MACBETH: Development of a Training Game for the Mitigation of Cognitive Bias

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ABSTRACT

This paper describes the process of rapid iterative prototyping used by a research team developing a training video game for the Sirius program funded by the Intelligence Advanced Research Projects Activity (IARPA). Described are three stages of development, including a paper prototype, and builds for alpha and beta testing. Game development is documented, and the process of playtesting is reviewed with a focus on the challenges and lessons-learned. Advances made in the development of the game through the playtesting process are discussed along with implications of the rapid iterative prototyping approach.

Keywords: *Case Study, Playtesting, Rapid Prototyping, Sirius Program, Training Video Game*

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INTRODUCTION

While under constant pressure for quick and accurate judgments, intelligence analysts must gather information from a variety of sources, and rapidly process it incrementally as it is received. In his book *The Psychology of Intelligence Analysis,* Heuer (2006) refers to this process as "a recipe for inaccurate perception" (p. 27). As part of their work, intelligence analysts must not only evaluate the credibility of information they receive, they must also attempt to synthesize large quantities of data from a variety of sources, including intelligence collection assets from their own organizations, and from other agencies.

In their "Sirius" program, the Intelligence Advanced Research Projects Activity (IARPA) posed a challenge for researchers to create a training video game capable of prompting players to recognize cognitive biases within their decision making, so as to mitigate their occurrence during critical stages of intelligence analysis (IARPA, 2011). IARPA set forth a number of requirements for game development, including mandating which cognitive biases should be examined, while leaving research teams open to determining the form and content of their games, as well as the key theoretical mechanisms underpinning their design and function. Our team's response was to develop a game called MACBETH (Mitigating Analyst Cognitive Bias by Eliminating Task Heuristics) in which players are challenged to gather and assess intelligence data to stop an imminent terrorist attack within a fictional environment.

This paper provides a design narrative (Hoadley, 2002) of a rapid prototyping, user-centered approach to developing MACBETH. It builds on (1) design narratives of rapid prototyping approaches to game design for learning (c.f., Aldrich, 2003; Jenkins, Squire, & Tan, 2004; Squire, 2008, 2010, 2011), (2) models of rapid prototyping within instructional design (Desrosier, 2011; Jones & Richey, 2000; Tripp & Bichelmeyer, 1990), and (3) modern versions of entertainment game design (Lebrande, 2010) to articulate an integrated approach to designing games for learning. This approach addresses the requirement that training games (1) must have mechanics appropriate to the target domain (2) suffice the requirements of multiple stakeholders, and (3) be backed by evidence that games are achieving their intended impact without causing unforeseen negative consequences. Before proceeding with these development issues, however, we first provide a brief overview of cognitive bias.

THEORETICAL APPROACH TO COGNITIVELY BIASED INFORMATION PROCESSING

A primary causal mechanism cited for biased information processing and poor credibility assessment is the reliance on heuristic social information processing—a nonanalytic orientation in which only a minimal set of informational cues are considered as long as processing accuracy is deemed sufficient. As defined by Chaiken's *Heuristic-Systematic Model* of information processing (HSM; Chaiken, 1980; Todorov, Chaiken, & Henderson, 2002), heuristics are mental shortcuts, or simple decision rules, arising from conventional beliefs and expectations used repeatedly in daily interactions. In contrast to heuristic processing, systematic information processing requires more careful consideration of all available evidence, and is thus much more cognitively taxing (Chen & Chaiken, 1999).

The HSM posits that reliance on heuristics is often preferable because it minimizes cognitive effort while satisfying motivational concerns with sufficient reliability. Heuristics often provide swift solutions to complex, ill-structured problems (Silverman, 1992; Van Boven & Loewenstein, 2005), however, reliance on heuristics can also lead to insufficient consideration and/or disregard of relevant, diagnostic information. Consequently, although heuristics do not always lead to bias, an overreliance on them can result in decreased soundness of credibility assessments. According to the HSM, *motivation, time*, and *ability* to process information are critical elements for reducing analytical reliance on heuristic processing, and encouraging more optimal systematic, deliberative processing.

Unfortunately, although there is a vast research literature documenting the existence of cognitive biases, the literature on the *mitigation* of cognitive biases, especially in the area of credibility assessment, is scant (Silverman, 1992). Because credibility assessment is cognitively demanding (Vrij, Fisher, Mann, & Leal, 2008), decision-makers are prone to adopt mental decision rules that require less cognitive effort. However, within the context of intelligence analysis, the present project offers an immersive training game to help analysts recognize when cognitive heuristics are disadvantageous, and encourage them to engage in more systematic processing so as to reduce the incidence of biased reasoning within their decision making.

