Changes of User Experience in an Adaptive Game: A Study of an AI Manager

Francesca Foffano
University of Trento
Departments of Psychology and Cognitive Science,
and Information Engineering and Computer Science
Trento, Italy
francesca.foffano@studenti.unitn.it

David Thue
Reykjavik University
School of Computer Science
Reykjavik, Iceland
davidthue@ru.is

ABSTRACT

Many questions remain unanswered in relation to player experience, particularly with respect to adaptive video games. To explore this topic, our research seeks to investigate how a player's awareness of an Artificial Intelligence (AI) experience manager affects their perceptions while they play a game. In this paper, we describe a first investigation of this topic, toward identifying areas that could be interesting for further study. The results of our study hint that the awareness of an AI manager might change a player's perceived self-efficacy, depending on the player's gender.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**; • **Computing methodologies → Intelligent agents**; • **Software and its engineering → Interactive games**;

KEYWORDS

Video Games, Experience Management, User Perceptions, Agency

ACM Reference Format:
Francesca Foffano and David Thue. 2019. Changes of User Experience in an Adaptive Game: A Study of an AI Manager. In *The Fourteenth International Conference on the Foundations of Digital Games (FDG '19), August 26–30, 2019, San Luis Obispo, CA, USA.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3337722.3341857

1 INTRODUCTION

Video games offer complex and stimulating experiences. To make such experiences more engaging, some games use an Artificial Intelligence (AI) agent to tailor the game experience to the user, creating a personalized experience during each gameplay session. Some examples of such AI agents in games include *Mario Kart* [17, 20], where the agent adjusts the game's difficulty in relation to the player's abilities, *Left 4 Dead* [18], where the "AI Director" manages the arousal of the player [7], and *Rimworld* [16], where the "AI Storyteller" generates events to ensure a narratively rich experience. Following Thue and Bulitko [21], we define an *AI manager* as an AI agent that tunes the parameters of a running game to affect each player's experience therein.

Previous research has highlighted the importance of considering user experience (UX) in terms of player reasoning and expectation [8]. While that work focused on understanding the designs of interactive storytelling games and how players understand them, we focus on a similar family of questions in a different domain: In games that adapt to their users using an AI manager, how does a user's knowledge of the manager affect their experience of the game? To increase our understanding of how players experience a game with an embedded AI manager, we designed an exploratory experiment to consider three main hypotheses:

- **H1:** A player's awareness of an AI manager can change their perception of agency.
- **H2:** A player's gender can help predict their perception of agency when aware of the presence of an AI manager.
- **H3:** A player's awareness of an AI manager can change how the player attributes power to it.

2 BACKGROUND & RELATED WORK

To inform our hypotheses, we examined literature from several different areas, including Computer Science, Cognitive and Social Psychology, and Human-Computer Interaction.

Lim and Reeves found that a player's arousal can decrease when they are convinced that they are interacting with an AI agent in a game, rather than a human-controlled avatar [15]. Differences that arise from playing against either an AI agent or an avatar have also been demonstrated in neurological research. In particular, Gallagher et al. found that a player's belief in playing with another player activates the anterior paracingulate cortex (bilaterally), an area related to the attribution of mental state [9]. AI agents that stand-in for player avatars (like the zombies in *Left 4 Dead*) effectively play the game with or against players, but AI managers are different: they adapt the game itself (e.g., by changing its difficulty). This difference leads us to suspect that AI managers might affect players in a different way. Specifically, we suspect that a player's awareness of the presence of an AI manager could affect their perception of having control over the game's virtual environment, and as a consequence, their perception of agency over the game (Hypothesis **H1**). Gender-based differences in virtual environments have been reported by many researchers. Guadagno et al. described an experiment wherein participants played a game of virtual blackjack against what they believed were either avatars or AI agents [10]. The experimenters found that players generally conformed more

FDG'19, August 26-30, 2019, San Luis Obispo, CA, USA

ACM ISBN 978-1-4503-7217-6/19/08…$15.00
https://doi.org/10.1145/3337722.3341857

with the bets of other players in the presence of an avatar, as compared to an agent, and the effect was more pronounced in women than in men. Bailenson et al. studied the relationship between the personal space of participants and avatars in virtual reality [2, 3]. In one study, they discovered that women maintained a larger distance when the avatar demonstrated a gaze behaviour toward them, while this behaviour was not present in the male subjects [2]. However, they noted that women generally noticed the gaze behaviour more than men, and that the experiment only included avatars that were men. In a follow up experiment by the same team [3], they replicated the study by adding a virtual human that was stated be either an avatar or an AI agent, depending on the experimental condition. In this study, both male and female virtual humans were used. Similarly with the results of their previous work, women maintained more personal space between themselves and the virtual human when it was stated to be an avatar than when it was stated to be an agent, and they did so more than men. A related experiment was conducted by Thue et al. [22]. In their study, they analyzed the effects of stating modest or exaggerated claims about a game concerning the presence of an AI manager; no AI manager was present in the game. They observed a decrease in fun for women who received the exaggerated information, but no such decrease for men. They suggested that the decrease in fun for women could have been caused by them believing that they were interacting with an AI manager. Together with the previously discussed findings of gender differences in how AI agents are perceived, Thue et al.'s experiment led us to consider gender as a possible predictor in our experiment (Hypothesis **H2**). As we discussed above, players can perceive virtual agents differently, depending on whether they perceive them to be AI- or human-controlled. One theory that can help explain this perception is Social Presence – one's "sense of being with another in a mediated environment", and, more specifically, to a *sense of accessibility* to the other's identity and emotional and intentional states [5]. Biocca et al. demonstrated that social responses occur even when the user is aware that they are interacting with a machine and not a real person [6]. They also found that this tendency does not apply only to human-shaped virtual agents, but also to differently-shaped artifacts. Nass and Moon reported that people apply social rules and bias to computers in many ways, if presented with the right clue: gender stereotype, ethnic identity, and social behaviour [19]. The authors explain it as the overapplication of human attributes and behaviours towards computers.

