Transmedial and Paramedial Serious Game Deployment

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ABSTRACT

Despite extensive research, training to overcome cognitive biases has proven largely ineffective. Critical decision-making in the face of uncertainty is difficult because participants employ heuristics that are unconscious and subtle, but which can produce very serious impacts. It has often been demonstrated that even cognitive bias experts make judgment errors by falling prey to the very biases they study (Heuer, 1999).

Our team designed and developed a video game to teach cognitive bias recognition and mitigation as an alternative to current classroom methods. Then we performed an empirical study of that game's learning and training efficacy. The results indicated that the game was effective for learning, but impacts on biased behavior were inconsistent for the different cognitive biases addressed by the game. Additional training aids to reinforce the game learning may be critical in order for it to reliably supplant higher education courses in cognitive thinking.

This paper provides a high-level overview of the project and the particular cognitive biases taught in the game. We discuss the blend of instructional theories, techniques, and media used in the game and the results of our effectiveness study. The paper describes the transmedia training package we created to provide a variety of out-of-game experiences which show promise for increasing the learner's ability to mitigate these cognitive biases. This training package provides: a) an on-going reminder to apply their new knowledge and skills; b) additional practice honing their skills; and c) refresher training to reduce knowledge and skill decay. The use and ratios of the in-game transmedia types and the use of out-of-game transmedia has not been studied yet. The paper concludes with suggested research of the effectiveness of post-learning transmedia.

ABOUT THE AUTHORS

Brandt Dargue is an Associate Technical Fellow performing research into current and future training technologies including simulations, automated performance assessment, adaptive scenarios, intelligent tutoring, virtual environments, mobile platforms, gaming concepts and gaming technologies. Employed at Boeing for 25 years, he has chaired or participated in several international standards development and study groups, and was the Program Manager and Principal Investigator for *The Enemy of Reason* serious game and training effectiveness studies.

Dov Jacobson leads a studio of talented, happy and committed workers at GamesThatWork. Dov has been the Principal Investigator in eight successful federally sponsored game research projects. Since 1981, he has led the development of 44 games, including award winning titles in both entertainment and learning genres. He focuses GamesThatWork's formidable creative resources on the problems faced by the studio's sponsors. Dov is a frequent presenter at game and learning conferences and is known for his merciless sense of humor.

John Sanders, LTC (ret) has broad experience in training and simulation for Army and Joint Service applications. At Boeing, his duties included Lead Systems Integrator for collective training of the Future Combat Systems (FCS) core program and Spin-Out 1 systems. Mr. Sanders participated in projects for serious games, adaptive training, mobile apps to train and sustain proficiency of operators in Afghanistan using the Army's Joint Recovery and Distribution System (JRaDS), and adaptation of an automated progressive training program for the Brigade Combat Team Modernization project. As a government employee, he worked in program management and operational requirements for a variety of simulators, simulations, part-task trainers, and worked on various training technology research projects including Project Scimitar (SASC project), Force XXI, and the Staff Group Trainer.

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INTRODUCTION

The study of cognitive biases is one of the most popular research topics in modern psychology. The study has also bridged into the study of economics such as Nate Silver's book, *The Signal and the Noise: Why So Many Predictions Fail — but Some Don't* (Silver, 2012), best sellers such as Daniel Kahnneman's *Thinking Fast and Slow* (Kahneman, 2011), and television shows such as *Brain Games* on the National Geographic Channel. Avoiding biases has proved to be difficult because they are processed by the brain without our awareness and the consequences can be grave (e.g., (Kahneman, Slovic, & Tversky, 1982) (Nisbett & Ross, 1980)). Although knowing about cognitive biases helps, even cognitive bias experts need to be reminded to consciously mitigate biases during their analysis of the evidence because the processing is done subconsciously (Heuer, 1999). Therefore, one must consciously apply particular techniques to prevent the biases from influencing decisions that need to be made (Heuer, 1999). This paper describes a project in which an interactive video game was developed to teach people how to identify and mitigate certain cognitive biases. The paper focuses on how the instructional design was enhanced with a blend of media inside and outside of the game.

The Sirius Project

The Intelligence Advanced Research Projects Activity (IARPA) and the Air Force Research Laboratory (AFRL) sponsored multiple teams to develop various interactive computer games and conduct training effectiveness studies of those games as compared to a training video used as a control. Each team designed and developed alternative versions that tested hypotheses each team proposed to increase the training effectiveness of their game. The cognitive biases addressed by the games as defined in the Broad Agency Announcement (BAA) (Intelligence Advanced Research Projects Activity (IARPA), 2011, p. 7) were:

- "Phase 1
  - **Confirmation Bias (CB)**: The tendency to [preferentially] search for or interpret information in a way that confirms one's preconceptions. Often preceded by priming.
  - **Fundamental Attribution Error (FAE)**: The tendency for people to over-emphasize personality-based explanations for behaviors observed in others while underemphasizing the role and power of situational influences on the same behavior (also called attribution bias).
  - **Bias Blind Spot (BBS)**: The tendency for an individual to be unaware of their own cognitive biases, even when the individual can recognize [these] cognitive biases in others.
- "Phase 2
  - **Anchoring Bias**: The tendency to rely too heavily, or "anchor," on one trait or piece of information when making decisions (related to focalism or focusing illusion).
  - **Representativeness Bias**: The tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data. Also sometimes referred to as the "small numbers" bias.
  - **Projection Bias**: The tendency to unconsciously assume that others share one's current emotional states, thoughts and values."

The studies were set up like a typical training effectiveness evaluation where a pretest is given to all participants to measure each person's baseline knowledge and skills; alternative versions of instruction are given to different randomly selected participants; a posttest measures the new level of knowledge and abilities; and a follow-up test is given at a later date to measure retention of the knowledge and skills. The participants only saw the in-game media. They did not experience any of the out-of-game media this paper discusses. The tests were comprised of a cognitive bias knowledge test and a behavior test which was designed to induce specific cognitive biases and measure the degree of bias exhibited. The change in cognitive bias knowledge and mitigation abilities is the difference in the measures

between the pre- and post- tests. An effective training condition in the study was one with a positive training outcome where the subject's measure of cognitive bias knowledge increased and degree of bias decreased.

The Enemy of Reason

The Enemy of Reason game teaches how to recognize and mitigate the biases by teaching knowledge about the biases, giving players experience in seeing game characters who exhibit biases, providing experience in using mitigation techniques for those characters, and being immersed in situations that are designed to elicit biased behavior.

Three versions of the game were built for the studies to enable different game conditions to vary the independent variables for each of the study groups. Using the results of the study analysis, we identified scenes in the game that were correlated to reduced learning outcomes. Using this information, we made improvements to a fourth version of the game that was tested by the Independent Verification & Validation (IV&V) team (Boeing Research & Technology, 2013) (Dargue, Jacobson, & Sanders, 2014).

Story Line(s)

The learner plays the game as Ian Solitaire and as other members of Ian's team of agents. The goal is to save Capital City from an unknown enemy and a mysterious "Red Cloud" weapon by solving a series of challenges. In each challenge, the player holds conversations with non-player characters (NPCs) to uncover hypotheses and gather evidence, until he or she commits to a course of action (Boeing Research & Technology, 2013, p. 8). The Red Cloud is traced to a series of Bias Bombs each of which releases an infectious Bias Virus that spreads throughout Capital City. This plot device embedded in a classic espionage game filled with ambiguity and uncertainty provides players with many opportunities to explore cognitive bias. For example, many news reporters as well as the experts and public being interviewed by the reporters about the weapon or the perpetrators had subtle, obvious, or compound cognitive biases. The player has to dialog with these and other characters such as the police chief, and many suspects.

INSTRUCTIONAL APPROACH

James Paul Gee, author of several books on learning in games, notes that games offer several key factors for players to develop experiences and learning (Gee, Learning and games, 2008). He describes how players develop interest and attention through identification with a character or entity, feelings of agency and control with that character or entity, and interaction through feedback from the game and non-player characters (Gee, 2005). Video games also provide goal-oriented, low risk experience that calls for performance before competence (Gee, 2008). Unlike traditional learning experiences, games encourage players to test their skill prior to mastery and motivate them to take risks and try new things with few penalties for failure. Finally, games condition players to transfer skills through properly ordered problems of increasing difficulty to challenge the competency of the player and forcing them to think laterally to solve problems while providing situated meanings to terms and encouraging systems thinking to develop relationships between actions and results (Gee, 2005 and Gee, 2008). These aspects of games match traditional learning concepts such as engagement, experiential learning with feedback, practice at retrieval, practice-spacing, and over-learning.

Donovan et. al. state that experts are not just "smart" or knowledgeable on factual information, but are able "to generate responses, with minimal cues, repeatedly over time with varied applications so that recall becomes fluent and is more likely to occur across different contexts and content domains." (1999). The best way to develop this ability is by requiring students to frequently retrieve the knowledge in a variety of contexts and settings (Halpern & Hakel, 2003).

The instructional flow used in T*he Enemy of Reason* is to provide knowledge about each bias, present a few examples of biased people, and provide practice exercises with instructional feedback. The game immerses the learner in role-playing scenarios. Early scenarios challenge the player to uncover and mitigate the bias of other characters. Later scenarios require introspection. The player's own biases must be uncovered and mitigated. Players learn mitigation techniques through examples, drills, and problem-solving role-play. We felt it was very important to provide as many examples as possible and developed more than any one player will encounter during the game's five hours of gameplay. In total, the game includes over 200 Cognitive Bias Interactions (CBIs) that are woven into the overall storyline of the game.

EFFECTIVENESS STUDY

Research Design

We used a pre-test/post-test control group design. Post-testing includes both an immediate post-test, upon completion of the training, and a retention post-test, 8 weeks later. The test instruments were on-line written tests that had both a knowledge test and a behavior test. One was designed to measure the participant's knowledge about the cognitive biases. The second section of the test was designed to measure the participant's degree of cognitive bias. An effective game would then show an improvement in the "knowledge of biases" and a reduction in "cognitive bias" from pre-test to post-test.

The Enemy of Reason study involved the manipulation of two independent variables: the use (or withholding) of a structured analysis technique (SAT) (see section below and Figure 5); and the manipulation of training duration/repetition. These two independent variables were used to form 3 experimental groups, to which a control group is added. The resulting 4 training treatment groups in the study are as follows (Boeing Research & Technology, 2013, p. 10):

1. Six Game Segments with SAT (SAT-6). This group received six 30-minute segments of game-based training with access to the SAT. The 6 segments used in SAT-6 involved combinations of abbreviated forms of the 10 segments used in SAT-10.
2. Ten Game Segments with SAT (SAT-10). This group received ten segments of game-based training with access to the SAT. Each level lasted approximately 30 minutes.
3. Ten Game Segments without SAT (No SAT). This group received ten 30-minute segments of game-based training, but without access to the SAT.
4. Control. Training for the Control group was limited to one viewing of a government-provided, 30-minute instructional video on cognitive biases.

We selected a sample size of 30 participants per treatment group. Participants were drawn from the Mercyhurst University Institute for Intelligence Studies.

Study Results

The program had five metrics defined by IARPA: Improved knowledge of biases; immediate reduction in cognitive biases; persistent reduction in cognitive biases; game that trains more effectively than the instructional video; and a game that is engaging. IARPA provided the instructional video on DVD as a high-definition video file for playback on computer screens. We used eye-tracking equipment to measure engagement.

- **Improved Knowledge of Biases**:
  - All of our training treatments produced significant increases in the knowledge test scores at both the immediate and retention post-test.
- **Immediate Reduction in Cognitive Biases**:
  - One or more game conditions exceeded the instructional video control. Averaged across all biases, SAT-6 was the best condition with 10.3% reduction in the immediate test and No SAT was the best condition for the retention test with 1.8% reduction. When looking at the individual biases for both immediate and retention, SAT-6 was best at FAE mitigation training, and No SAT was best for BBS mitigation training.
- **Persistent Reduction in Cognitive Biases:**
  - Averaged across all biases, No SAT was the best condition with 1.8% long term reduction in bias; Bias reduction for Control was -7.5% (student's score in post-test after watching video).
- **Game that Trains More Effectively than an Instructional Video**
  - For the Knowledge retention test, all game conditions trained better than the control video. For the immediate behavior test, SAT-6 trained better for FAE and No SAT trained better for BBS. For the retention behavior test, there were no significant differences between the control and any version of the game.
- **Game that is engaging**:

- The mean level of engagement across all participants was 80.2%, compared to the Program objective of 75%. The minimum level of engagement for any participant was 53.1%, compared to a Program objective of 50%

Dargue et al (2014) provides more information about the study and details how we used an analysis of data captured during the study to make improvements to the game for the studies performed by the government-selected IV&V team.

PARAMEDIA

In addition to its traditional game mechanics, *Enemy of Reason* employs three learning technologies that are independent of the game itself. All three of these were incorporated into the game narrative with credible plot exposition, but all three are also viable outside the game as independent learning devices. These include several pedagogic songs, an array of instructional minigames and the Think Machine, a job aid that realizes a powerful structured analytic technique.

These elements are similar to the transmedial assets which are addressed later in this paper, as both use the game's style, storyline, and characters to extend the learning experience. Whereas transmedial assets project elements of the game world into the player's real world experience and exist external to the game, these features - songs, minigames and tools - are fully functional within the game medium. Being independent of the game, they are vital entertainment and learning features outside the game as well, standalone or incorporated into other media. We call these paramedia.

Song

The Enemy of Reason includes "mini games" with music written to stimulate recall of statements typical of exhibiting the cognitive biases. The use of songs for recall of information has been used by many societies for centuries. Music has been found to serve as potent retrieval cues for memories (Janata, Tomic, & Rakowski, Characterisation of music-evoked autobiographical memories, 2007) (Coon, 1997) (Carruth, 1997) (Janata et al. 2007, Coon, 1997, and Carruth, 1997). Lately, there has been research using functional magnetic resonance imaging (fMRI) that has presented evidence that musical hearing and ability is essential to language acquisition (Janata, 2009). GamesThatWork often employs song to help players internalize a game's learning objectives. The power of song is manifold. Music refreshes the attention of a player. Rhythm and rhyme are potent mnemonics for verbal formulas. The emotional dimension of song can makes points that are more convincing and at times even more legitimate than logical argument (Jacobson, 2012).

The transmedial value of song is readily available to instructional teams. Although the game introduces each song to the player in a specific context, the song is actually self-contained and can deliver its instructional value to the player outside of any game context.

The Enemy of Reason employs a variety of songs to teach players about cognitive bias. Among the favorites are:

Jump to the Conclusion, a Nashville love song:

I can't be wrong
'Cause I know I'm right.
Don't second guess
Love at first sight.

Anvil Chorus, a Verdi parody, sung by biased journalists

Choose, Choose,
Choose your news!
If it won't fit,
Ignore it.

Unscrew You, rapped by the game's manipulative mastermind villain

My plans are all resisted - cause the folks to whom I tell 'em
Get the facts all twisted - inside their Cerebellum

Your life is in a crisis? Really? Oh, boo hoo.
Well, I've invented some devices that can unscrew you.

Other songs include a mock Chinese opera and a distorted hymn. Each illustrates one or more cognitive biases or walks the player through the steps of a mitigation technique. In the case of the arch-villain's rap, the song is meant to exacerbate rather than mitigate cognitive bias, but this appears only in the game's tenth and final level.

Mini-Games

Mini-games were incorporated into Game of Reason as a method to enhance player interest, reinforce key learning objectives, and to integrate alternative training media (Freifeld, 2013) to increase student mastery of cognitive skills. The placement of these mini-games was strategically inserted into the game sequence based on the recommendations of the team training experts and serious game designers.

In Jump to the Conclusion (Figure 1), the player must decide whether lines of lyrics in the song are indicative of cognitive bias. To play, he or she places the coin with song lyrics into one of the coin slots of the juke box to indicate which cognitive bias is at fault. In the Free Press Tower Defense mini game (Figure 2), the player is shown previews of headlines for news articles and must use bias mitigation techniques to help journalists make the stories less biased. In one game level, the player must interview a leader of a group of pirates but to get to him, the player must get through a maze of pirates in the bar (Figure 3). As the player "walks" Ian Solitaire along the tables, pirates hurl insults or comments. The player must decide if the pirate has FAE – that is, whether the pirate has judged the actions based on personality or the situation.

Figure 1. Jump to the Conclusion Mini Game

Figure 2. Free Press Tower Defense Mini Game

Figure 3. Pirate Bar FAE Mini Game

Figure 4. Wason Task Chess Game

Another "mini-game" within *The Enemy of Reason* provided an implementation of the Wason test. In 1968, Peter Wason developed a four card experiment to test how people selected evidence to confirm or disconfirm a rule. The findings of these experiments became the basis for the modern understanding of confirmation bias, as people searched only for confirmation of their preconceptions while discrediting disconfirming evidence. We adapted this classic experiment using standard chess pieces and statues of characters from the game rather than cards.

Structured Analytic Technique (SAT)

One of the primary hypotheses of our study was that teaching cognitive bias mitigation using SAT would be more effective than without. The SAT that works best for mitigating confirmation bias is the *Analysis of Competing Hypotheses* (ACH) (Heuer, 1999). While simple in principle, ACH can become quite complex and some college courses are fully dedicated to teaching this technique.

We believe that to provide the true value of structured analytic techniques in mitigating the effects of cognitive biases, the game only needs to provide enough of the SAT to trigger "System 2" thinking. "*Heuristic judgments, which lead to biases, are associated with System 1, and analytic reasoning, which may intervene with these judgments and improve them, are linked to System 2*" (Evans, 2008). One strategy for triggering System 2 thinking is to replace intuition with formal analytic techniques (Milkman, Chugh, & Bazerman, 2009). This is consistent with Lehner et al's (2008) study, which found that the use of ACH was helpful even when executed poorly:

> *"Use of the templates improved performance, even though the templates were often filled out incorrectly, [which] suggests that the benefits were obtained from the reasoning process invoked by the templates. Participants using the templates did better because they devoted more time and effort to reasoning about alternative causes."*

After testing several prototypes, GamesThatWork designed an interactive SAT that captured the essence of ACH, to encourage the analyst to examine competing hypotheses over the favorite hypothesis (Anderson, Inoculation and counterexplanation: Debiasing techniques in the perseverance of social theories, 1982) (Anderson & Sechler, 1986); (Hirt & Markman, 1995); (Lord, Lepper, & Preston, 1984); and provide a visual way of analyzing the hypothesis against each piece of new evidence. Since the goal of the SAT is to help the player to think clearly without bias, the SAT was called "the Think Machine." To fit the retro style of the game, the Think Machine was implemented as shown in Figure 5 and quickly became known as "the test tubes."

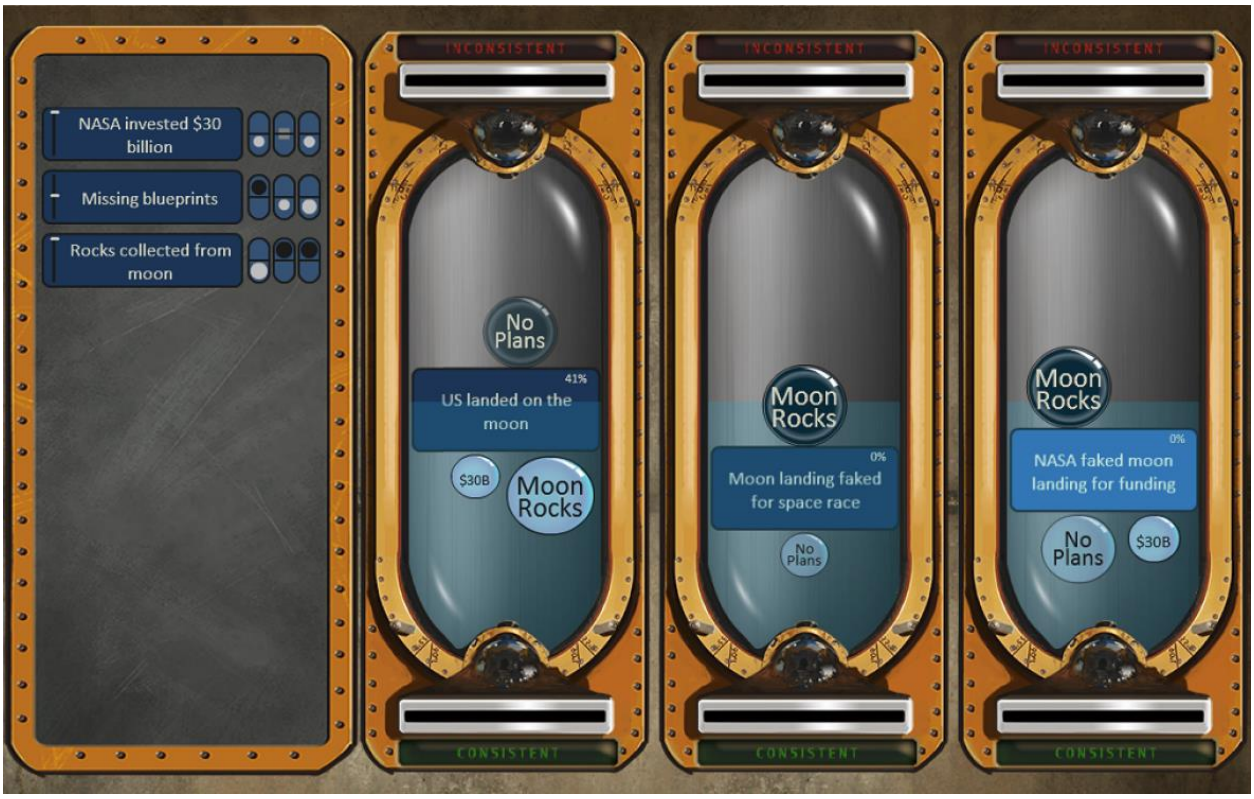

Figure 5. Test Tubes Variant on ACH

Each vial or tank was a test tube for a particular hypothesis which was represented by a float in the half-filled tube. Evidence that supported the hypothesis was placed under the float as a bubble supporting the buoyancy of the hypothesis. Evidence that disconfirmed/undermined the hypothesis was placed on top of the float, weighing it down in the liquid. For the example shown in Figure 5, there are three hypotheses, one in each tube: US landed on the moon; moon landing faked for space race; and NASA faked moon landing for funding. Three pieces of evidence are listed on the left: NASA invested $30 billion; the Apollo blueprints are missing; and rocks were collected from moon. As can be seen in the figure, moon rocks evidence has been placed as a bubble which supports the hypothesis on the left, but has been placed as a weight on top of the other hypotheses, indicating that the evidence of moon rocks confirms the hypothesis that the US landed on the moon, but disconfirms both hypotheses that the landing was faked.

We do not want learners to become dependent on the game's particular SAT tool, but to recognize its benefit and to employ the reasoning techniques that it embodies. For this reason, the game plot takes away Ian's tool at critical points in the game and the player must learn to employ ACH without a job aid. This practice helps make the player effective at mitigating the biases outside of the game without the tool.

TRANSMEDIA

To help the learner apply the knowledge, skills and attitudes learned in the game to real life, we wanted to let the player/learner incorporate elements of the game into his or her daily life. One method discussed was to develop a story engine that would provide endless game play. We also planned to let the learners play the video game at home. However, letting the study participants play the game at home would have made it difficult to compare our study results with those from other teams. The primary notional use case for the project was as a video game used (played) in class.