Few systematic attempts to mitigate cognitive bias through comprehensive training programs exists with a few exceptions in medical education (Stone & Moskowitz, 2011) and law enforcement (van den Heuvel, Alison, & Crego, 2012) however the effectiveness of training programs, especially over the long term is unknown (Neilens, Handley, & Newstead, 2009). Using games for training, especially in the realm of intelligence analysis or decision-making is a relatively new approach. For example, Crews et al. (2007) describe a web-based, learner-centered, multimedia training system called AGENT99 Trainer that was more successful at teaching people to detect deception than traditional pedagogical techniques although it was not a game per se. Games have been used to train in many different domains and a recent meta-analysis by Sitzmann (2011) found that computer-based simulation games were more likely than control conditions to improve factual knowledge and skills with a higher retention rate. The main advantage that games provide is replayability. While a student is unlikely to hear a lecture, lesson, or instructional video more than once, they can receive repeated exposure to training when implemented in a video game. They can also receive feedback on their mistakes more quickly and learn from those mistakes without suffering real-world consequences. Thus, a videogame is an ideal medium to train about cognitive biases which operate outside of conscious awareness and may be resistant to training.

The IARPA Sirius program asked us to address three particular cognitive biases in the first phase of the program, namely: the *fundamental attribution error (FAE), confirmation bias (CB)*, and *bias blind spot (BBS)*. The FAE is the tendency for people to over-emphasize stable, personality-based (i.e., dispositional) explanations for behaviors observed in others, while simultaneously under-emphasizing the role and power of transitory, situational influences on the same behavior (Harvey, Town, & Yarkin, 1981). People engage in CB when they tend to search for and interpret information in ways that serve to confirm their preconceived beliefs, expectations, or hypotheses (Nickerson, 1998). Similarly, BBS is a form of selective perception characterized by the tendency to see bias in others, while being blind to it in one's self due to a failure in introspection (Pronin, 2007; Pronin & Kugler, 2007; Pronin, Lin, & Ross, 2002). In our approach to developing methods for mitigating these three biases within the MACBETH video game, we applied the HSM to examine ways players may be encouraged to engage in systematic processing while simultaneously limiting their reliance on heuristics.

OVERVIEW OF MACBETH

Our response to the IARPA challenge of building a training video game to train intelligence analysts to mitigate cognitive bias, was to create a fictional environment in which players are confronted with a global terrorist threat they must prevent, as a clock counts down the time remaining before the imminent attack. Players take on the role of an intelligence analyst who must gather intelligence from assets around the world in order to assess the credibility of the information, try to determine the accuracy or truthfulness of the intelligence, and then apprehend the suspect before the attack. Players must determine the location of the terrorist attack, the identity of the suspect, and the method of attack (i.e., the weapon used). The game was originally designed as a single-player game to be played against other non-playable character (NPC) analysts but was later expanded to allow for human players to collaborate with one another to solve the scenarios together. MACBETH has four distinctive sections (*Intel Collection, Archive, Case Files, and Intel Review*), and one game tool—the *Notebook* used for tracking and organizing information gathered for determining location, suspect, and weapon. Each game section is available at least once per turn, however, turns always end with *Intel Review*, where players make a hypothesis, or assists other players in making hypotheses. Below, the four game sections and *Notebook* tool are each described in turn.

Intel Collection

In *Intel Collection*, players collect two pieces of intelligence per round from up to six different sources (each holding three pieces of information). For example, players can request an analysis of satellite data on suspect movements, find out about internet chatter regarding suspicious local activities, or ask an asset about dubious money transfers possibly aiding a known terrorist group. In response to the two questions posed, players are presented with answers of varying specification and reliability that can be used to confirm or disconfirm locations, methods of attack, and/or attributes of a suspect. Certain pieces of intel that are lacking in specification may require further investigation, in which case a "chip", obtained in the *Archive* section of the game, is necessary.

Archive

In *Archive*, the player is given the profile of an unidentified subject and asked to determine if that person represents a potential threat. Players are told to review the case files and determine whether the person should have been considered a threat at the time their case was active. Threat determinations are informed by collecting clues based on either dispositional or situational information. Players may collect up to 12 cues (6 dispositional and 6 situational) upon which they must make their "threat" or "not a threat" assessment. If a correct assessment is made based entirely on situational clues (thus avoiding the FAE), a "chip" is earned, which can be used later in the game to follow-up on ambiguous or under-specified intelligence gathered during *Intel Collection*. The purpose of *Archive* is to help players reduce FAE, thus MACBETH makes dispositional cues (e.g., "has a quick temper") less useful in identifying threats than situational cues (e.g., "is currently a subject of interest in a police investigation"). When justifying their position, players must indicate the top three pieces of evidence they used to inform their assessment, and only correct assessments based on three situational clues earn points (toward their overall game score) and a chip that will later prove useful in verifying ambiguous intel.

Case Files

In *Case Files*, players can browse information related to suspects, weapons, and potential attack locations. For example, if players learn from a source during intel collection that a suspect has a history of depression, they can read the case files on the suspects to learn which ones may be taking drugs for depression. Once a player reviews information in case files, that information is automatically added to the *Notebook* and is subsequently available for later decision making.