We supposed that stating that an AI manager is adapting to the player might create a sense of social presence, and, more specifically, cause them to attribute some kind of intelligence to the AI manager. Specifically, we wondered whether having awareness of the AI manager during gameplay (versus only becoming aware *after* gameplay) could affect how players attribute power to the manager (Hypothesis **H3**).

2.1 Chosen Game: Mario Kart Wii

Mario Kart is a series of competitive racing games created by Nintendo Entertainment. In this game, characters compete in a race that takes place in a fantasy setting; each player chooses a character and vehicle to use, and characters that are not controlled by players are controlled by an AI system that can steer each vehicle. During a race, players have the opportunity to activate *item boxes*, each of which provides some *power-up*. Power-ups include bonuses to use on one's own vehicle or hindrances to use against the opponents' vehicles, but the particular power-up that the player will receive is revealed only after the player activates an item box. Winning a race requires the player to balance both careful driving and the strategic use of power-ups. We chose *Mario Kart Wii* [17] for this study because of the AI manager present in the game, which is used to assign power-ups based on the player's rank [20]. For example, the trailing players receive powerful items (e.g., rocket or star) that help them advance in the race. Meanwhile, the leading players receive less useful items (e.g., banana and green shell). The intention of these differences is to balance the race across players with different levels of skill. It is possible that other mechanisms are affected by the AI manager, such as the abilities and speed of the AI agents. In addition to its use of an AI manager, we also chose *Mario Kart Wii* for other reasons. First, there is some chance for its AI manager's influence to be observed with relatively little exposure to the game. Second, it is a user-friendly game that allowed us to reduce the time that we spent training each player at the start of the experiment. The majority of games with an AI manager that we considered were too complex to be learned only for our experiment. Third, the fame of *Mario Kart*, and the fact that it has been available for many years, means that many potential participants have already experienced the game at least once in their life, or at least have knowledge about the goal and the mechanics of the game. This further simplified training players to play and allowed the player to consider their mental representation of the game's mechanics in the context of their previous experiences and elaborate more complex explanations. Fourth,we preferred to use a pre-existing, commercial game (rather than a toy game created for an experiment) to help improve the relevance of our work to the wider game development community. One limitation of using *Mario Kart Wii* is that participants could have joined our experiment being already aware of the presence of its AI manager. In our experiment, we obtained data from both kinds of participants: those who were aware of the manager before playing, and those who only became aware of it after they had finished playing.

3 EXPERIMENTAL DESIGN

Participants in the experiment were not required to have any prior experience with video games or with *Mario Kart*. All participants were invited to play on the same track on *Mario Kart Wii* [17], called "Luigi Circuit". This track was chosen for its simplicity, to facilitate participation for those who had never played *Mario Kart* and limit the difficulties (e.g., traps) that are present in other tracks.

Figure 1 shows the structure of the experiment. We divided the participants randomly into two groups: a Control Group who completed two gameplay tasks without being aware of the presence of the AI manager, and an Experimental Group (which we sometimes call the AI Group) who we informed about *Mario Kart Wii*'s AI manager before they began the second gameplay task. The participants of Control Group were also informed of the presence of the AI manager, but at a different point in the process; they were informed just before proceeding with the last questionnaire (Q4) and interview. The definition and statement about the AI manager