Another way to bring elements of the game outside of the game into the daily lives of the learners is to develop materials using media other than the video game. In this way, we would implement the primary mitigation technique of reminding oneself that cognitive biases exist in everyone (including oneself) and a conscious, deliberate attempt to counteract the biases must be employed for decisions under uncertainty (Heuer, 1999).

Transmedia storytelling has been garnering a lot of attention since the concept was introduced by Henry Jenkins in his 2003 article in the MIT Journal Review (Jenkins, 2003), described in his 2006 book, *Convergence Culture: Where Old and New Media Collide* and refined in a blog post titled "Transmedia Storytelling 101" (Jenkins, 2007). In a pair of blog posts in late 2009, Jenkins defined "Transmedia storytelling represents a process where integral elements of a fiction get dispersed systematically across multiple delivery channels for the purpose of creating a unified and coordinated entertainment experience. Ideally, each medium makes its own unique contribution to the unfolding of the story" (Jenkins, 2009).

According to Elaine M. Raybourn (2013), transmedia learning is a term coined by Frank DiGiovanni, during a presentation to the President's Council of Advisors on Science & Technology Meeting. Transmedia learning is defined by Dr. Raybourn as "*the scalable system of messages that represents a narrative or core experience that unfolds from the use of multiple media, and emotionally engages learners by involving them personally in the story* (Raybourn, 2012b, 2013)."

The Characters

We made the characters somewhat familiar yet memorable so that the player would recognize the traits exhibited by the character in people encountered in the real world. For example, the main character was Ian Solitaire, a lovable cross between James Bond and Austin Powers with a very large ego (see Figure 6). Anything to remind the player of the game in general or, possibly more importantly, particular characters, should remind the player to look for the signs of cognitive bias and apply the mitigation techniques. This is one of the best cognitive bias mitigation techniques – to intentionally be cognizant of the biases and remind yourself that everyone's brain often uses these heuristics without their awareness (Heuer, 1999). In this way, even promotional items that were developed in the style of the game and featured characters or scenes from the game help remind the people who played the game of these cognitive biases. Items that we developed and distributed included coffee mugs with Ian Solitaire and several different ceramic coasters which each featured a game character.

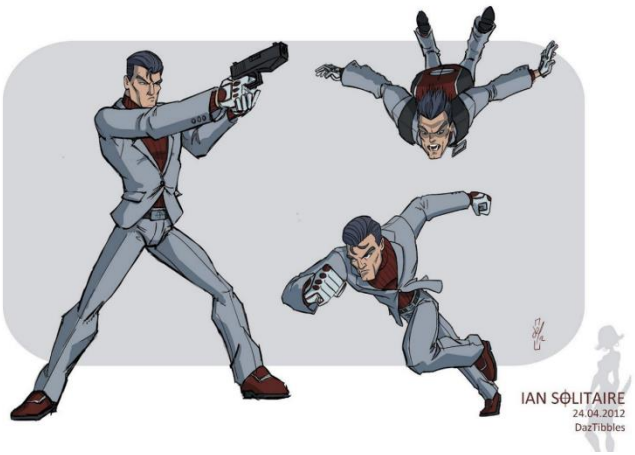

Figure 6. Ian Solitaire Character Drawings

Mitigation Techniques

Of the primary terminal learning objectives, mitigating the cognitive biases, is more important and much harder than recognizing and identifying the individual biases. To aid in learning the techniques, we used rules of thumb developed by cognitive bias experts. For example, to mitigate confirmation bias, one should seek disconfirming evidence; for FAE, one should try to look at the entire situation and ignore the personality; and for BBS, one needs to remind themselves that everyone is influenced by these biases (Heuer, 1999) (Pronin, Gilovich, & Ross, 2004). One medium used outside of the game to reinforce the mitigation techniques was fortune cookies, popular little tan cookies with a slip of paper placed inside before they are folded and individually wrapped. Instead of fortunes, each strip of paper in our cookies had *The Enemy of Reason* logo and a rule of thumb for a mitigation technique. In total, we had several different "fortunes" in the cookies. Some people collected and traded these "fortunes" and many posted them to their cubicle/office walls. We even brought bowls of these cookies to meetings and other classes. At times, spontaneous "drill and practice" games would emerge with people indicating which CB would be mitigated by the technique on the paper. Even people who did not play the game found this fun and learned from the experience and people who were familiar with the cognitive biases from the game or other experiences helped mentor the others and people became engaged in new conversations about this interesting topic.