Intel Review

In *Intel Review*, players are faced with two potential interactions, one of which involves the ultimate submission of a final hypothesis. In their initial visits to *Intel Review*, players are encouraged to formulate a running hypothesis, or assist a fellow analyst (and thereby earn points) by providing new evidence. In both cases the player must select evidence collected during *Intel Collection* to justify the hypothesis or the assist. When assisting a fellow analyst, the game encourages the use of disconfirming evidence through both feedback and point awards. On their second visit to *Intel Review*, players are offered a choice between requesting confirming or disconfirming evidence from a fellow analyst, and this information can be used to justify a change on the player's hypothesis. Just as *Archive* encourages the selection and use of situational clues to mitigate FAE, *Intel Review* encourages the selection and use disconfirming evidence to mitigate CB.

Intel Review requires players to interact with the AI which, depending on whether they are in the single or multi-player versions of the game, could be quite different from one another. In the single-player version of the game, the other analysts (NPCs named Hal and Joshua) are not very interactive and it is clear to participants that they are not making decisions or hypotheses collaboratively. The player can request to receive either confirming or disconfirming intel from the other analysts and can either disconfirm the AI hypothesis or justify his or her own hypothesis. The player receives feedback based on this choice. When the player submits a final hypothesis they gain points based on correct items and a bonus for the turn in which it was submitted. If the player had insufficient evidence to prove the hypothesis they receive a penalty. Thus, in the single-player version of the game, the AI was simply sending intel to the player and was not directly communicating with the player.

For the multi-player version, the player can play either with another human partner or can play with AI that was designed to simulate human actions based on the playtests of human players. A player can request assistance from another analyst through intel received in a dropbox. The dropbox is a messaging system used for communication between each player in the multi-player version. A player fulfilling a request receives feedback based on the type of intel submitted. When a player submits a final hypothesis, it must be approved or rejected by the other player. To reject a hypothesis, a player must submit disconfirming intel, which then appears in the other player's dropbox. If a hypothesis is approved, the submitting player receives a bonus. If a hypothesis is rejected, the rejecting player receives points and the submitting player receives a penalty. Both players share the final approved hypothesis, gain points based on correct items, and gain points based on the round of the player who is farthest in the scenario. The multi-player AI is more interactive and collaborative than the single-player.

The Notebook

The *Notebook* is not a section of the game, but rather a tool for the player. In the *Notebook*, players collect information from Case Files that later can be consulted and rated as more intel becomes available. Up to the moment of final hypothesis submission, the *Notebook* holds all the intel collected, organizing it both by source, and by type—i.e., locations, suspects and weapons. When players are ready to submit their hypotheses during *Intel Review*, suspects, locations and weapons can be selected from the *Notebook* to form running hypotheses, and eventually a final solution to the game.

RAPID ITERATIVE PROTOTYPING PROCESS

In the game development process known as rapid iterative prototyping (RIP), the game is played, evaluated, adjusted, and played again, allowing the design team to optimize adjustments to successive iterations or versions of the game (Eladhari & Ollila, 2012). The purpose of RIP is to gather feedback on the design while production is underway so that changes can be made during the development process rather than waiting until the game is finished. The rapid development cycle allowed by RIP serves to leverage input from intelligence and cognitive bias experts on the project team, who are able to provide continuing feedback on design, playability, and coherence while simultaneously making sure the theoretical mitigation goals of the project are maintained during each iteration.

At present, MACBETH has been through more than 100 builds, and has seen dramatic changes accrue over its first year of development. This process may be broken down into three distinct phases: The first of which involved the "Paper Prototype" created as a cartoon version of the game, capable of illustrating the basic concepts and mechanics within the game to our cognitive and intelligence subject-matter experts (referred to as CSE and ISE respectively) as well as the IARPA review team. During the second phase of the development process, termed the "Alpha Phase," the *Archive* mini-game was developed and then tested with a small group of student playtesters, who continued to offer feedback as new features of the game were added with each prototype developed. Finally, after assuring the validity and design specifications of MACBETH during the "Beta Phase" (Gold & Wolfe, 2012), a game build prototype was developed for use in our first experiment, assessing game mechanics and functionality with over 700 users (Dunbar, Miller, et al., 2013).

Phase 1: Paper Prototype

A primary goal of prototyping in design research is to understand the problem of a design through cycles of design and feedback, rather than through speculation. Just as importantly, the paper prototype was intended to begin a conversation among all project staff, including game designers, subject matter experts, cognitive psychologists and measurement specialists about project goals informed by tangible materials, rather than speculative goals; in short, rather than spend months discussing what a game could be, and debating different visions free of any tangible products or shared experience, we wanted to encourage grounded discussion around a shared object (see Boling & Bichelmeyer, 1998). In the first designs written for the IARPA proposal, it was felt the game might appear too much like deskwork for an intelligence analyst (see Figures 1 and 2), which might lessen engagement (Schoenau-Fog, 2011). After contracting with a team of designers to help make the game more engaging, they were able to take our initial idea and collaborate with the development team, ISE, and CSE personnel to add elements based loosely on the board game *Clue*, in which players would have to identify a suspect, weapon, and location for the fictional attack in a turn-based style. Through several face-to-face working sessions with cognitive researchers and game developers, the design team proposed five high-level game concepts that leveraged unique game mechanics to allow players to learn about and diminish the targeted biases within both single- and multi-player game versions.

Drawing from common practices in visual design, we created five initial designs, rather than "one master design" in order to: (1) Unearth

Figure 1. Early design of MACBETH game

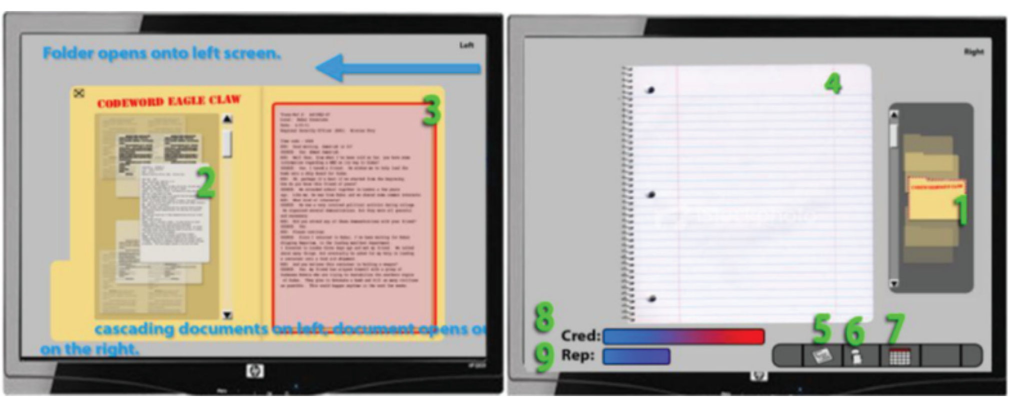

Figure 2. The first paper playtests of MACBETH

multiple plausible game designs and prevent the team from becoming too stuck on one idea; (2) Uncover implicit functional specifications that may not have been made explicitly; and (3) Create a cohesive vision for the ultimate design which would work from multiple perspectives. After careful consideration of the strengths and weakness of each design, the design team moved forward with the development of a paper prototype concept merging elements of three of the initial designs into a single play experience. One of these concepts was called "*Threat!,*" a mini-game addressing the FAE that was later developed into *Archive*, and integrated as one component of MACBETH, so that the rest of the main game could focus on the BBS and CB training via the use of a hypothesis testing approach within what eventually became the *Intel Review* portion of the game. Following two months of development, the design team had a working prototype of MACBETH (designed for four players at a time) available for the CSE and ISE teams, and IARPA review personnel to play, and consequently provide feedback to the design team through RIP.

Consistent with an RIP approach, both the ISE and CSE teams had early and persistent roles in playtesting to assure realism and verify that the implementation of the bias elicitation mechanisms were performing as planned. The CSE team also reviewed the efficacy of the instructional material in informing players of mitigation strategies for each bias, and assisted in balancing the game feedback systems to reward mitigation of bias and redress players who committed a bias. All researchers were provided access to scheduled builds of the game, and asked to play and provide feedback via an on-line discussion board. Although they helped provide insights on usability and design elements, the ISE and CSE teams focused primarily on the implementation of content-dependent game systems.

The development team subsequently analyzed feedback from the CSE and ISE teams following the paper playtest, and although many suggestions for improvement were offered, one of the most important lessons learned was that people did not like being rushed to make a hypothesis too early in the game. Players wanted time to gather intelligence and weigh the information further before making their hypotheses, thus the original prototype requiring a guess after the first turn was modified. Relative to bias mitigation, the concern was that players could not commit CB unless they indeed had a relatively firm hypothesis in mind, otherwise there would be nothing to confirm or disconfirm. On the other hand, players who waited until the end of the game to make a hypothesis would never have a chance to commit—or mitigate—CB or BBS. So, as a result of this playtest iteration, a mechanic was developed to institute "commitment points," encouraging players to make an early hypothesis, while rewarding them for retaining their original positions, unless they had contradictory evidence—all before ultimately being allowed to make a final hypothesis only after their third turn.

A second important piece of feedback from these early playtest sessions involved the dossiers of the suspects in the main game. Players wanted to see more variety, both in terms of gender and background. Indeed, if the suspects were all Muslim extremists, that could easily encourage stereotypes and inadvertently increase both CB and BBS. Thus the development team worked with the CSE and ISE teams to create dossiers of the suspects, as well as old case files for *Archive*, which could provide a richer, more diverse body of potential suspects and threats for players to engage and analyze.

A third important lesson from the paper playtests involved the turn-based approach to the game. When playing a board game with other players face-to-face, it is possible for one player to have a turn while other players observe, but even when players know what their opponents taking a turn are doing, they may grow impatient waiting for their turn. In a digital game, when players are unable to see what others are doing, this may become even more critical as players are more prone to impatience and boredom awaiting their own turn. Consequently, the game mechanic was altered to make the turn-taking simultaneous, so that within a single-player version of the game, artificial intelligence could be employed to interact with the players by creating two NPCs as fellow analysts, named "Hal" and "Joshua."

This development sped up the action by allowing a player to be informed that Hal or Joshua would like assistance in testing their hypotheses, without the player's assistance interrupting the player's own turn, nor requiring the player to wait for the NPCs to make their turns. In a later multi-player version of MACBETH, turn-taking remained simultaneous and the dropbox system was implemented so that play could continue even while the other players were making decisions.

In sum, the paper prototyping phase enabled the team to minimize project risks by identifying critical tensions in the game design (i.e. managing sufficient investment in hypotheses), bringing team members together on a common goal, and providing evidence for the potential of a game to reach its intended learning goals.

Phase 2: Alpha Testing

The development team took over the project from the design team, and began converting the paper prototype into a digital game. The first aspect of the digital version was the *Archive* mini-game, designed to teach players about FAE and help reduce the reliance on dispositional attributes (see Figure 3). The CSE team took the lead on creating the case files and chose historical figures about which the fictitious intelligence agency would have old case files. Thus 32 distinct Archive case files were created based on biographical information about a range of characters, from serial killers and terrorists, to historical heroes and literary figures. Based on the feedback received during the paper playtests, these profiles varied in age, gender, country of origin, and religious affiliation, with the objective being to choose characters players would be familiar with, so as to produce an "aha" moment upon deeming someone to be a threat or not a threat. Calling Mother Theresa a threat, for example, should accentuate players' realizations that they had indeed used faulty decision-making techniques. Thus, MACBETH attempts to make players aware of their biases by making the dispositional cues non-diagnostic and misleading, whereas the situational cues are diagnostic and useful. However, the cues and characters within *Archive* needed to be as factually correct as possible, which required a great deal of research.

The first independent playtest population during Alpha Testing consisted of undergraduate students who had signed up for a semester-long course in which they spent several weeks learning about the educational capabilities of videogames, and playing builds of MACBETH

Figure 3. Archive mini-game design

as they became available. Student playtesters (N = 13) made one-hour appointments using online appointment scheduling software, and had one-on-one sessions with a graduate research assistant, during which they played the most current build of MACBETH. The research assistants observed their game play and noted specific in-game behaviors. After completing a play session, students responded to questions and metrics designed to elicit feedback about their play experience, which were recorded, summarized, and incorporated back into the next build of the game. The CSE teams also played each week's build and made content recommendations based on feedback from playtesters, as well as their own experiences. In-game behavior was also observed by the development and CSE teams using Morae Observer software, whereupon completing a playtest session, researchers assigned to facilitate the playtest coded each student playtester's in-game behaviors for markers of bias elicitation, mitigation, and performance feedback.

In addition to the playtest feedback on *Archive*, the dispositional and situational cues were administered to a larger sample (N = 130) of undergraduate students with a brief definition of the terms "dispositional" and "situational" to determine whether the Archive cues were clearly identifiable as such. From those results, cues that playtesters were unable to distinguish as dispositional vs. situational were revised easier identification. Out of the 374 possible cues, any cue that 50% or more of the sample mistakenly categorized, or reported uncertainty as to their dispositional vs. situational nature, was revised. As a result, nearly 100 cues were modified before being incorporated into *Archive*.

One of the most important changes made to *Archive* during Phase 2 was that players were asked to rank the top three cues that lead them to their threat assessment, so it could be determined exactly what information they were using to make their decisions. If they correctly identified a threat but did so using dispositional cues, they would get a message informing them they were relying on cognitive biases despite making the correct threat assessment. Analysis of the players' trials in *Archive* indicated they were often winning chips while relying on dispositions; thus, the decision was made to only award chips when situational cues were made as the players' top three choices. This way, players would not be rewarded for relying on dispositions, and thus, FAE would not be encouraged. It was also determined that players would need chips in order to win so that they could not skip the FAE training in Archive while playing MACBETH.

Qualitative data were collected throughout the course of the Alpha testing to assess player affect (i.e., whether the player had positive or negative game experience), software performance (how responsive, stable, and scalable the software was), usability (perceptions of the interface and navigation), and game interactivity (i.e., how much the player interacted with the game). Overall, players responded positively to the game concept, and showed they enjoyed the investigative and educational nature of the game, indicating that "pretending to be an agent was fun." Some users saw a connection between media outside the game and the game content, and the familiarity made the game more enjoyable. For example, one user associated the game with television crime shows and said she put herself "in the shoes of the psychologist from *Law and Order: SVU* and approached the information as if I were taking the case to trial." Negative comments on the concept of the game centered on the repetitive nature of determining threat. At this phase however, players were only testing *Archive*, thus the negative comments were due to the iterative nature of the playtesting and the limited game content available during Alpha Phase.

Comments regarding programming issues were used to detect bugs inadvertently overlooked by the design team. For instance, some users repeatedly chose situational cues but corresponding feedback advised them to "look for situational cues." Despite the game being programed to avoid repetition of suspects, some players were given the same suspects multiple times. Oftentimes the game would not enter full screen mode, or graphics would cover a portion of text, etc. Discovering software glitches like these during review sessions within the RIP process allowed the design team to improve the technical quality of the game for each successive build.

In addition to detecting technical problems, participants also commented on the game's aesthetics and informative content. The 3-D graphics received mixed reviews, for example, one user said he "liked the graphics, they were better than what I expected," while another complained she didn't care for the 3-D and "immediately wanted to change it." A couple users indicated the 3-D was "distracting" and "difficult" at first, but once they got used to it, one "liked it" whereas the other felt "it didn't add anything to the game."

To determine the ways players interacted with the game, users were observed by graduate assistants, and asked how they made decisions regarding threat. The purpose of *Archive* was to teach players to use situational cues over dispositional cues in decision making, yet 58% of participants either admitted or were observed using other techniques to make decisions. Some players approached the task as a "guessing game" instead of using deductive skills. One player described this tactic as a "matching game" where the user "was able to recognize and guess the characters' identities from the clues" before making a choice. Only 27% of users read the game feedback and realized they should be using situational cues over dispositional cues (the remaining 15% of playtesters did not indicate how they made decisions). Thus, the challenge for the design team centered on increasing players' interactions with the feedback—encouraging them to read and learn from the instructions and feedback provided by integrating the feedback into the course and narrative of the game, rather than having it function as a "toll booth," slowing down play, and requiring them to break the flow of the experience.

Once *Archive* was complete, the development team focused on improving the rest of MACBETH,(i.e., the main game) which included: the *Intel Collection* section, in which players can query sources and collect answers to questions about the suspects, weapons, and locations under investigation; the *Case Files* section, where players can read background on the suspects, weapons, and locations; the *Intel Review* section, where players can try out different hypotheses and request help from the other analysts; and finally, the *Notebook,* where players are able to keep track of their intel in preparation for submitting their hypotheses.

In addition to the first group of student playtesters described above, three additional tests with various groups of players were conducted. In the second on-campus playtest, faculty and graduate students were recruited from the University of Okahoma. In the third playtest, nineteen Intelligence officers with at least five years of experience were recruited from a variety of governmental agencies for a day-long session, which included multiple play-throughs of the game. The final playtest involved playtesters selected by the IARPA project management team, which also incorporated multiple play-throughs as well.

After each playtest session, players participated in one-on-one feedback sessions with a researcher, then engaged in focus groups during which a moderator asked questions to stimulate discussion. Overall, playtesters in the three groups expressed positive feedback regarding the changes in *Archive* and the analytical concept of the game. For example, when commenting on *Archive*, one playtester noted. "All of the profiles in archive... those were interesting. I like the archive exercises, choosing whether or not people were a threat was fun. I liked the idea that this was a mini game in the whole game." Similarly, in response to the question: "What was your favorite part of the game?" one playtester commented, "Trying to put together all of the options. The analytic part, it works for me."

In addition to noting which parts of MACBETH they liked, feedback from the focus groups also suggested numerous refinements. For example, at each playtest, players were presented with a new way of orientating on their play, along with instructions on alternative ways of navigating the game. During each session, playtesters noted how difficult and confusing the game was, with its steep learning curve. Thus, a variety of training methods were evaluated, including a short video tutorial, and the use of brief printed instructions. Initially however, the tutorials proved to be frustratingly short, or were presented too quickly, hence, the learning curve remained steep, as one playtester noted: "Some of the sections were not intuitive…. Wasn't clear what I was supposed to do or why there were choices…. Two minute video didn't cut it…" When asked for a suggestion on how to make the game more intuitive, this playtester responded: "Some mechanics need to be simplified or explained. I hate to say fix it with a tutorial, but it needs to be more intuitive and obvious. Figure out how to fix the mechanics to be self-teaching and obvious like tooltips." In response, a tutorial scenario (called "Scenario Zero"), was developed to function as a walkthrough of a shortened and simplified game scenario. In Scenario Zero there are only three weapons, locations, and suspects; and the AI walks players through two turns, demonstrating all the important elements, including the basics of *Archive*, *Intel Collection,* the *Notebook*, and *Intel Review*.

One build of the game had a "sandbox" feature where players could test and explore different hypotheses, but playtesters found it caused more confusion than it alleviated since they could not transfer their sandbox hypothesis to the actual *Intel Review* section. A more pressing problem was that while playing in the sandbox, players were not receiving any bias mitigation training and thus, it served as a distraction from the main purpose of the game. Subsequent builds replaced this feature with a new hypothesis session within *Intel Review.*

Another aspect of the game receiving an overhaul after the focus group playtests was the *Notebook*, which, in the original design, was a separate area available only from the main menu of the game (see Figure 4), which meant players could not access it while navigating within *Intel Collection, Case Files,* or *Intel Review*. One player commented, "[I would] like to see info from suspect bios easier to access. Would like to be able to drag a clue from one side of notebook to the other … to keep track of which clues [led] to which decision." This and similar comments were instrumental in changing the *Notebook* in successive builds, so as to make it accessible on every screen, and thus available to players throughout the game (see Figure 5).

Figure 4. Original design of main page for game

Figure 5. Notebook re-design

In addition to playtester feedback regarding notebook accessibility, players were observed taking copious notes on paper while they played. "Notebook is not intuitive," one player commented, "I need paper." Although their paper notes were helpful in revealing how players were copying details from the case files page on the weapons, locations, and suspects, they ultimately took players out of the flow of the game. A key focus group finding showed how players desired more options for organizing intel within the *Notebook* so they could read profiles more easily while seeing suspect data simultaneously. Based on these observations and feedback, the *Notebook* section was revised so that as players visited *Case Files*, the intel they accessed on weapons, locations, and suspects automatically populated in their *Notebook*.

Their notes also revealed players to be rating their confidence of intel validity as they played, and flagging pieces of intel they thought to be particularly important. During the focus group sessions players said they wanted to gauge their certainty of intel validity so they could more easily keep track of what they'd learned, and which pieces would be most useful. Regarding how realistic the game was, one intelligence officer stated, "You need a credibility assessment for every piece of intel. This game doesn't have that. The collector does this." Another stated, "You will never totally be sure about an answer. So you have to play on levels of certainty, and that is very important for an analyst to understand." Based on these and similar pieces of feedback, subsequent builds of the *Notebook* developed both a flag function, and a slider for players to assess their confidence in the credibility of the information accumulated during *Intel Collection* (see Figure 5).

Phase 3: Beta Testing

Once Alpha Testing had demonstrated the game to be both playable and engaging, the CSE and development teams began manipulating key variables and game mechanics within MACBETH to test the efficacy of the game at mitigating cognitive bias. Although the experimental design and results of the first experiment are beyond the scope of this paper (they are reported elsewhere; see Dunbar et al., 2013), the primary purpose of Experiment One was to test the difference between *explicit training,* in which players are given overt definitions of the three biases along with priming about those biases throughout the game, and *implicit training,* in which players may only learn the bias terminology (such as the difference between dispositional and situational cues or confirming and disconfirming information) through the process of playing the game. Two additional experiments, testing the efficacy of the feedback system and the difference between single- and multi-player were also conducted.

To create the explicit training condition, short multiple-choice quizzes were created and delivered with definitions of the biases at relevant points in the game. For BBS, the bias training and the quiz were given at the start of the game, for CB, the bias training and quiz were given at the start of *Intel Review*, and for FAE, the bias training and quiz were given before entering the *Archive* mini-game. The purpose of each quiz was to ensure players read and understood the definition of each bias before continuing. If a player did not answer the quiz question correctly, the definition of the bias was repeated and they were given a new quiz question until they answered correctly, demonstrating their understanding of the bias definition.

Two experiments testing the effectiveness of the explicit training version of the game were conducted, the first of which consisted of a small pilot study ($N = 85$) of a bias priming prototype, in which game engagement was measured physiologically (Dunbar, Jensen, et al., 2013). The second version consisted of a large-scale study ($N = 703$) in which priming and other independent variables were tested (Dunbar, Miller, et al., 2013). As mentioned, the results of these experiments are outside the scope of this paper; however, both experiments provided opportunities for gathering player feedback about the effectiveness of MACBETH. In the post-game survey of Experiment One, players were given the option to provide feedback about their experience, which included open-ended responses from 263 participants. All the issues within the responses were categorized as either generally positive, negative or neutral, of which, 50% were deemed positive, 66% negative, and 3% neutral—with some players giving both positive and negative feedback.

Most of these 263 responses addressed more than one theme, of which 12 were distinctly identified, representing 635 unique pieces of data. The positive feedback mostly focused on how enjoyable and fun the game was to play (41%), how engaging the game was (9%), and how much players liked the game design/graphics (5%). For example, one player said, “I want to play it some more, it makes me think in a different way from most video games. I really enjoyed it.” Regarding the immersive elements of the game, this user also declared, “It was engaging and I feel like I learned a lot about FAE, BBS, and the difference between social dispositions and current environment.” Moreover, on the aesthetics of the game design, this player commented: “Great graphics, one of the best I’ve seen in these simulations. kudos!”[1]

The negative feedback mostly focused on how confusing the game was (41%); time constraints for playing the game (32%) which were restricted by the IARPA rules; and frustration with the tutorial (22%). For example, one player’s feedback regarding confusion about how to play the game was, “I feel that I probably could have completed the game had I understood the controls and the flow of the game better. I spent a lot of time muddling about in menus that weren’t useful, because I wasn’t sure how to play.”