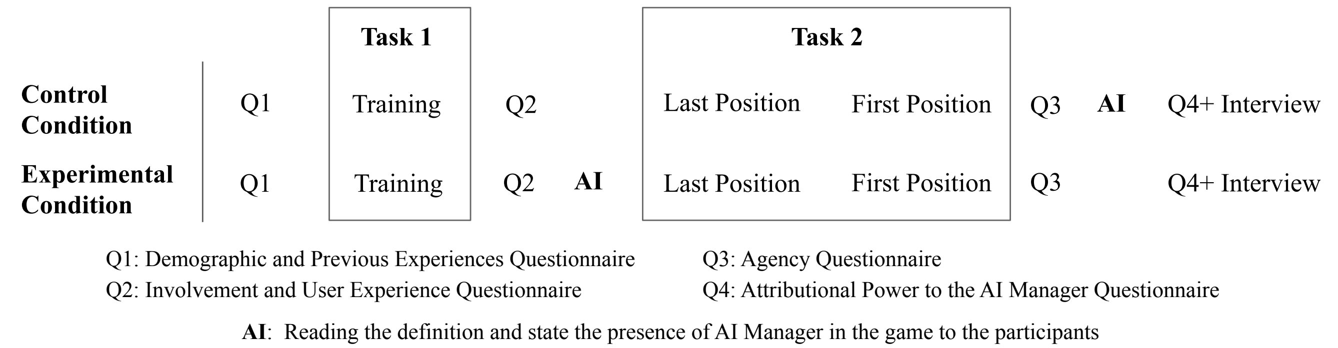

Figure 1: Progression of the experiment.

was as follows: *"In the game there is an AI manager, that adjusts how the game works in relation to the capacity of the player."*

3.1 Gameplay Tasks

All participants were asked to complete two gameplay tasks, all of which took place on the Luigi Circuit track of *Mario Kart Wii*, against 11 computer-controlled opponent racers.

- **Task 1:** *Training/Free Session*
  Participants who had not previously played *Mario Kart Wii* were invited to play 2 to 3 rounds of the Luigi Circuit track as training, until they reported feeling confident enough with the game to continue with the experiment. Participants who already knew the game were requested to play a free session of 2 to 3 rounds. Including this task helped us ensure that all of the participants had a sufficient knowledge of the game's mechanics and sufficient confidence in playing to potentially perceive the presence of the AI manager inside the game. In particular, we checked that every participant understood the use of power-ups via first-hand experience. Each player was meant to use about 9 power-ups per round.

- **Task 2:** *Last Position and First Position*
  All participants were instructed to play two rounds of the Luigi Circuit track, as follows. In the first round, they were requested to try to stay in the last (12^{th}) position of the race for as long as possible. In addition, they should collect as many power-ups as possible, and use each one before the next line of item boxes appeared in the road. If a power-up helped them to achieve a better position in the race, they were expected to slow down or stop until they returned to the last position before to continuing the race. In the second round, all participants were instead asked to stay in the first position as much as they could, or compete to achieve the best position possible. As in the previous round, they were also invited to pick up as many power-ups they could and use them during the race.
  By asking participants to remain in the last place and then in first place, we aimed to place them in situations in which they could perceive the influence of the game's AI manager. In particular, when players remained in the last position, we expected a general decrease in the competitiveness from the computer-controlled racers, and an assignment of the most powerful power-ups (e.g., star, rocket, or golden mushroom) to the player. Indeed, during the experiment, some players were forced to stop their kart to remain in the last position, because of the low speed of the opponent racers. When players worked to remain in the first position, we expected an increase in the competitiveness of the other racers and a higher chance for the player to receive less useful power-ups (e.g., banana, fake cube, green shell). Overall, this task was meant to maximize each participant's exposure to the extremes of the AI manager's behaviour, so that they could observe how the game adapts itself according to their rank during the race.

3.2 Questionnaires

All participants were asked to complete four different questionnaires, following the schedule shown in Figure 1.

Q1: Demographic and Previous Experience (8 items)
This questionnaire covered demographic and other data, (age, gender, nationally, work or study fields) including the participant's prior experience in playing games, both generally (How often do you play videogames?) and in the *Mario Kart* series (Have you never played Mario Kart before? For which console? How confident you feel in playing Mario Kart?).

Q2: Involvement and User Experience (25 items)
This questionnaire was meant to evaluate the general experience of the participant's interaction with the game. We evaluated the involvement and engagement of each player (Flow, Presence, and Enjoyment), as well as their user experience. All of the questionnaire items were collected from the IRIS evaluation toolkit [13].

Q3: Agency (11 items)
The objective of this questionnaire was to analyze different aspects of how players perceived their agency over the game. We considered three concepts in this questionnaire: Effectance, Controllability, and Self-Efficacy. The Effectance items were collected from the IRIS evaluation toolkit [13], while the items for Self-Efficacy and Controllability were created for this research, based in part on previous work

from a different context [1].

Q4: Attribution of Power to AI Manager (15 items)
This questionnaire contained questions related to the mechanics of the game that the AI manager might affect. Since a full description of the AI manager's abilities is not publicly available, we created 15 possible statements of changes that the AI manager might make. The goal of this questionnaire was to understand whether being aware of the AI manager's presence while playing the game can affect a player's perception of what power the AI manager has over the game. The questions can be categorized in three groups, based on the subject of the AI Manager's influence: the *Power-ups* (e.g., the AI manager affects the power-ups that you get), the *Opponents* (e.g., the AI manager affects the ability of other racers) or the *Environment* (e.g., the AI manager adjusts the statistics of the player's kart). This questionnaire was read aloud to each participant.

Participants were asked to respond to every questionnaire item using a 5 point Likert scale [14], ranging from "Strongly Disagree" (1) to "Strongly Agree" (5).

