSDVOXTNU	Acuity: (circle last correct named letter) 0.1: NXV 0.2: MCTH 0.3: AFDZE 0.4: BGLYCKI 0.5: HDFZVXT 0.6: DLVBNCMF 0.7: FNOPHDVLX 0.8: AGDUZBMFK 0.9: CHNFLDTUPZ 1: IBSDVOXTNU
Contrast: (circle last correct named letter) PVSHDR CHKOVZ NSDVSK DRCZHR NOSCNK	Contrast: (circle last correct named letter) PVSHDR CHKOVZ NSDVSK DRCZHR NOSCNK
Flanker score:	Flanker score:
Stroop score:	Stroop score: