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From a Video Game in a Virtual World to Collaborative Visual Analytic Tools

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Abstract

We investigated collaboration during a riddle-solving video game in a virtual world that drew elements from massively multiplayer online role-playing games and serious games. This disclosed benefits of collaborative game play over non-collaborative play in a virtual world. Participants were in the digital natives age range. Collaboration conditions varied over five sessions. We derived implications for accommodating collaboration in visual analytic (VA) tools. We have determined future research directions with respect to borrowing from video games to design VA tools that accommodate the unique characteristics of digital natives who become information analysts as evidenced during collaboration in a virtual world.

Keywords: virtual worlds; video game; visual analytic tools.

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What does the gaming research community have to offer the world of information analysis? A principal goal of our research is to understand the behaviors and skills that young analysts will bring to the workplace for the purpose of applying this understanding to development of visual analytic (VA) tools. One goal of these tools is to support the work of information analysts 30 years of age or younger. To achieve this, VA tools must accommodate these users' skills and behaviors. In particular, we are interested in learning how collaborative skills acquired playing video games in virtual worlds can be applied to interaction with VA tools. We define collaboration as players' interaction with each other towards a common goal.

The next generation of information analysts is highly computer literate (Jonas-Dwyer & Pospisil, 2004). Known as the digital natives (Prensky, 2001a), they have grown up with computing. A subset of digital natives is called digital game natives (Zyda, 2005) because they have grown up playing video games. Many of them participate in massively multiplayer online role-playing games (MMORPGs), internet-based interactive games played in an ongoing virtual world where players take on roles. They can participate at levels ranging from passive observation to active interaction with other players in various forms including competition and collaboration. There is growing evidence that video game players develop visual attention processing capabilities that are superior to those of non-game players (Green, & Bavelier, 2003, 2007). They are prone to collaborate, developing collective knowledge (Oblinger, & Oblinger, 2005; Rainie, 2007). They require immediate feedback to their actions both within and outside of gaming environments (Prensky, 2001b). Looking at the attributes of digital game natives, we have focused our studies on collaboration, and, in particular, synchronous collaboration in a virtual world.

VA tools often have complex visualizations, representing huge amounts of data and relationships among data in various degrees of abstraction. Thousands of reports, maps, charts, photos, recordings, etc. may be represented as infographics, e.g., clustered colored dots or icons, positioned or visually emphasized according to relevance to an analyst's information needs. Dense displays represent complex relationships and networks, e.g. social or financial. These displays are often three-dimensional (3D), giving visual, spatial and audio feedback. Animation indicates state changes, evolving views of information, trend development or movement through a geographic plane. These tools are highly interactive. They are electronically networked to facilitate information access and dissemination.

In many aspects, VA tools resemble online games. The two share properties such as high interactivity; complex displays that are often 3D; animation; visual and audio feedback; movement of objects through geographic planes; and electronic networking. In both, collaboration can be synchronous or asynchronous, planned or spontaneous. Players' ability to collaborate is a primary characteristic of MMORPGs. Collaborating information analysts can work together in real time, or pass work products or information to each other asynchronously. They can be co-located or distributed across physical locations, but connected electronically.

The information analysts' workplace is often a high-pressure environment. Data is often abundant, but its reliability varies. Today's analysis may become incomplete or incorrect tomorrow as new information is added or false information discredited. Sometimes, information analysis resembles riddle solving with finding clues, making sense of them and developing answers.

Our research to date has drawn from many fields e.g., cognitive psychology, social psychology, education, computer science and biology. However, our work primarily resides in the domains of human-computer interaction (HCI) and usability engineering. Thus, it is user-centered, focused on understanding human factors that impact the user experience when using technology. Much gaming research proceeds without considering usability per se. In those instances where video game usability is considered, its definition ranges from fun (Song, Lee, & Hwang, 2007) to supporting task performance and satisfaction (Cornett, 2004) to playability (Desurvire, Caplan, & Toth, 2004). In our work, we apply a standard definition of usability to gaming, i.e. user efficiency, effectiveness and satisfaction (ISO, 1997), using methods developed specifically for evaluation of VA tools (Choong & O'Connell, 2008).

We are particularly interested in applying the serious game paradigm to VA tools. Although the purpose of serious games is not entertainment, they use entertainment techniques and processes to achieve real-world goals with impacts outside the game play environment (Libes & O'Connell, 2007). It is this potential to achieve real-world goals that has made serious games a topic of interest to HCI gaming researchers and developers of interactive VA tools for information analysts (Libes et al., 2007). Entertainment techniques that are essential in gaming include supporting interaction and cooperation among players (Sweetser & Wyeth, 2005). Serious games often share this support of collaboration.

We designed a user-centered methodology to study the effect(s) of collaboration in a virtual world. We designed a riddle-solving video game within an existing virtual environment. The game borrowed elements from serious games and MMORPGs. User recruitment was limited to digital natives between eighteen and thirty years of age. This age range included people entering the field of information analysis as well as younger people who had grown up after video games became widely available.

Experimental Design

We started by defining the aspects of efficiency, effectiveness and satisfaction to be measured and then set appropriate metrics for each measure. Efficiency was measured in terms of the length of time players spent solving a set of six riddles. Measures of effectiveness included the number of riddles solved and forfeited and the number of wrong answers given. We studied satisfaction across two dimensions, enjoyment and comfort. The first measure, enjoyment, derives from the gaming research literature which identifies enjoyment as integral to game play (e.g., Song et al., 2007). The second measure, comfort, is an integral component of user satisfaction when interacting with software (e.g., Dinda, Memik, Dick, Lin, Mallik, Gupta, &

Rossoff, 2007). To these usability measures, we added engagement, a topic addressed in the gaming research literature (e.g., Sweetser et al., 2005).

Although we were not evaluating the usability of the game itself, we followed standard usability engineering methods to investigate the effects of collaboration during a serious game. The research objective was to see if there were any differences between the experiences of collaborating players and players who did not collaborate, and, if so, to understand the nature and effect of those differences. Thus, one of the ways we report our findings is in terms of collaborators (COL) and non-collaborators (N-COL). To understand the nature of collaboration among young players, we ran an experiment with five conditions: *Condition 1 (Control with no Collaboration Conditions); Condition 2 (Collaboration Prohibited*); *Condition 3 (Collaboration Mandatory)*; *Condition 4 (Collaboration Optional but Penalized)*; and *Condition 5 (Collaboration Optional and Rewarded*).

Players

For each condition, we recruited four players, a total of 20 players. Among the 17 players who provided optional demographic data, ages ranged from 21 years old to 29 years old with the average as 24.76. There were three female players with one each in *Condition 2*, *Collaboration Prohibited*, *Condition 3, Collaboration Mandatory,* and *Condition 4, Collaboration Penalized*. There were 17 male players. Players' self-rated computer expertise was above medium; nine rated themselves as expert, and eight rated themselves as medium. Eight players had no experience playing interactive computer games. Within the other nine players, three reported their frequency of playing video games as 1 to 5 hours weekly, five players reported 6 to 15 hours weekly, and one player reported 16 to 25 hours weekly.

Experiment Environment

The experiment was run on four identical desktop computers, each with an Intel Xeon 3.0 GHz processor; 2 GB of memory; an nVidia Quadro FX 1400 128 MB 3D graphics card; a standard 101/102 keyboard; a 3-button click/scroll-wheel mouse, one 20-inch monitor set to 1680 x 1050 resolution; headphones and a noise-cancelling, free-standing desktop PC microphone. We developed a riddle solving game called ScavHunt in a virtual environment, using the On-Line Interactive Virtual Environment (OLIVE) platform provided by Forterra Systems Inc. (2007).

The ScavHunt Game

The ScavHunt game resided in a virtual city and its environs. Peninsula City resembled a location near the coast of California, U.S.A. Its 30 city blocks covered 1,000 square kilometers, with over 80 architectural models. Ten models had unique interiors: a Grand Hotel with a conference center, a high school, a hospital, an airport, a stadium, a high-rise, a surf shop, a bank, a warehouse and a train station with train cars.

Players, represented by avatars, could walk or run at a pace that scaled to real life walking or running. Ground vehicles, such as an automobile, accommodated a driver and one passenger and traveled up to 40 kilometers per hour scaled. Air transportation, such as a helicopter, accommodated a driver and four passengers and traveled up to 100 kilometers per hour scaled. Air vehicles had the added benefit of giving their passengers a bird's-eye view of the virtual world.

The goal of ScavHunt was to earn points by solving six riddles selected from standard IQ test and riddle-listing Web sites. Reward points were based on the difficulty of the riddles as determined by the research team. The two most difficult riddles were worth 200 points each, two riddles with medium difficulty were worth 100 points each, and two easy riddles were worth 50 points each. We randomized the difficulty level when presenting riddles to the players. Both 200 point riddles had three clues. All others had two. Clues resembled posters with black text on white backgrounds. Each clue included the number of the riddle to which it pertained. Each clue was lettered to show players if it was the first, second, or third clue for a particular riddle. Players had to move through the virtual world to find the clues for a riddle (See Fig. 1.). Clues were located in or around the hospital, high school, airport, high rise, surf shop, and stadium. Players solved riddles either individually or collaboratively based on assigned experimental conditions.

Distracting objects made hunting for clues more challenging, e.g., clues to other riddles were distracters as were clues that did not pertain to any of the riddles. Using clues to solve a riddle reduced the reward points by 50%. A wrong answer caused a 25 point deduction. Players could choose to forfeit a riddle, losing 100 points. A 100 point riddle, solved on the first try without using clues, earned a bonus of a ground vehicle. A 200 point riddle, solved on the first try with no clues, earned a flying vehicle. The highest possible score was 875 for *Condition 5, Collaboration Rewarded* and 700 for the other four conditions. The higher possible total for Condition 5 is due to potential bonus points for collaboration.

Figure 1. Two players view a clue posted outside of the High School in Peninsula City.

In addition to the player role, there was a Game Master (GM) role. The GM provided immediate feedback to players who submitted answers to riddles. Raising a hand in acknowledgement, the GM's avatar responded in turn to players' avatars who waved to him. The GM's avatar used a combination of gestures to indicate a correct answer; he nodded his head, clapped and made thumbs-up hand gestures. To indicate an incorrect answer, the GM's avatar shook his head from left to right. The GM awarded vehicles when appropriate; accepted forfeits; and presented the next riddle to players.

ScavHunt was a serious game. Drawing on MMORPG entertainment strategies such as moving avatars through a virtual world and providing rewards, it mimicked a real world situation in which an information analyst must either answer a difficult question or gather information to inform an answer. The answer was passed to an authority figure, the GM, mimicking submission of a report to a supervisor. It imitated the workplace in that players often had to wait their turn for direction on the correctness of answers or assignment of a new task. As in the workplace, the authority figure had the power to reward high achievement. There were penalties for wrong answers. There were costs and benefits to collecting and using resources to answer questions.

ScavHunt and the task were designed primarily for riddle solving, an important aspect of analysts' work. The virtual world aligned with information analysts' real workplaces in two ways. The riddles did not gradually increase in difficulty. Rather, task difficulty level was random. Secondly, there was no iterative increase in gratification level; rewards were tied to the difficulty of the riddles, not a rising level of expertise in playing the game.

Procedure

Players were randomly assigned to one of the five experiment conditions. For each condition, four players were present together in our research lab, but in separate cubicles. Players were briefed on the research project and each signed a consent form. Players were asked to wear headphones at all times during the game and to use the microphone for communicating. Each player received an avatar. One member of the research team assumed the role of the GM. Another provided technical assistance. As players trained, completed the competency test and played the game, the research team followed formal usability engineering user observation protocols, e.g., two usability engineers unobtrusively observed players' interactions with the game or with each other, taking time-stamped notes and noting signs of engagement, frustration, fatigue and collaboration.

Training and Competency Test

Before play, there was a 15-minute, self-paced training session. A written training guide familiarized players with the ScavHunt controls and operations. During training, players customized their avatars by choosing physical characteristics and clothing. After training, players took a competency test individually to ensure that each had acquired adequate skills to play the game. Observers gave each player the same competency tasks, in the same order and using the same prompts. All players demonstrated that they could perform all of the basic operations needed to manipulate their avatars and to navigate in the virtual world.

Players' Instructions

After the competency test, each player received a paper map of the virtual city and a paper game sheet. The experiment conditions were controlled by the instructions in this game sheet. Each session was set to a maximum of 90 minutes of playing time. Instructions constrained players from using any note-taking tools such as word-processing programs or paper and pencil. The only tool available to players was the MS Windows® calculator, made available because solving some of the riddles required mathematics. (It was not unusual to see multiple instances of the calculator open on one player's screen.) In the game sheets, other instructions varied according to experimental conditions.

Condition 1(Control)

Players (called P1, P2, P3, and P4) received a game sheet describing ScavHunt and how the points were calculated, including consequences of using clues, giving a wrong answer, or forfeiting a riddle, as well as gaining bonuses by solving more difficult riddles on the first try. No indication of encouraging or prohibiting collaboration was mentioned in the players' instructions for this condition.

Condition 2 (Collaboration Prohibited)

Players (called R1, R2, R3, and R4) received the same game sheet as the control group with an additional rule stating that all players had to work on the riddles by themselves. No communication was allowed among these players.

Condition 3 (Collaboration Mandatory)

Players (called T1, T2, T3, and T4) received the same game sheet as the control group with an additional rule stating that all players had to work on the riddles together as a team, using a specific in-game voice-chat channel as their sole means for communication.

Condition 4 (Collaboration Optional but Penalized)

Players (called C1, C2, C3, and C4) received the same game sheet as the control group with an additional rule stating that if a riddle was solved by players working together, each collaborating player would receive only 75% of the points that the riddle was worth.

Condition 5 (Collaboration Optional and Rewarded)

Players (called J1, J2, J3, and J4) received the same game sheet as the control group with an additional rule stating that if a riddle was solved by players working together, each collaborating player would receive 125% of the points that the riddle was worth.

Game Play

After reading the instructions, all players started the game in the hotel auditorium. Here, they received riddles one at a time; a new riddle appeared to them on a screen in the auditorium after the previous one was solved or forfeited. With each new riddle, the GM gave players a paper bearing the riddle number. A player who left the auditorium to seek clues for a riddle had to return there to report the answer to the GM. All players received the same six riddles in the same sequence. All clues remained available to all players throughout the game, regardless of which riddle players were addressing at any point in time.

Survey and Interview

After the game, players filled out an optional online survey. Players also had the option of not answering individual questions. The survey collected players' demographic data. It also collected players' opinions on their game play experience with three questions on a 7-point Likert scale (1 as lowest, 4 as neutral, and 7 as highest). These questions addressed enjoyment, comfort level, and engagement.

Question 1: Please rate how enjoyable the entire ScavHunt experience was. (*Enjoyment*)

Question 2: How comfortable were you playing the game? (*Comfort Level*)

Question 3: What kept you engaged? (*Engagement Factors*)

3a. Trying to get the most points

3b. Customizing your avatar

3c. Interacting and collaborating with others

3d. Solving the riddles

3e. Hunting for clues

3f. Trying to finish as fast as possible

After the survey, all players in each condition participated in focus group interviews. Interviewers avoided leading questions, instead posing open-ended questions that encouraged players to freely discuss their ScavHunt experiences.

Preliminary Findings

This was a preliminary study that set directions for future research. As we are still in the process of data analysis, we report the preliminary findings. We do not include an analysis or in depth reporting of interview data. Because we had a small sample size of 20 Participants, we did not perform statistical analyses. However, we did derive averages to facilitate discussions of the findings. Out of the 20 players, six engaged in collaborative play. In *Condition 1, Control,* and *Condition 4, Collaboration Penalized,* no players chose to collaborate. In *Condition 2, Collaboration Prohibited,* no players collaborated. In *Condition 3, Collaboration Mandatory,* all four players collaborated. In *Condition 5, Collaboration Rewarded,* two players strategically (J1 and J3) chose to collaborate.

Game Play Results and Discussion

Game scores ranged from -200 to 475. The six COLs all earned a final score of 475 out of a possible 700 for the mandatory condition and 875 for the optional rewarded condition. The only points deducted for COLs were for using clues. The scores of the 14 N-COLs ranged from

-200 to 225. Three players (J1, J2 and J3 in *Condition 5, Collaboration Rewarded*) received ground vehicle bonuses. One player, P3 in *Condition 1, Control,* received a flying vehicle.

Regarding efficiency (time to complete), the four COLs in *Condition 3, Collaboration Mandatory* solved all the riddles in 75 minutes. The two COLs in *Condition 5, Collaboration Rewarded,* took the full 90 minutes. All N-COLs took the entire 90 minutes, except for player C3 in *Condition 4, Collaboration Penalized* who completed the game in 77 minutes (score = -75: 3 solved riddles; 3 forfeits; 1 wrong answer), and player C2 in *Condition 4, Collaboration Penalized* who stopped playing by the end of the first hour, solving no riddles.

With respect to effectiveness (number of riddles solved, number of riddles forfeited and number of wrong answers), the COLs did not forfeit any riddles, nor give any wrong answers. The number of riddles solved by N-COLs ranged from 0 to 4; no N-COL solved all six riddles. Fifty percent (7 out of 14) of the N-COLs solved only three riddles. Three N-COLs did not forfeit any riddles; and the other 11 players forfeited between one and three riddles. Nine of the 14 N-COLs gave wrong answers at least once.

Game play results indicated a trend: COLs had higher efficiency and effectiveness than N-COLs.

Survey Results and Discussion

We looked at survey results both by condition and by comparing COLs to N-COLs. For the enjoyment question, players in *Condition 1, Control* (average = 2.75) and *Condition 4, Collaboration Penalized* (average = 2.5) gave lower ratings compared to players in other conditions where averages ranged from 4.5 to 5.5. For the comfort level question, players in *Condition 4, Collaboration Penalized* (average = 3.25) gave the lowest ratings, whereas players in other conditions gave average ratings ranging from 5.5 to 6.0. Survey question 3d asked if solving the riddles engaged players; solving riddles was the players' most agreed upon engagement factor. The average ratings for question *3d* were 6.25 (*Condition 1, Control*), 6.5 (*Condition 2, Collaboration Prohibited*), 6.5 (*Condition 3, Collaboration Mandatory*), 5.25 (*Condition 4, Collaboration Penalized*), and 6.25 (*Condition 5, Collaboration Rewarded*). Fourteen players gave question *3d* the highest rating and six players gave it the second highest rating, among questions *3a* to *3f* which all pertained to engagement. There was no consensus on other engagement factors across the experiment conditions.

Table 1

Survey Results for Enjoyment and Comfort Level, Collaborators COLs (n = 6) vs. Non-collaborators N-COLs (n = 14).

	Enjoyment				**Comfort Level**			
	COLs		**N-COLs**		**COLs**		**N-COLs**	
Ratings	T1	6	P1	5	T1	7	P1	6
	T2	6	P2	4	T2	5	P2	6
	T3	4	P3	n/a	T3	n/a	P3	5
	T4	6	P4	2	T4	6	P4	6
	J1	5	R1	2	J1	6	R1	7
	J3	6	R2	5	J3	6	R2	6
			R3	6			R3	4
			R4	5			R4	5
			C1	4			C1	4
			C2	1			C2	2
			C3	3			C3	3
			C4	2			C4	4
			J2	5			J2	5
			J4	5			J4	7
Average		**5.5**		**3.8**		**6.0**		**5.0**

COLs enjoyed the game more and felt more comfortable with their ScavHunt experience than N-COLs. Table 1 gives individual players' ratings and averages for the enjoyment and comfort level questions. In Table 1, an "n/a" indicates that a player chose not to answer a question. COLs had a positive level of enjoyment (average = 5.5 out of a possible 7), whereas N-COLs gave negative ratings for enjoyment (average = 3.8). On average, players gave positive ratings for comfort (average = 6.0 for COLs, average = 5.0 for N-COLs). C1, C2, C3, and C4 in *Condition 4, Collaboration Penalized*, gave the lowest ratings among all players regarding their in-game comfort level.