3.3 Interviews

We conducted a semi-structured interview with each participant to gather additional information to compare with our quantitative results. While participants were reading Q4, we invited them to both rate their level of agreement on the questionnaire and also explain their answer to the researcher (e.g., by giving an example of something that happened during gameplay). Once Q4 was complete, we interviewed each participant to further investigate their experience with the AI manager and their opinions about its role in the game. Every interview lasted between 10 and 30 minutes and included questions about: (i) whether (and if so, when) they noticed the AI manager (e.g., Have you noticed the AI Manager during the experiment?), (ii) their feelings, behaviour and opinion toward the AI manager (e.g., Do you think that knowing about the AI Manager will change your future experiences with Mario Kart?) and, (iii) the perception of their abilities (e.g., Do you think that your results in the game were due to your abilities or to the presence of the AI Manager?).

3.4 Awareness of the AI manager

To ensure the reliability of our data, we checked whether or not each participant knew, prior to their participation in our study, that *Mario Kart Wii* has an AI manager. Specifically, at the beginning of Q4 (after all participants had been informed about the game's AI manager), we asked each participant if they had been aware of the AI manager *before* the experiment began. In the Control Group, 2 out of 14 participants (14%) reported having known about the AI manager before the experiment. Meanwhile, 5 out of 14 participants (36%) in the AI group reported the same. For our consideration of Hypotheses H1 and H2, we excluded the data that we collected from the two subjects in the Control group who reported that they were aware of the AI manager before they took part in the experiment. This was done to ensure the validity of our tests. During the experiment, the researcher asked each participant to confirm that the definition of the AI manager was clear and well understood.

3.5 Variables

3.5.1 Immersion. Before collecting our main data (Agency) we decided to present a questionnaire on Involvement and User Experience (Q2) to ensure the reliability of the following data. Our interest in this case was to obtain some assurance that each participant's experience of the game was not disrupted by poor engagement or difficulty with interacting with the game's interface. By verifying that the participants' interaction was sufficiently smooth, we hoped to ensure that any changes of agency in our data was due to the participant's awareness of the AI manager, rather than the game itself.

3.5.2 Agency. Two of our hypotheses were related to player agency (H1 and H2). In particular, we considered different concepts related to agency, to better understand the nature of the relationship between the player and the virtual environment: Effectance, Controllability, and Self-Efficacy. These concepts have been demonstrated to be important for the player's interaction with the game, as well as their ability to plan, select, and maintain actions therein. In particular, Effectance and Self-Efficacy are related to a player's willingness to start a game and their inner motivation to continue playing it [11]. Effectance creates a sense of gratification from having an effect on the environment, while Self-Efficacy comes from the personal belief of being able to plan and resolve a situation. We consider Controllability to assess whether any kind of perceived limitations imposed by the game might adversely affect the player. Previous studies have demonstrated that Effectance is important for the player to feel enjoyment, and that Controllability might also have an effect [12]. We offer the following definitions for each of our selected variables:

- *Effectance* is one's perception that the world will change in response to their actions.
- *Controllability* is one's perception of being able to choose and enact actions freely in their environment, without substantial limitations being imposed by the environment. They are "in control" of what they do.
- *Self-Efficacy* is one's belief in their ability to plan and pursue actions that achieve their desired goals (based on Bandura's definition [4]).

3.6 Pilot test

We ran a pilot test during the month of October on 6 subjects (2 female, 4 male) to ensure that the tasks and the questionnaires were clear to the participants. Based on the pilot test, we decided against our initial plan to randomize the second task between playing in first and in last position. We made this decision because we noticed that if the player was supposed to play the second task starting in first position, they could not perceive the difference between the first and the second task, since their goal effectively remained unvaried (try to stay in the first position). Beginning Task 2 with the participant remaining in last position ensured that they could perceive a difference between Tasks 1 and 2. Moreover, in the last position it was more likely that the participant could perceive the AI manager, because regularly using power-ups (as was required by the instructions), would actively cause the player's ranking in the race to improve. We hoped that if the player perceived the presence of the AI manager, they might pay more attention to the manager's effects when later trying to stay in first position in the race. To streamline our process, we decided to simplify some of the questions and include a shorter version of the interview.

4 EXPERIMENT

We conducted the experiment at Reykjavik University during November 2018, with a total of 28 students: 14 male and 14 female. A researcher greeted each participant and introduced them to the purpose of the research, which was stated as understanding their perception of the game by presenting four different questionnaires and an interview. The researcher informed the participants that none of their gameplay, skills, or level of experience would be judged, and reminded each participant that their comfort was important to our research; they could make any request, including for the researcher to leave the room. Each participant was asked to complete a Consent Form containing details on the aim of the project, which also included their consent for audio to be recorded and transcribed for analysis. After signing the documents, the researcher presented the first questionnaire: the Demographic and Previous Experiences Questionnaire (Q1). Next, in relation to their experience with Mario Kart, the researcher explained the mechanics of the game and presented all the possible power-ups that the player could find in the game. Even if the player was experienced in Mario Kart, the researcher asked them to confirm, by showing a list of the possible power-ups, that they recognized everything and knew the effect of each item.

The researcher then invited the participant to start Task 1: playing the training/free session. During the experiment, the researcher was present in the room to offer support and answer participant questions, but, unless requested, did not directly pay attention to the game. When the participant felt confident enough to proceed (after 2 or 3 rounds, depending on the person), the researcher asked them to complete the Involvement and User Experience Questionnaire (Q2). Depending on the group assigned, the researcher then read (Experimental Group) or not (Control Group) the definition of an AI manager, as given above. To proceed with the experiment, the participant played through Task 2. At the end of the task, the researcher presented them with the Agency Questionnaire (Q3). When the participant finished the questionnaire, the researcher continued the experiment for participants of the Control Group by reading the definition of AI manager. Next, the researcher started the audio recording for the final interview (with consent).

Finally, the researcher asked the subjects to answer the sentences related to the last questionnaire, which concerned their Attribution of Power to the AI manager (Q4). They did so by reflecting aloud about whether they have noticed the AI in the game, giving some practical examples of when it happened and what they noticed, and rating the questionnaire items from 1 to 5 in relation to their agreement with each one. All of the items were read aloud by the researcher, and repeated or explained when necessary. At the end of this last questionnaire, the researcher continued with a semi-structured interview aimed to understand the general ideas of the player in relation to their awareness of the presence of the AI manager. The questions were guided by the answers and examples that the participants provided in the step before.

4.1 Data Analysis

In this section, we present our analysis of the data that we gathered for each condition of the experiment, and consider our hypotheses. As we stated in Section 3.4, we removed the data from two male subjects in the Control Group from our analysis, because they were aware of the game's AI manager before the experiment began. To simplify our writing, we will use the following abbreviations henceforth:

M: **M**ale — **F:** **F**emale
C: **C**ontrol Condition — **AI:** **AI** Condition
μ: Mean — σ: Standard Deviation
r: Pearson Correlation Value

When **C** or **AI** are used to identify a group without a gender specifier (**M** or **F**)[1] being stated, it can be assumed that all players in the group are being discussed.

Due to the initial and exploratory nature of this work as well as the small size of our samples, we do not report the results of any statistical tests in this work, and thus our findings should *not* be generalized to any larger population.

4.1.1 Demographics. We include the demographic data of our participant group to offer a better overview of its composition. Via Q1, gender was expressed according the following options: male or female, or prefer not to say. The participants identified themselves as 14 males and 14 females, with ages from 18 to 27 ($\mu = 22$, $\sigma = 2.5$). The majority of the sample were students of Computer Science or Engineering (10 Engineers, 15 Computer Scientists, 3 others) from 11 different nationalities, mainly from Europe (11 Icelandic, 17 others). We also asked each participant to rate their familiarity with playing video games, ranging from 1 (I play video games daily) to 7 (I never played). Both female ($\mu = 5.2$, $\sigma = 6$) and male ($\mu = 5$, $\sigma = 4.5$) players reported similarly high levels of experience playing video games (though with more variation in females).

4.1.2 Immersion. By collecting data related to player immersion, we aimed to ensure that our subsequently gathered data was not compromised by a lack of engagement with the game. We calculated the mean of all the responses related to immersion to obtain a general score. All the data presented here are related to both conditions (**AI** and **C**), and were collected before reading the definition of the AI manager to any participant. The researchers agreed in advance to a threshold of 3.5 points out of 5 on a Likert scale, above which the game's immersion could be deemed sufficient to not bias our subsequently collected data. The results show that the means were higher than our pre-defined threshold (**M**: $\mu = 3.61, \sigma = 0.61$; **F**: $\mu = 3.57, \sigma = 0.35$), suggesting that the game was sufficiently immersive for all participants.

We additionally decided to analyze the mean of each Immersion variable to check for any score below our 3.5 threshold. These data are presented in Table 1 for both male and female participants. The immersion appeared to be sufficient for our aims, although the variance was relatively high.

[1]Gathering data from non-binary players remains as future work.

Table 1: Mean and Standard Deviation for male and female subjects in both the conditions.

Immersion Variables				
	Flow ($\mu \pm \sigma$)	Presence ($\mu \pm \sigma$)	Learnability ($\mu \pm \sigma$)	Enjoyment ($\mu \pm \sigma$)
M	4.21 ± 0.47	3.80 ± 1.00	3.61 ± 0.40	4.05 ± 0.60
F	4.04 ± 0.52	3.52 ± 0.92	3.35 ± 0.40	4.25 ± 0.36

4.1.3 Agency. According to our initial hypothesis (**H1**), we suspected that player perceptions of agency might differ across the control condition (**C**) and the experimental condition (**AI**). We analyzed the mean and the standard deviation for all the Agency variables. The results are presented in Table 2, broken down by gender and experimental condition. With respect to gender, the data shows opposite trends in how knowledge of the AI manager affected Self-Efficacy. In particular, for men in the Control condition, the mean Self-Efficacy was lower than it was for men in the AI condition (by 0.35), while the corresponding values for women show the Control condition's mean being *higher* by 0.81. These results lend some initial support to Hypothesis **H1** (that knowledge of an AI manager can affect perceived agency). They also offer some support for Hypothesis **H2** (that gender can mediate how one's knowledge of an AI manager affects perceived agency) – they suggest that having knowledge of the AI manager might affect Self-Efficacy positively for men, but negatively for women. We will consider this possibility in more detail later on.

To investigate whether these trends might be explained by the other Agency variables, we computed the Pearson correlations between all pairs of the Agency variables. The data are shown in Table 3. In the Control group, there are at least moderate ($r > 0.3$) correlations for all the variables. Compared to the Control group, all but one of the AI group correlations are lower, with the value for M: Self-Efficacy vs. Controllability being the only exception (M-C $r = 0.41$ to M-AI $r = 0.60$). This exception might be important; if we consider four correlations between Self-Efficacy and Controllability that are shown in Table 3, a similar, gender-based trend as before can be seen. Specifically, while the correlation for men is lower in the Control condition than it is in the AI condition (M-C $r = 0.41$, M-AI $r = 0.60$), the correlation for women is higher in the Control condition than it is in the AI condition (F-C $r = 0.89$, F-AI $r = 0.53$).

We offer one potential explanation for these results, which was inspired in part by our initial analysis of the interviews that we conducted with each player. We suspect that women in our study thought that the AI manager could interfere with their own ability to control the game (the mean Controllability for F-C is lower than F-AI). This belief may have then led them to doubt how directly their inputs (re: Controllability) were related to their ultimate success in playing (re: Self-Efficacy). Furthermore, we suspect that the men in our study thought of the AI manager as a part of the game that could be learned and exploited (and thus found it to be as controllable as the rest of the game; M-C $\approx$ M-AI). This view may have led them to feel more certain about how their inputs were related to their success in playing. We discuss these suspicions further in the following sections, but further analysis and experimentation is needed to confirm or deny our explanations.

Table 3 contains another point of interest: the relatively strong positive correlations between Effectance and Controllability in the Control group (M-C: 0.82, F-C: 0.31, All: 0.60) all but vanish in the Experimental group (M-AI: −0.10, F-AI: −0.06, All: −0.09). At the same time, the means for Effectance and Controllability seemed relatively *un*affected by knowledge of the AI manager (women's perception of Controllability was an exception).

These results suggest another way in which knowing about an AI manager might change how players perceive the relationship between different notions related to agency. Recall that feeling Effectance requires one to perceive that their actions have consequences. Since the lack of change in Effectance suggests that players where able to observe the consequences of their actions both conditions, we suppose that what changed instead was how they *attribute* the consequences of their actions, either to themselves (via the game's mechanics) or to the AI manager. We suspect that in the Control condition, players attributed the consequences of their actions to themselves. That is, after all, how typical video games (without AI managers) function. In the Experimental condition, even if the participants were able to observe the consequences of their actions, they were no longer certain whether they should attribute each consequence to their own abilities or to some adaptation triggered by the AI manager. In our data, this effect was stronger for men than it was for women, but this and our other suppositions must be tested more thoroughly before any firmer claims can be made.

4.1.4 Attribution of Power. According to Hypothesis **H3**, we suspected that the way that players attribute power to the AI manager might differ between our Control and Experimental groups. The data that we collected in relation to this hypothesis (from Q4) aimed to measure the level of influence over the game that the player attributed to the AI manager. After collecting this data, we calculated the mean and standard deviation of the results, separated by both our experimental conditions and by gender; see Table 4.

There appears to be little to no variation across the conditions or the participants' genders, as the means are all equal within a margin of 0.16.

In general, our data do not support making any claims about Hypothesis **H3**. Further investigation is needed to confirm or deny that knowing about an AI manager while playing (versus finding out afterward) can affect how players attribute power to the manager.

4.1.5 Interviews. To further explore our research questions, we performed an initial qualitative analysis of the interviews. We focused our efforts on the analysis of three sets of questions related to our hypothesis: *Gameplay Behaviour* (e.g., if the player expected to experience differences in playing the game again), *Ability Perception* (e.g., if the awareness of the AI Manager affected the player's perception of their own abilities, and *Events Attribution* (e.g., to whom they attribute the results of different events). For the last question, we focused on two specific cases: successes (e.g., winning a race after losing the last one) and failures (e.g., if an opponent hits you using a green shell). We aimed to understand if the players were more likely to attribute the results to an adaptation of the AI Manager or to their abilities as players.

We found that in the case of gameplay behaviour, males expressed a stronger intention to use their acquired knowledge about

Table 2: Mean (μ) and Standard Deviation (σ) of the Agency variables in the Control group (C) and Experimental group (AI) for male (M) and female (F) subjects.

	Effectance				Self-Efficacy				Controllability			
	Control		Experimental		Control		Experimental		Control		Experimental	
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
M	3.70	0.57	3.60	1.32	3.93	0.64	4.28	1.60	3.50	0.46	3.42	0.81
F	3.71	0.22	3.64	1.32	4.14	0.57	3.33	0.43	3.07	0.40	2.75	0.30

Table 3: Correlation results for agency data from males (M), females (F), and all participants.

