The Effect of Camera Perspective and Session Duration on Training Decision Making in a Serious Video Game

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***Abstract*—In this paper, we examine the effects of three video game variables: camera perspective (1st person versus 3rd person point-of-view), session duration, and repeated play on training participants to mitigate three cognitive biases. We developed a 75 minute, 3D immersive video game for use as an experimentation test bed. One-hundred and sixty three participants either watched an instructional decision video or played one of the four versions of the video game. Each participant's learning was assessed by comparing his or her post-test scores and pre-test scores for knowledge of the biases and demonstrated ability to mitigate them. Results indicated that repeated game play across two sessions produced the largest improvement in learning, and was more effective than the instructional decision video and single session game for mitigating biases. Surprisingly, session duration did not improve learning, and results were mixed for the third person perspective. Overall, the video game did improve participants' abilities to learn to mitigate three cognitive biases. Implications for training using video games are discussed.**

Keywords—decision making; training; serious games; video games, video game experiment platform, experimentation

I. Introduction

Video games provide numerous benefits to students, such as increasing motivation to practice, facilitating guided deliberate practice in an environment where the student can safely fail, and allowing the student to explore and test new strategies [1]. Together, these features of video games are expected to improve players' understanding and shape their behavior [2, 3]. The same material, embedded within a video game may be more effective than if presented in an instructional video because the learner can interact with the information, receive feedback on that interaction, and consequently remember it [3, 16]. One goal of this research is to experimentally examine the effect of game features on learning. In the past 10 years, there has been an expansion of virtual game-like training in a variety of domains from education to aviation.

A. Game Research

Understanding what people learn when playing video games has been a popular and important topic [2, 4]. While there has been considerable research on game features in general very few experimental studies have explored specific game features empirically and the results have been mixed [4, 6, 7]. Furthermore, video games have been shown to be effective for developing perceptual and motor skills [10], but few experiments have attempted to develop and empirically test video games for training more complex cognitive processes. This paper is a contribution to this growing body of research.

In this paper, we evaluate the effectiveness of three game variables on learning to use better decision strategies. Two of these game variables have been studied extensively in the psychological literature, session duration and spaced practice [26, 27]. Research suggests longer game durations and more deliberate practice will improve learning [1, 25, 26, 28]. The third variable, player point-of-view, has not been studied as much. The research related to 3rd person perspective has suggested that player point-of-view might enable altered perspective-taking. It has been suggested that camera

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perspective shifts can reorient a player toward the world, while also changing their focus [8]. It is this reorientation toward the environment that, if true, could improve the mitigation of two of the three cognitive biases that we examined. The 3rd person perspective has been associated with engagement more than cognitive strategies [8, 12].

B. *Decision Making and Debiasing*

People rely on heuristics to make estimates or judgments when they have limited information, are under time constraints, and are in uncertain situations [23]. These decisions often result from a bounded rationality. More than 30 years of research has demonstrated that debiasing is difficult [9, 13, 21] in both cognitive and social situations. Could a video game be more effective than previous methods for debiasing due to the interactivity and replayability?

We developed and experimentally tested a 75-minute serious game called Heuristica [32], which was designed to train participants to mitigate cognitive and social biases. An intelligent tutoring system, a student model, was built into the game to tailor each player's learning experience [31]. The three biases that were trained included: confirmation bias, fundamental attribution error, and bias blind spot.

- *Confirmation bias* (CB) is a cognitive bias that has been studied extensively [14, 17 for a review]. It refers to the tendency to favor confirming information over disconfirming information when searching for information or testing hypotheses. Confirmation bias may lead to the disproportionate weighting of information that confirms a given belief, story, or hypothesis, and discounting of information that disconfirms those beliefs [24]. Considering both types of information can mitigate this bias.
- *Fundamental Attribution Error* (FAE) occurs when individuals weight personal or dispositional explanations for others' actions, while neglecting the role that situational forces have in determining behavior [11, 20]. For example, one might assume a person is lazy because he arrives late for a meeting and not consider that traffic might have been bad. Related to the camera perspective, this bias could be mitigated if, by redirecting the camera focus, the player shifts their attention toward the situation and away from the person [8, 15].
- *Bias Blind Spot (BBS)* is a meta-cognitive bias in which people report that they are less susceptible to a bias than others [18, 19]. This bias can be mitigated by having a person take the other person's perspective.

Ecological rationality theory [23] suggests that simple heuristics are adaptive, and that these heuristics, or rules of thumb, cause problems mainly when underlying cognitive strategies are mismatched to situations. Consequently according to this theory, people need to learn to calibrate their strategies to the environment to avoid bad decisions. One strategy we taught for mitigating these three biases was to shift one's perspective (e.g., look at the problem from the other's perspective).

II. HYPOTHESES

In this experiment, we empirically evaluated the effect of three game variables (session duration, session repetition, and 3rd person perspective or point-of-view) on learning to mitigate biases immediately and after 8 weeks. Our research questions included: Does length of game play affect learning? Does spaced practice in the form of multiple game sessions improve learning relative to a single session? Does a change in video game visual perspective to focus more on the context improve one's ability to mitigate biases that result from not focusing on the situation (e.g., fundamental attribution error)? To the extent that this camera shift would cause participants to focus more on the situation in their estimates, it was expected to reduce errors such as the fundamental attribution error and bias blind spot. Each of the game variables was predicted to improve different aspects of learning in the context of the video game.

III. METHODS

A. *Participants*

Data were collected from 169 university participants who took part in this experiment for pay. Six participants were excluded from the analysis because they did not follow instructions. Most participants were between 18 and 25 years old, with an average age of 21 years. Participants included 58% men, and 42% women. There were 37% non-gamers (never play video games), 35% moderate gamers (play 1-6 hours a week), and 28% gamers (defined as 7 or more hours of game play per week) in the sample.

B. *Experiment Design and Independent Variables*

The data were analyzed using a 3 (Cognitive Biases: Confirmation Bias, Fundamental Attribution Error, Bias Blind Spot) x 5 (Condition: Decision Video, Baseline Game, Short Duration Game, Repetition Game, 3rd Person Perspective Game) multivariate ANOVA. Bias was a within-subject variable and Condition was a between-subjects variable in the analyses. Additional analyses include one-way ANOVAs and t-tests to compare two conditions (e.g. single game session vs. two game sessions). Approximately 35 participants took part in each condition.

Four versions of the game, Heuristica, were created. There was a control version, or Baseline Game Condition, and three additional game versions to compare to the engaging instructional training video (i.e., the Decision Video Condition). The Decision Video was 30 minutes long and included an entertaining host and vignettes of social situations where these cognitive biases might occur that were acted out by a cast (e.g., dating relationships, logistics for a group trip). This was not a lecture with power point slides. This condition served as one of the control conditions to compare to Heuristica, in order to evaluate what is possible in passively conveyed instructional material. The game conditions varied systematically by the game duration, point-of-view presented (1st person vs. 3rd person), and the number of sessions. In the Short Duration Game Condition, participants played only the tutorial and training phase of the video game (approximately 30 total minutes of game play). This condition was compared to the 75 minutes of time needed to complete the full, Baseline Game Condition. To examine the effects of repeated game play on performance, participants completed either one full game session (Baseline Game Condition) or two game sessions over three days (Repetition Condition). Finally the 3rd person perspective game, in which players viewed game play from behind the avatar, was compared to the Baseline Game Condition (1st person point-of-view).

C. *Heurisitca: A 3D immersive video game to train decision making*

We developed Heuristica, a 3D immersive serious game, using the Unreal 3 game engine to train decision making [32]. Our team developed 19 learning opportunities in the game that covered different types of learning activities and provided up to 120 minutes of game play. Most of these focused on having the participant play and learn by making decisions and assessments of other players, crewmembers, and non-player characters [3]. Feedback about a player's outcome and strategy were included. We also included worked out examples in response to specific errors that players made regarding a bias. The game was fully instrumented for experimentation to provide experimental control for manipulating game variables. Heuristica was designed to train participants to learn to mitigate biases in the context of competing for a position as commander of a space station (Fig. 1).