Table 2

Survey Results for Engagement Factors, Collaborators (COLs) vs. Non-collaborators (N-COLs)

		Engagement Factors					
		3a	**3b**	**3c**	**3d**	**3e**	**3f**
COLs (n = 6)	T1	2	6	6	6	7	3
	T2	5	4	5	7	6	7
	T3	3	2	7	7	4	6
	T4	4	4	6	6	6	3
	J1	5	2	6	7	6	6
	J3	7	2	6	7	5	5
	Average	**4.3**	**3.3**	**6.0**	**6.7**	**5.7**	**5.0**
N-COLs (n = 14)	P1	7	1	2	7	5	2
	P2	1	1	n/a	7	1	4
	P3	5	1	2	7	2	4
	P4	4	1	1	4	3	6
	R1	4	1	1	7	7	1
	R2	5	6	1	5	2	n/a
	R3	4	1	1	7	7	5
	R4	5	1	n/a	7	6	4
	C1	2	4	n/a	6	7	1
	C2	1	4	1	1	1	1
	C3	7	1	2	7	2	1
	C4	7	1	3	7	4	7
	J2	1	3	1	5	7	1
	J4	5	2	4	6	6	4
	Average	**4.1**	**2.0**	**1.7***	**5.9**	**4.3**	**3.2**

* The ratings of N-COLs on 3c-Interacting and collaborating with others were not meaningful as the players did not interact nor collaborate during the game. Thus, they were excluded from the results discussion.

When answering survey questions 3a-3f, COLs tended to give higher ratings than N-COLs. Table 2 shows that both COLs (average = 6.7) and N-COLs (average = 5.9) rated *3d-Solving the riddles* as the highest of six investigated engagement factors. COLs and N-COLs prioritized the other five engagement factors differently. The second highest rating factor for COLs was *Interacting and collaborating with others* (average = 6.0). The third highest for COLs, *3e-Hunting for clues* (average = 5.7), was the second highest for N-COLs (average = 4.3). Both COLs (average = 3.3) and N-COLs (average = 2.0) gave their lowest ratings to *3b-Customizing your avatar*.

Players were observed to be very focused on the game. It was noted that distracting objects such as clues to other riddles did not cause players to deviate from achieving their goals.

All players except C2, who showed signs of frustration early in the game, remained engaged until either time ran out or they had completed the game. J4, the only other player who showed signs of frustration, continued to play and remained engaged. There were five players observed to show signs of fatigue, P1 and P4 in *Condition 1, Control;* C1, C3, and C4 *in Condition 4, Collaboration Penalized*. Those five players remained engaged in the game despite their fatigue. None of the six COLs showed signs of frustration or fatigue.

None of the players in *Condition 3, Collaboration Mandatory* knew each other before the experiment, yet they spontaneously formed a team with self-defined roles. One player (T2) quickly became the de-facto leader. The COLs volunteered for tasks based on their abilities. Discourse among these four COLs was continuous and courteous, but concise and focused on riddle solving. The four COLs formed a body of collective knowledge. When they moved to a new riddle, they recalled and shared clues that they had seen earlier in the game. Sometimes these clues were very complicated. All four players were observed to enjoy their collaborative experience.

J1 and J3, the COLs in *Condition 5, Collaboration Rewarded* were workplace colleagues. Their collaboration started with J1 putting out a dedicated voice channel call to the other three players for COLs. The J1-J3 collaboration differed from that of the players in *Condition 3, Collaboration Mandatory* in that J1 and J3 had a peer to peer collaboration. Neither asked permission of the other; they shared leadership responsibilities. They took on roles according to their own capabilities. They were observed to enjoy their ScavHunt collaboration experience very much. During the interview, J2 reported that he did not collaborate because he liked to work at his own pace.

Implications for VA Tool Design

The study shed light on the nature and effects of collaboration in a riddle-solving video game. There were benefits to collaborative play over non-collaborative play in terms of user efficiency, effectiveness and satisfaction. COLs did better across all three dimensions than N-COLs. The higher average ratings for satisfaction and engagement by COLs may be due to the fact that digital natives tend to collaborate (Oblinger et al., 2005; Rainie, 2007). Our preliminary findings indicate a need to design VA tools to facilitate collaboration among digital natives. Below, we present strategies to facilitate digital native information analysts' collaborative experiences with VA tools by borrowing attributes from video games.

Roles, e.g., the player's *job* or *class,* constitute a major aspect of MMORPGs which directly affects player collaboration. Each role class has specific strengths and weaknesses which affect players' in-game abilities. For example, in a combat-based MMORPG, one class is suited for hand-to-hand combat but is weak in magic attacks, whereas another class is resistant to magic attacks but takes damage from hand-to-hand combat. These two classes can team to better protect each other from their individual weaknesses while combining their combat strengths. In ScavHunt, teams benefited from players taking on roles based on their individual strengths. VA tools that give analysts this ability will empower the analysts to leverage their own strengths to the benefit of a team's final analytical products. A VA tool that empowers analysts to volunteer for subtasks must first show those users the required roles so each can see where they can best contribute, i.e., where their strengths or skills best fit.

During collaboration in interactive serious games and MMORPGs, an essential aspect is communication, e.g., synchronous communication through chat or dedicated voice channels or asynchronous communication by leaving messages. Providing ready access to communication mechanisms in the VA tools will empower information analysts to easily, at any point in the analytical process, discuss joint work in the same way game players do.

In MMORPGs, COLs benefit from seeing each others' avatars and being aware of their activities. These abilities facilitate three aspects of collaboration: planning, designating responsibility, and achieving goals. Similarly, VA tools can facilitate collaboration among information analysts by giving them an awareness of each others' activities, e.g. by identifying which analysts are working on the same or related problem or an aspect of that problem.

In many MMORPGs, players store objects for future use. Players also give and receive objects. An example is a player acquiring an object which is not presently useful, but has been recognized as having potential for future use for that player or another player. The player then stores the object until it is useful, or until the player chooses to share the object with another player. In ScavHunt, players were not allowed to take notes. Once they left the auditorium, they had to remember the riddle. (They did have a paper with the riddle number on it, but not the content of the riddle). If they happened upon a clue for a riddle other than the one they were currently solving, they had no way to record that clue's content or location. Players had to memorize both clues and riddles. This gave us the opportunity to observe if players employed any strategies to address this difficulty. Collaborating players were observed discussing memorized clues found while solving other riddles. They made this part of their team strategy. Survey respondents expressed a desire to copy and save clues for future reference. The need to remember the clues constituted a cognitive burden. VA tools have the responsibility of relieving information analysts of such cognitive burdens whenever possible. In much the same way that players in MMORPGs store and share objects, VA tools need to empower information analysts to gather and store data for future use and for sharing with COLs. Typically, VA tools help analysts develop analytical products, but they do not typically help them pass these products from one analyst to another. Such functionality will facilitate collaboration.

Future Work

An emerging literature on the science of gaming (e.g., Zyda, 2005, 2007) is beginning to identify research directions, but little work has yet been done on setting formal usability engineering directions for studying players' interactions with each other during game play in a virtual world. It is our belief that methods and metrics for measuring player collaboration in a virtual world should be an integral part of the science of gaming. Therefore, our future work will address this need, starting with developing more sensitive methods and metrics for measuring players' efficiency, effectiveness and satisfaction as they experience collaboration in virtual worlds while gaming. This will serve our ultimate goal of applying what we learn about players' interaction with each other to the design of VA tools for young information analysts. We will start by applying metrics we have already developed for measuring collaboration in VA tools to collaboration in video games (O'Connell & Choong, 2008). We recognize the need for a longitudinal study that will generate data for statistical analysis. Our future studies will also collect a wider range of data types. To date, most gaming research has focused on survey, observation and anecdotal data (Ducheneaut, Yee, Nickell, & Moore, 2006). We plan to use logging data, voice recordings, screen captures and video captures to document users' experience collaborating in a virtual world. To better understand all the contexts of collaboration in MMORPGs and serious games, we need to investigate both collaborative and non-collaborative interaction among people playing video games in general. Such a study can open windows into other areas of collaboration that need to be addressed. Some interactions may not be viewed as collaboration, but may indirectly benefit collaboration or other aspects of information analysts' experience with VA tools. We expect that not all the aspects of collaboration in video games are applicable to collaboration using VA tools. Starting broadly will help us focus our research on identifying those areas that will yield the highest benefits to design of VA tools, e.g., does collaboration cause coordination overhead that diminishes benefits for the group? Or, conversely, does collaboration result in economies of learning or effort?

We recognize that to broaden our scope, our future work must add more experimental conditions. We plan to add more dimensions to the user experience to further investigate the human factors that pertain to collaboration during game play. For example, because skills and responsibilities associated with roles are fundamentally important to interaction in MMORPGs, we envision a study on VA tools involving assigning specific jobs or skills to analysts based on their real world skill sets and knowledge domains. We will apply the role-playing attribute of MMORPGs to a VA tool and study the effects on collaboration. One possibility is to compare effects over two conditions. One condition will provide visual indicators of information analysts' roles to mimic the condition in an MMORPG where players know each other's roles. The other will not identify roles.

We plan to expand our investigation of the function of rewards and their impact. We would also like to better understand the motivational factors behind the choice to collaborate or not. In the social domain, we would like to investigate the effects of peer pressure, the presence of other players and a player's sense of one's own presence. We need to investigate what aspect(s) of collaboration yield higher satisfaction and engagement. In addition, our early investigation has led us to realize that there is a fertile linguistic area to study, discourse during collaboration.

In this short-term study, time allotted for designing ScavHunt and implementing modifications to OLIVE was limited. Thus, ScavHunt had technical limitations that impacted the study's scope. Communication among players in the conditions where collaboration was optional could only be initiated through the use of in-game avatar gestures, signaling each other to join the same voice channel. This required first getting the other player's attention. There was no way to know that one avatar was signaling to another unless the player had the other avatar in view. It was necessary that the two players be aware of each other and each other's location in the virtual world prior to initiating communication. We observed that players who did not initiate communication and collaboration in the beginning of the game did not do so later when players were working on different riddles, seeking clues in different parts of the virtual world or already engaged in collaboration. We see a need for a more comprehensive communication mechanism to empower players to more easily locate other players, as well as choose collaborators based on their progress in the game. To investigate replicating the capabilities of state-of-the art VA tools, we need a list of active players; notifications of which riddle a player is currently working on; speaker identification; a list of conversation participants; and related features. We recognize that the lack of written chat, a primary means of readily available communication in MMORPGs impacted players' interactions with the game and with each other.

Conclusions

Digital natives who become information analysts will bring to their workplaces collaboration skills honed by collaborating in virtual worlds while playing video games. An investigation of collaboration during a game that borrowed elements from MMORPGs and serious games disclosed that there were benefits to collaborative play over non-collaborative play. We have looked at collaborative game play from a usability engineering perspective, following usability engineering methods to investigate the impact of collaboration on players' experiences while solving riddles in a virtual world.

Based on our understanding of information analysts and their tasks, we have seen that there are opportunities to borrow from MMORPGs and serious games when designing VA tools to leverage the collaboration skills of digital native information analysts. We have demonstrated some of these opportunities and translated them into design recommendations for VA tools.

This was a preliminary study. We have identified directions for future research. Our research to date has drawn from fields in addition to human factors and usability. We look forward to learning from the contributions of our colleagues in the many fields that will converge in the emerging science of gaming in virtual worlds. We believe that further multidisciplinary research into video games will uncover more opportunities for VA tools to borrow video game attributes to the benefit of digital native information analysts.

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