Even more fun, challenging, and instructional is a card game developed as a companion to the video game. The deck has two types of cards: Bias Virus Attack Character Cards and Virus Attack Mitigation cards. Character cards (Figure 7) have an image of a game character and a statement from the character such as "Street people are homeless because they are too lazy to work." Mitigation cards (Figure 8) have an image of a main character and a mitigation technique such as "Examine the situation." To be able to collect the character card and advance in the game, a player must choose a mitigation card with the correct technique to mitigate the character's bias or one that indicates that the statement is not showing bias. A "decoder ring" style mechanical indication of whether the cards match. Prototypes and the final printing of this game were play tested in several groups of different ages including the target audience of college students. In general, the testers in an informal play testing session indicated they enjoyed the game, would play it on occasion, and that it helped their knowledge, skills, and attitude toward cognitive bias identification and mitigation.

Figure 7 - Bias Virus Attack Character Cards

Figure 8 - Bias Virus Attack Mitigation Cards

As part of the program, we designed a second game and study for Phase 2 with three different cognitive biases and new independent variables. The story would continue in the phase 2 game with the main characters but take place at a later time. Dr. Wheaton from Mercyhurst University wove some of the examples he had collected or authored for these new biases with *the Enemy of Reason* characters and backstory to create an interactive book in the style of the "Choose Your Own Adventure" series by Chooseco, LLC (CYOA.com). The original intent of this book was to test the CBIs for the new biases to see if they were effective in eliciting biases in the reader. As the phase 2 video game design emerged, the notion of using the book format as a transition between the video games emerged.

The narrative of the book covers timelines before the original video game as well as after. In that way, it satisfies the learner in filling the gaps of the original backstory as well as completing the ending of the first game. All while reminding the learner of the previous cognitive biases and preparing the learner for the next set of cognitive biases. Because interactive stories can be very engaging and memorable, even in book form, integrating books with video games can provide continued learning or a bridge to the next topic in the video game. Although the book provides some instructional mentoring, a video game, intelligent tutoring system, or human instructor can help the learner better with information tailored on the individual learner's trends.

The SAT

We also thought it was very important that we remind the player of the Think Machine's test tubes SAT. As stated above, we wanted the player to realize how beneficial the technique is, even in its most simple form and remember the thought process that the tool provided. We dismissed ideas such as a Magic 8 Ball to avoid the notion that the mitigation techniques are magic or should be randomly selected. We developed multi-dimensional Judgment Tool in the shape of a small, clear yellow plastic cube printed with *The Enemy of Reason* logo and three bubble levels on orthogonal axes (see Figure 9). Although this item had a bubble in a vial of liquid with a goal to obtain a balanced equilibrium like the test tubes in the game, the resemblance was too vague and did not really function like the Think Machine. Additionally, a multi-dimensional bubble level is not a tool the typical person (especially the target audience) uses every day. Therefore, this item is not likely to increase the learning effectiveness of the game.

Figure 9. Multi-Dimensional Judgment Tool

SUGGESTED RESEARCH & CONCLUSIONS

This paper presents a topic of learning for which a serious game was beneficial and possibly more memorable than classroom study. However, to continue to be effective outside of the game, one must continuously remember to

consciously apply the skills learned in the game. Because the heuristics used by the brain that lead to these cognitive biases are applied on a subconscious level, continuous practice and conscious as well as subliminal reminders to apply the mitigation techniques are required. This is an ideal application for transmedia that reminds the person of the knowledge and skills they learned while playing the game. Examples of several transmedial items were discussed: a card game that provides further exercises in a fun challenging way; fortune cookies that provide simple advice and stimulate conversations in mitigating cognitive biases; coffee mugs and coasters that remind the player of the characters in the game and how they overcame cognitive biases in others and themselves; and an interactive book that stimulates thought, provides further knowledge, and prepares the learner for more studies. Transmedia does this by extending the story and the characters across diverse media outside of the serious game. The game's cartoonish retro-future artistic style was very appealing and was likely to evoke a warm feeling that is beneficial to learning and probably helps snap the learner back into the story when they encounter other transmedia done in that style.

The term paramedia was introduced to identify media elements that are playable both within the game and independently. Common examples include mini-games, songs, cinematic cut scenes and task-specific tools. The paramedia mini-games provided spaced repetition, check on learning, and remediation while keeping the player immersed in the game. The paramedia music provided subliminal learning and the catchy tune/lyrics enabled the players (as well as the developers and researchers) to sing/hum to themselves, recalling the cognitive biases while doing other tasks. The built-in Test Tubes SAT provide experience in using portions of the most effective mitigation technique for confirmation bias.

The use and ratios of the in-game paramedia and the use of out-of-game transmedia has not yet been studied. Because this project was funded as part of a multi-team competitive study we could not study the effects of withdrawing paramedia other than the SAT and could not study whether using transmedia would show more effectiveness. Further research into those variables has been designed but not yet performed.

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REFERENCES

Intelligence Advanced Research Projects Activity (IARPA). (2011). *Sirius Broad Agency Announcement: IARPA-BAA-11-03_20110321*. Washington, D.C.: Office of the Director of National Intelligence.

Anderson, C. A. (1982). Inoculation and counterexplanation: Debiasing techniques in the perseverance of social theories. *Social Cognition, 1*, pp. 126-139.

Anderson, C. A., & Sechler, E. S. (1986). Effects of explanation and counterexplanation on the development and use of social theories. *Journal of Personality and Social Psychology*(1), 24-34.

Boeing Research & Technology. (2013). *The Enemy of Reason Phase 1 Final Report, Contract # FA8650-12-C-7234.* Boeing Research & Technology.

Carruth, E. K. (1997). The effects of singing and the spaced retrieval technique on improving face-name recognition in nursing home residents with memory loss. *Journal of Music Therapy, 34*(3), 165-186.

Coon, D. (1997). *Essentials of Psychology.* New York: Brooks/Cole Publishing.

Dargue, B., Jacobson, D., & Sanders, J. (2014). Serious Game User Data Analysis and Visualization: Savoring the Breadcrumbs. *Interservice/Industry Training, Simulation and Education (I/ITSEC).* Orlando, FL: (in print).

Donovan, M. S., Bransford, J. D., & Pellegrino, J. W. (1999). *How people learn: Bridging research and practice.* Washington, D.C.: National Academy Press.

Evans, J. S. (2008). Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. *Annual Review of Psychology 2008, 59*, 255-278.

Freifeld, L. (2013, July 26). A Theory of Learning. *Training magazine*. Retrieved June 13, 2014, from www.trainingmag.com/content/theory-learning

Gee, J. P. (2005). Good video games and good learning. *Phi Kappa Phi Forum, 85*(2), pp. 33-37.

Gee, J. P. (2008). Learning and games. In K. S. (Ed.), *The ecology of games: Connecting youth, games, and learning* (pp. 21-40). Cambridge, MA: The MIT Press.

Halpern, D. F., & Hakel, M. D. (2003). Applying the science of learning to the university and beyond. *Change, 35*(4), pp. 36-41.

Heuer, R. J. (1999). *Psychology of Intelligence Analysis.* Center for Study of Intelligence.

Hirt, E., & Markman, K. (1995). Multiple Explanation: A Consider-An-Alternative Strategy for Debiasing Judgements. *Journal of Personality and Social Psychology, 69*, 1069-1086.

Jacobson, D. (2012). Song as a Learning Vector. *Defense GameTech Users' Conference.* Orlando, FL.

Janata, P. (2009). The neural architecture of music-evoked autobiographical memories. *Cerebral Cortex, 19*(11), 2579-2594. doi:doi:10.1093/cercor/bhp008

Janata, P., Tomic, S. T., & Rakowski, S. K. (2007). Characterisation of music-evoked autobiographical memories. *Memory, 15*(8), pp. 845-860.

Jenkins, H. (2003, January 15). Transmedia Storytelling. *MIT Technology Review*. Retrieved from http://www.technologyreview.com/news/401760/transmedia-storytelling/

Jenkins, H. (2007, March 27). *Transmedia Storytelling 101*. Retrieved from Confessions of an Aca-Fan: http://henryjenkins.org/2007/03/transmedia_storytelling_101.html

Jenkins, H. (2009, December 12). *The Revenge of the Origami Unicorn: Seven Principles of Transmedia Storytelling*. Retrieved from Confessions of an Aca-Fan: http://henryjenkins.org/2009/12/the_revenge_of_the_origami_uni.html

Kahneman, D. (2011). *Thinking, Fast and Slow.* New York: Farrar, Straus and Giroux.

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases.* Cambridge: Cambridge University Press.

Lehner, P. E., Adelman, L., Cheikes, B. A., & Brown, M. J. (2008). Confirmation bias in complex analyses. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, 38*(3), 584-592.

Lord, C. G., Lepper, M. R., & Preston, E. (1984). Considering the opposite: A corrective strategy for social judgment. *Journal of Personality and Social Psychology, 47*, 1231-1243.

Milkman, K. L., Chugh, D., & Bazerman, a. M. (2009). How can decision making be improved? *Perspectives on Psychological Science, 4*(4), 379-383.

Nisbett, R. E., & Ross, L. (1980). *Human inference: Strategies and shortcomings of social judgment.* Englewood Cliffs, NJ: Prentice-Hall.

Pronin, E., Gilovich, T., & Ross, L. (2004). Objectivity in the Eye of the Beholder: Divergent Perceptions of Bias in Self Versus Others. *Psychological Review, 11*(3), pp. 781–799.

Raybourn, E. M. (2013). Transmedia Learning: A Paradigm for Transcending Stand-Alone Training & Education. *Interservice/Industry Training, Simulation and Education (I/ITSEC)*, (pp. 13084-13084). Orlando, FL.

Silver, N. (2012). *The signal and the noise: why most predictions fail-- but some don't.* New York: Penguin Press.