	Control Group					
	Self-Efficacy			Controllability		
	M	F	All	M	F	All
Effectance	0.84	0.58	0.69	0.82	0.31	0.60
Self-Efficacy	/			0.41	0.89	0.60

	Experimental Group					
	Self-Efficacy			Controllability		
	M	F	All	M	F	All
Effectance	0.55	0.50	0.33	-0.10	-0.06	-0.09
Self-Efficacy	/			0.60	0.53	0.51

Table 4: Summary statistics for how players attributed power to the AI manager.

	Attribution of Power to AI Manager			
	Control		Experimental	
	μ	σ	μ	σ
M	3.20	0.61	3.28	0.52
F	3.36	0.26	3.28	0.55

the AI manager in the next game (7 participants) in comparison to women (2 participants).

> " *I do sometimes break the game, like finding something out [...], and then [taking it] at my own advantage. It's one way to improve your performances of playing a game.*" - Participant 12, Male.

Moreover, in agreement with the results we found for Self-Efficacy, gender seemed to influence players' perceptions of their own abilities. Women reported feeling less proud, competent, and/or confident in judging their own abilities in most of the cases (6 participants), while some males reported more competence regarding their skills (3 participants).

> "*I think that know what [the AI manager] could be doing, [and] I have less control over the races.*" - Participant 17, Female.

In the questions concerning events attribution, the female participants were mixed between attributing the causes of their successes or failures to the AI manager (5 participants) or their own abilities (6 participants). Meanwhile, men were more likely to attribute their successes and failures to their own abilities (6 participants) or to both themselves and the AI manager, depending on the specific event (3 participants).

These qualitative analyses support our findings about potential gender differences in our study, and it suggests how how self-efficacy and one's perception of their own abilities can be related to the presence of an AI manager in the game. We find it interesting that males seemed more motivated to use their acquired knowledge to develop new strategies of playing, compared to women. A full analysis of our interview data remains as future work.

4.2 Discussion and Limitations

As we discussed in our analysis, we observed some changes in how players perceive Agency across two conditions: one in which players did not know about *Mario Kart*'s AI manager (Control group), and one in which they did (Experimental/AI group). Not only did players' Self-Efficacy change (in opposite directions for men and women), but the relationship between Self-Efficacy and Controllability changed as well. We supposed that men perceived themselves as being more competent when aware of the AI manager because the manager recognizes their personal abilities through its adaptation. For women, we suspect the manager's adaptive behaviour might make them feel judged by the system, and thus less secure of their own actions. Despite the gender diffidence, it is important to note that all players perceived Effectance in roughly the same amounts, and that Controllability only showed a small variation across the Control and Experimental conditions. We also noted a change in the relationship between Effectance and Controllability, in that the strong, positive relationships in the Control condition do not appear in the Experimental condition. We supposed that players in the Control condition felt more sure of their role in causing consequences in the game. On the other hand, we suspect that players in the Experimental condition became less sure of their role in causing consequences in the game, since they could instead attribute arbitrary observations to the AI manager's influence, rather than their own. We consider our experiment to be exploratory research, and some limitations should be discussed. First, the number of the participants in our study was low, and was further reduced by our removal of two subjects in the Control group from the data that we analyzed. Second, most of the participants come from a common, overly homogenous background in Computer Science or Engineering. We hope in our future studies to increase the number and diversity of our participants. Another limitation was related to our choice of *Mario Kart Wii* for our investigation. Specifically, we suspect that the level of each participant's experience in playing Mario Kart could have influenced their probability of noticing the

AI manager inside the game. Indeed, some of our inexperienced players reported not having noticed the AI manager because they were too concentrated on the mechanics of the game. We have already discussed in Section 2.1 how our understanding of *Mario Kart Wii*'s AI manager is incomplete, due to lack of publicly available information concerning its operation. For the same reason, some of our planned data analysis remains incomplete – in particular regarding how players attribute power to the AI manager. Lastly, the AI manager in *Mario Kart Wii* operates differently than an AI manager in another game would; this likely limits the generalizability of our findings.

5 FUTURE WORK

Given the exploratory nature of our work, it should be considered a work in progress; more research is needed to confirm or deny the new hypotheses that we have generated. Moreover, a deeper cross-referencing of our data with a qualitative analysis of the interviews could offer additional information about how players perceive their agency in the context of an AI manager.

Based on the results, one of the next steps is to study the relationship between Self-Efficacy and knowledge of an AI manager. In particular, we would like to investigate the factors that modify the perception of the player, and how it might be possible to overcome any decrease in Self-Efficacy that occurs as a result of learning that an AI manager exists.

More energy could also be spent exploring gender-based differences (including expanding beyond a binary notion of gender), and particularly with respect to the relationship between gender and Controllability. We believe that more careful analysis could allow us to better understand how players perceive and respond not only to games with AI managers, but also to other kinds of virtual environments.