Another player mentioned his frustration with the time component of the game, “I didn’t realize that the time was for every part of the game and not just the subsections. So I didn’t start to consider time as a variable until midway through the third round.” Concerning Scenario Zero, this player stated:

The tutorial moved kind of fast to know exactly what we were required to do for the game. When I got to the scenario to do it by myself, I wasn’t really sure where to start or what to do, so I just clicked random buttons. I started to get the hang of it towards the end of the game and wished I could have kept playing.

Neutral feedback mainly consisted of observations or statements about the game that were difficult to interpret. For example, “I was slow at first but then I was able to get faster” and “The game grew increasingly harder as the levels went on.” In addition, many players addressed problems they encountered (17%) and provided suggestions on how to improve the game (10%). Most of the problems addressed involved Scenario Zero, and time restrictions; however, other problems encountered included the functionality of the controls and navigation, as well as glitches found within the game. For example, one user commented: “I struggled with the functionality of the game. It was somewhat confusing in the necessary order and operation of the different menus.” This user described a bug encountered while playing the game: “there was a glitch in the Hawk game (third level, including training). It said I missed points, but the image was a reward-- and then a popup awarded me 2 more points...”. We used feedback like this to find and repair problems within the game feedback logic and to improve game playability.

One of the most common suggestions mentioned was to include a back button feature in the game (48%), e.g., “I would accidentally click ‘change hypothesis’ when actually I believe I had the correct hypothesis, and once that was done, there was no going back, I had to change something, even though I did not want to.” Other suggestions addressed the time restriction and the tutorial feature. For example, with regard to the time restriction this user suggested:

Take the clock off for the training, I felt like I had to quickly get through the tutorial to finish that level on my own instead of the entire level being the tutorial. Removing the clock would remove pressure to quickly work through the tutorial and be better prepared for the real level.

Regarding Scenario Zero, this user suggested:

Sometimes, I got lost in the middle of the game. For example, I had some trouble selecting and confirming the suspect, location, and weapon. Having the option to open the tutorial in the middle of the game would have helped. But other than that, I real[l]y enjoyed the game!

In summary, players generally were positive toward the game, with their negative feedback largely addressing the time pressure within the game, which was deliberately designed to add cognitive load because the ability to process information is one of the key variables in our theoretical guide, the HSM. The time pressure was designed to provoke players into both committing and mitigating biased decisions. By increasing time pressure, there was an increased likelihood of players relying on heuristics, thus provide opportunities within MACBETH for them to learn about and correct their own biased decision making.

In subsequent builds of the game, mentors have been provided to guide players along, so they can receive priming and feedback about their decision-making as they play MACBETH. To alleviate confusion, a "tool tip" bar has been added and made prominent to indicate what the various icons mean, and the first few scenarios have been made simpler to solve, so as players learn to advance, the difficulty of these initial scenario will not impede the more important bias mitigating aspects of the game. We are exploring other ways to reduce the confusion experienced within the game as we continue development and prepare for our next set of experiments.

CONCLUSION

This case study of MACBETH represents a learning experience in which the rapid iterative prototyping used by the development team was informed by continuous consultation with content and intelligence experts. Performing extensive pilot testing with a range of playtesting populations was essential for preparing, implementing, and refining MACBETH in advance of a large-scale experimental test. Development of a training video game of this magnitude in under one year is a feat in itself. However, the key to its continued success will be a function of the care and attention to detail given to its design by the ISE, CSE and development teams. Many of the lessons learned through the playtesting were unique to this case study, however, the value of playtesting MACBETH, and the agility of the rapid iterative prototyping system have been critical for designing a game capable of being examined within a true experimental environment.

This general process of paper prototyping, developing alpha builds, and conducting beta testing may be a generalizable process when designing games for social impact. We believe any team of game developers, regardless of their development budget, can enlist the help of subject matter experts and design a training game that meets multiple goals. Using the RIP process enables the project to come into focus as researchers and developers better understand the dynamics of the design space. The process enabled this project to systematically identify and reduce potential unknowns and risks. With each phase, the project became increasingly in focus. We were also able to adapt to player feedback through the use of continuous feedback processes so that changes could be made before development advanced too far. Critical to this process (and indeed any social impact game, or game for training) is also bringing a multi-disciplinary *team* into focus, as each understands a project's multiple goals and competing needs. We recommend a team-based approach and the use of playtesting to garner feedback for developers throughout an entire development process to encourage the best game development process possible.

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ENDNOTES

1. Player comments are exemplars which are representative of other players in that category.

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