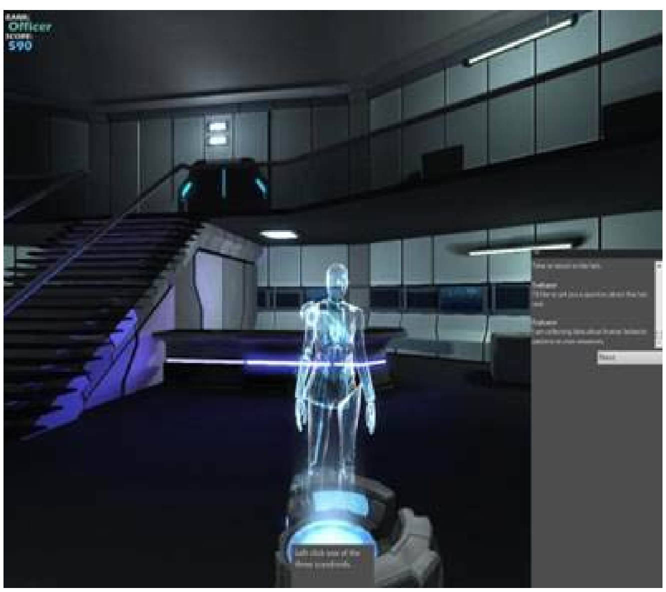

Fig. 1. Screenshot of the Evaluator, a non-player character, shown standing in Heuristica's hub.

In Heuristica, the player assumes the role of a human astronaut on a space station staffed by android and human crewmembers. The player is competing for command of the ship and needs to understand how the androids on board think in order to win. There is a key non-player character (NPC), the Evaluator (Fig. 1), who accompanies and works with the player at times during the game. The narrative supposes that there are key differences between the minds of androids and humans: where humans use cognitive and social heuristics, androids use computation. These heuristics leave humans vulnerable to cognitive biases. To successfully command androids, the player must demonstrate the ability to recognize and mitigate these biases.

The game is modular, consisting of a core narrative and game modules, called learning opportunities (Fig. 2), which can be presented in different orders to tailor learning. In the learning opportunity pictured in Fig. 2, participants choose a teammate (a NPC), to complete a task involving data transfer. They play the task themselves, then watch their teammate play and decide whether to keep this crewmember or switch to a new one. For some trials in this task, situational factors impact the chosen crewmember's performance, and the player must decide whether to attribute performance to these factors or to the crewmember's abilities or motivations (e.g., personal characteristics). This learning opportunity had three rounds and lasted about 10 minutes.

Fig. 2. Screenshot of an example learning opportunity addressing the fundamental attribution error.

The game is split into three stages: a tutorial, in which participants learn game controls and features, training, where participants are introduced to the three cognitive biases, and an action phase, where participants must apply what they have learned to successfully investigate the cause of an on-board crisis. As mentioned, we created 4 different versions of the game that were the same except for the game variable of interest.

D. Procedure

Participants were recruited for a “decision making study in a multimedia environment” through university web posts, flyers, and email lists. No mention of a video game was made in the recruitment material or by recruiters/schedulers, to ensure a wide variety of participants. Participants were randomly assigned to the Decision Video Condition or to one of the four game conditions. All participants completed a form of the Cognitive Bias Test before and after game play to measure learning. We developed two equivalent forms of the Cognitive Bias Test (see section E, below). Presentation order at the pre- and post-game time points was counterbalanced. That is, half the participants received Form A first, followed by Form B after they had played the game or watched the video. Participants in all conditions completed the experiment in a single session, with the exception of participants in the Repetition Condition who completed it in two sessions. After completing the Bias Test, participants filled out two engagement questionnaires, the Game Engagement Questionnaire [29] and the E-Game Flow [30], which captured participants’ subjective engagement, immersion, and flow experiences. Finally, participants took a Cognitive Bias Test again after 8-weeks to measure learning retention. At the end of the final session, participants were debriefed about the purpose of the experiment.

E. Dependent Measures

The three dependent measures were improved knowledge of biases knowledge, learning to mitigate biases, and subjective engagement. The first two measures were captured by the Cognitive Bias Test we developed. The engagement measures included two published measures of engagement and flow.