6 CONCLUSION

We tested 28 participants playing *Mario Kart Wii* across two conditions: one where players were aware of the presence of an AI manager that could adapt the game's mechanics according to their game play, and one where players remained unaware of this fact. Our aim was to investigate whether the awareness of the AI manager game could change the perception of the player. Our results showed that being aware of the presence of an AI Manager can change players' perception of agency, in particular in relation to the Self-Efficacy that they perceive, and that these perceptions might be better understood by considering a player's gender. We proposed several new hypotheses based on our observations, two of which suppose that having knowledge of an AI manager might alter the relationship between different aspects of perceived agency, spanning Effectance, Self-Efficacy, and Controllability. Given the exploratory nature of this research, we hope that it can serve a starting point for a more deeper investigation of the relationship between players, games, and AI managers, toward increasing our knowledge and supporting the creation of ever better virtual experiences.

REFERENCES

[1] Icek Ajzen. 2002. Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior 1. *Journal of applied social psychology* 32, 4 (2002), 665–683.

[2] Jeremy N Bailenson, Jim Blascovich, Andrew C Beall, and Jack M Loomis. 2001. Equilibrium theory revisited: Mutual gaze and personal space in virtual environments. *Presence: Teleoperators & Virtual Environments* 10, 6 (2001), 583–598.

[3] Jeremy N Bailenson, Jim Blascovich, Andrew C Beall, and Jack M Loomis. 2003. Interpersonal distance in immersive virtual environments. *Personality and Social Psychology Bulletin* 29, 7 (2003), 819–833.

[4] Albert Bandura. 1982. Self-efficacy mechanism in human agency. *American Psychological Association* 37, 2 (1982), 122–147.

[5] Frank Biocca and Chad Harms. 2002. Defining and measuring social presence: Contribution to the networked minds theory and measure. *Proceedings of PRESENCE* 2002 (2002), 1–36.

[6] Frank Biocca, Chad Harms, and Judee K Burgoon. 2003. Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators & virtual environments* 12, 5 (2003), 456–480.

[7] Michael Booth. 2009. The AI Systems of Left 4 Dead. Presentation at the Fifth Artificial Intelligence and Interactive Digital Entertainment Conference.

[8] Elin E Carstensdottir and Magy Seif El-Nasr. 2018. Interaction Maps for Interactive Narratives. *Tech- nical Report NU-CCIS-TR-2018-001* ., . (2018), .

[9] Helen L Gallagher, Anthony I Jack, Andreas Roepstorff, and Christopher D Frith. 2002. Imaging the intentional stance in a competitive game. *Neuroimage* 16, 3 (2002), 814–821.

[10] Rosanna E Guadagno, Jim Blascovich, Jeremy N Bailenson, and Cade McCall. 2007. Virtual humans and persuasion: The effects of agency and behavioral realism. *Media Psychology* 10, 1 (2007), 1–22.

[11] Christoph Klimmt and Tilo Hartmann. 2006. Effectance, self-efficacy, and the motivation to play video games. *Playing video games: Motives, responses, and consequences* (2006), 133–145.

[12] Christoph Klimmt, Tilo Hartmann, and Andreas Frey. 2007. Effectance and control as determinants of video game enjoyment. *Cyberpsychology & behavior* 10, 6 (2007), 845–848.

[13] Christoph Klimmt, Christian Roth, Ivar Vermeulen, and Peter Vorderer. 2010. The empirical assessment of the user experience in interactive storytelling: construct validation of candidate evaluation measures. *FP7-ICT-231824* D7.2, 35 (2010), 1–35.

[14] Rensis Likert. 1932. A technique for the measurement of attitudes. *Archives of Psychology* 22, 140 (1932), 55.

[15] Sohye Lim and Byron Reeves. 2010. Computer agents versus avatars: Responses to interactive game characters controlled by a computer or other player. *International Journal of Human-Computer Studies* 68, 1-2 (2010), 57–68.

[16] Ludeon Studios. 2013. Rimworld. https://rimworldgame.com.

[17] Nintendo. 2008. Mario Kart Wii. http://www.mariokart.com/wii/.

[18] Valve Corporation. 2008. Left 4 Dead. http://www.l4d.com/.

[19] Clifford Nass and Youngme Moon. 2000. Machines and mindlessness: Social responses to computers. *Journal of social issues* 56, 1 (2000), 81–103.

[20] Yasuyuki Ohyagi and Katsuhisa Satou. 2005. *Racing game program and video game device.* Technical Report US7278913B2. U.S. Patent and Trademark Office.

[21] David Thue and Vadim Bulitko. 2018. Toward a Unified Understanding of Experience Management. In *Proceedings of the 14th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE'18)*. AAAI Press.

[22] David Thue, Vadim Bulitko, Marcia Spetch, and Michael Webb. 2009. Exaggerated Claims for Interactive Stories. In *The Second Joint International Conference on Interactive Digital Storytelling*. Springer Berlin / Heidelberg, Guimarães, Portugal, 179–184.