Each form of the Cognitive bias test was comprised of a different set of 41 multiple-choice and 9-point likelihood rating items. Fifteen items assessed participant knowledge and recognition of the three biases, and twenty-six assessed participant ability to mitigate bias across different situational contexts. The two Cognitive Bias Test forms were developed to be equally difficult and internally reliable. The Cognitive Bias tests were developed through several rounds of testing using Amazon Mechanical Turk and university student populations.

The knowledge portion of the test was a 15-item (five per bias) multiple-choice test with an average initial score across experiment conditions of 59%. For this test, the overall internal reliability was good (Cronbach alphas $\alpha = 0.67$, and $\alpha = .65$ for Forms A and B respectively). The bias mitigation portion of the test resulted in mean responses from 5.9 ($SD = 0.59$) to 6.5 ($SD = 0.78$) on a 9-point likelihood scale, and the scores across conditions were not reliably different from each other initially. Tests for internal reliabilities were high across confirmation bias ($\alpha = 0.79$ and 0.8 for Form A and B respectively), fundamental attribution error ($\alpha = 0.65$ and $\alpha = 0.70$), and bias blind spot ($\alpha = 0.62$ and $\alpha = 0.76$). Construct validity was established by correlating test scores with other subjective measures with which it was expected to correlate, such as need for cognition, $r(168) = .15$, $p < 0.05$.

For engagement, we used two instruments to capture participants’ subjective game experience: the Game Engagement Questionnaire [29] and the E-Flow Scale [30]. The Game Engagement Questionnaire Scale is comprised of nineteen 9-point Likert-type scale items recoded from (1 – Strongly Disagree; 9 – Strongly Agree) ($\alpha = .83$) and includes immersion items such as “*Time seemed to stand still or stop*. We also used 10 items from the E-Flow Scale ($\alpha = .79$ for the 10 items). Example scale items include *I experienced an altered sense of time* and *I became involved in the game.*

IV. Results

A. Improved Knowledge of the Cognitive Biases

We operationalized our first dependent measure, improved knowledge of biases, as the difference between the Time 2 (post-test) and the Time 1 (pre-test) proportion correct scores for the 15 knowledge items on the Cognitive Bias Test. This measure focuses on declarative knowledge about each bias (e.g., definition, recognition). A one-way ANOVA of Condition on Time 1 pre-test scores was not significant, $F(5, 162) = .55$, $p = .91$, indicating, as expected, that the groups did not reliably differ in terms of their initial bias knowledge.

Overall, participants in every condition learned about the three cognitive biases. Collapsing across all conditions, the one sample t-test was significant, $t(162) = 10.9$, $p = 0.001$. This indicated that participants in all conditions improved their ability to recognize the cognitive biases (Fig. 3).

Participants in the Repetition Condition improved their overall score by 22% on average, while participants in the Baseline Game Condition improved by 10% overall as did participants in the Short Duration Game Condition (i.e., 30 minute game). Participants in the instructional Decision Video Condition improved their knowledge of the three biases by 17% on average.

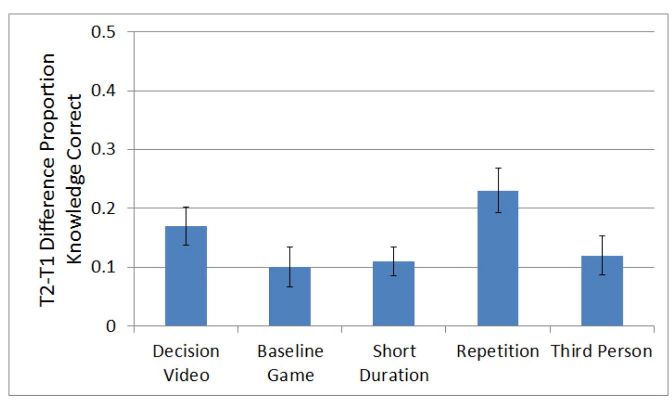

Fig. 3. Means and standard error of knowledge of biases improvement by experiment condition

Participants in the Repetition Condition (2 full game sessions over 2 days) showed the greatest improved knowledge across all three cognitive biases. In fact, it was the only condition that showed a reliable difference in learning for each bias. Planned pairwise comparisons indicated that overall, participants in the Repetition Game Condition learned more than those in the Baseline Game Condition (control), $t(63) = 2.5$, $p = 0.02$, and those in the Short Duration Condition, $t(62) = 2.66$, $p = .009$. These findings were consistent with our expectations. Spaced practice over two days and repeated game play doubled observed improvement in participants' knowledge of biases relative to a single session of gameplay. However, contrary to our expectations, participants in the Repetition Game Condition did not learn more about the biases than those in the instructional Decision Video Condition, $t(62) = 1.1$, $p = 0.27$. Video games can encourage repeated practice, but the knowledge improvement may be facilitated by aspects that both the decision video and our video game, Heuristica did well.

Unlike the number of game sessions, time spent practicing in a single game session did not affect performance. Participants in the single, 30 minute, Short Duration Condition improved their knowledge of biases as much as those in the 75 minute Baseline Game Condition, $t(66) = 0.11$, , $p = .91$. The Short Duration Condition included only the training phase of the game narrative and fewer trials, but contrary to expectations it resulted in similar overall improvement in learning. This suggests that the action phase where the players are dealing with the crisis may have been less effective for improving players' knowledge of the cognitive biases beyond what the cadet training phase covered.

Examining the pattern of learning across the cognitive biases revealed that improvement depended on the bias. Overall, participants learned more about bias blind spot, followed by confirmation bias, and the fundamental attribution error (Fig. 4). This was not due to the frequency of the bias occurring in the game, but could be due to the complexity of the cognitive bias.

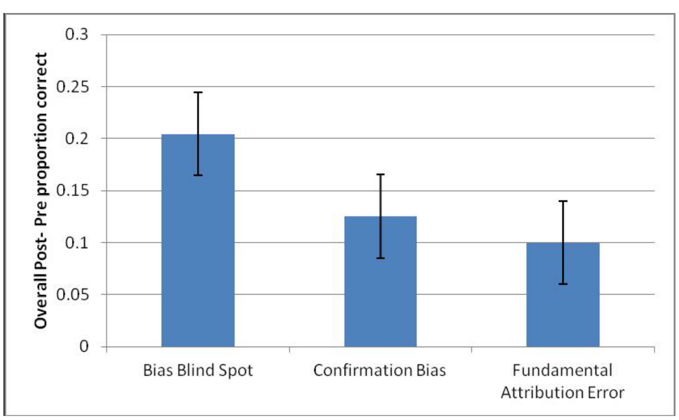

Fig. 4. Means and standard errors for proportion of improved knowledge of each bias

B. *Learning to mitigate biases*

Our second dependent measure, ability to mitigate biases, was operationalized as the difference between the post-test scores and pre-test scores normalized using a participant's pre-test scores. This analysis included 26 items from the Cognitive Bias Test in which participants rated the likelihood that they would use a particular piece of information for a decision. Means and standard errors for average reduction across all biases are in Fig. 5.

Participants learned to mitigate biases in all Conditions. It should be noted that participants in the Decision Video Condition learned to mitigate two of the biases, but increased their bias for the third, resulting in a low overall average. A MANOVA with Bias x Condition revealed a marginally significant main effect of Condition on learning, $F(3, 124) = 2.5$, $p = 0.06$. As can be seen in Fig. 5, this effect was driven by the decision video condition being different than the others, but there were no statistically reliable differences across the Game Conditions. Once again, the 30 minute version of our game (Short Duration) was almost as effective for training as our longer duration game. An interesting result appeared when we analyzed what participants retained 8-weeks after playing the video game. (Fig. 5)

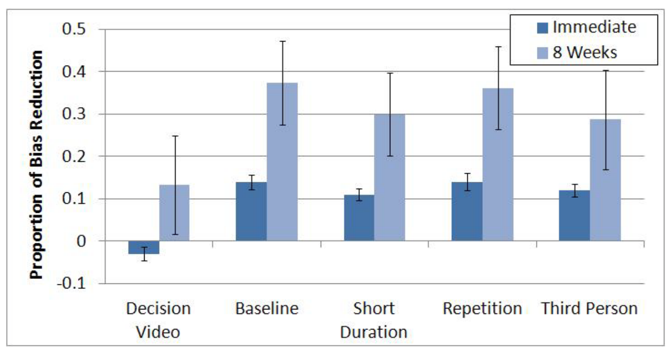

Fig. 5. Average reduction in cognitive bias by Game Condition

Participants who played Heuristica were able to retain their new strategies more effectively than those watching the instructional decision video. After an 8-week delay, participants in all Game Conditions outperformed the Decision Video Condition on average (Fig. 5). Consistent with our expectations, participants in the Repetition Condition retained more mitigation skills than those in the instructional Decision Video Condition, $t(47) = -1.860$, $p = 0.03$ (collapsed across biases). There was no difference in participant performance between the Repetition Condition and the Baseline Game Condition, $t(46) = .361$, $p = 0.36$. In fact, participants got better over time. That is, they performed better at 8-weeks than they did immediately after playing Heuristica. Most of this effect was driven by performance on one bias, the bias blind spot.

Whether participants played the game in first person versus third person, there was no effect on learning.

Contrary to our 3rd person perspective hypothesis, participants in 3rd Person Perspective Condition did not mitigate bias blind spot more effectively than those in the Baseline Game Condition (1st person perspective) overall $t(65) = .063$, $p=.95$. Changing the camera perspective did not seem to shift participants away from a self-oriented frame of reference and improve their mitigation of the cognitive biases. After an 8-week delay, participants in the 3rd person perspective tended to retain more of what they learned than those in the Decision Video Condition, but the difference was not reliable ($p > .05$). Participants in the 3rd person perspective did not improve their performance when compared the Baseline Game Condition (Fig. 5).

As we saw with the knowledge of the biases, bias reduction depended on which cognitive bias was being examined. Once again, participants in each of the game conditions consistently learned to mitigate bias blind spot more than the other two biases (Fig. 6). Heuristica, in general, was better at training this metacognitive bias. One explanation could be that after learning about the other cognitive biases, participants were more aware of their own susceptibility to bias (i.e., bias blind spot).

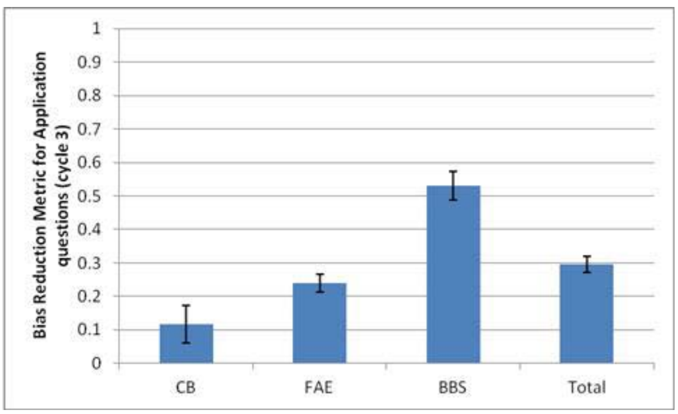

Fig. 6. Means and standard errors for proportion of bias reduction by bias

Furthermore, learning did not depend on whether participants had video game experience for immediate learning, $F(1,130)= 0.095$, $p =.91$, or after an 8 week delay, $F(1,130)= 1.72$, $p =.18$. This indicated that there were no reliable differences between non- gamers, casual gamers, and moderate gamers. There were no gender effects, men and women showed similar reductions in their cognitive biases, $F(1,163) = 1.72$, $p = 0.185$.

Finally, Heuristica was able to reach and train more participants than the instructional Decision Video Condition. Table 1 shows the percentage of participants that learned by game condition. As can be seen in Table 1, 67% of participants in two of the game conditions learned, as compared to 53% in the Decision Video Condition. This does not reflect how much each person learned, but shows that Heuristica reached about 26% more people than the video. One interpretation is that Heuristica, with its space station narrative, engaged participants to play. Once again, learning did depend on the bias. More participants learned about bias blind spot, followed by confirmation bias and fundamental attribution error.

TABLE I. PERCENT OF PARTICIPANTS WHO IMPROVED BY BIAS AND CONDITION

	Confirmation Bias	**Fundamental Attribution Error**	**Bias Blind Spot**	**Total**
Baseline Game	74%	59%	69%	67%
Short Duration Game	60%	51%	65%	59%
Repetition Game (2 sessions)	65%	47%	88%	67%
3rd Person Perspective	57%	58%	58%	58%
Decision Video	59%	45%	55%	53%

C. *Subjective engagement, immersion and 3rd person perspective*

Overall, participants rated the game engaging (above midpoint on the scale), but not reliably more engaging than the instructional decision video, $t(64)=0.037$, $p = .97$. To evaluate whether there was greater engagement and immersion in the 3rd person perspective compared to the first person Baseline Game, we compared engagement and flow scores for the Game Engagement Questionnaire scale. We also include Game Experience and Gender in the analysis based on some previous research suggesting differences. There was no main effect or interaction of Game Experience or Point-of-view on the Game Engagement Questionnaire, $F(8,149) = 0.842$, $p=.567$, or the Flow scale, $F(8, 150)=0.74$, $p=0.65$. There was also no main effect of Gender on Game Engagement Questionnaire, $F(1,64) = 0.003$, $p = 0.97$, indicating similar average engagement ratings from men and women. Supporting the immersion hypothesis, planned pairwise comparisons of the mean ratings indicated the participants playing in the 3rd Person Perspective Condition ($M=5.9$, $SD = 0.82$) were more engaged, $t(66)=1.98$, $p =0.052$, than those in the 1st person Baseline Game Condition ($M=5.4$, $SD = 1.36$). Participants in the 3rd Person Perspective Condition ($M=4.9$, $SD = 1.28$) also reported reliably higher flow, $t(66) = 2.1$, $p < 0.038$, than those in the Baseline Condition did ($M=4.1$, $SD = 1.62$). Furthermore, there was no significant Gender by Point-of-View interaction for flow, $F(1,64) = 0.668$, $p = 0.42$, nor a main effect of Gender, $F(1,64) = 4.19$, $p = 0.29$. Consistent with past research, the 3rd person point-of-view provided greater immersion than the first person view and this difference did not depend on participant gender or whether the participant was an experienced gamer.

V. Conclusion

This experiment quantified the effects of three game variables on learning. We observed some differences between what participants learned (knowledge) and what they could do (mitigate biases). Overall the instructional decision video and the game were similarly effective in teaching participants to recognize and discriminate among the three biases. This indicates that factual information (e.g., definitions, examples of bias) can be effectively taught with passive (video) or active (game play) strategies. Where video games can be powerful is in providing the player with the opportunity for effective practice and learning by making decisions in situations where a cognitive bias might arise [3]. Our findings indicate that at least one version of Heuristica was more effective for immediate learning than the instructional decision video. More importantly, the participants in the game conditions retained that learning after 8 weeks, while those in the decision video condition retained less.

Video games support spaced practice strategies which are known to be effective [25, 26, 27]. Repetition of game sessions was the most effective game variable in this experiment for both immediate learning and retention after 8 weeks. Participants improved because they got practice committing the biases, got to use their newly acquired mitigation strategies, and were able to space the practice over two sessions to improve memory. For immediate learning, it took two separate sessions of practice using the game to exceed the effectiveness of the instructional decision video. However, after 8-weeks participants who played a single session of the game retained more knowledge and mitigation skills than participants who watched the decision video.

Changing the player's point-of-view by changing the camera angle did not improve participants' ability to mitigate the fundamental attribution error or bias blind spot as hypothesized. Although, this hypothesis was a natural extension of the previous research on 3rd person perspective and immersion, the point-of-view does not seem to affect participants' cognitive strategies in our task. Most of the research comparing first versus third person point-of-view focuses on immersion and our findings regarding engagement were consistent with this work [8, 15]. However, the question still remains whether this change in perspective can affect cognitive strategies.

Although not all game variables improved immediate learning to mitigate cognitive biases, more people learned and the improvement stuck. Participants retained more information learned in the video game than from the instructional decision video after an eight week delay. Furthermore, the video game improved not just the magnitude or amount each participant learned over the instructional video, but Heuristica engaged more participants. A number of experiments have shown that playing action video games improves performance on certain perceptual and motor tasks [c.f., 10], but far fewer have demonstrated this for higher cognitive activities such as sensemaking and decision making. This paper provides a contribution to this latter category and evidence that serious video games can improve learning in ways traditional passive methods cannot. Our results provide some interesting questions for future research that we plan to examine.

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