STAGES - System for a Tangible Animated Game: Embodied Storytelling

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ABSTRACT

We present a system, named STAGES, which is built on principles of embodied cognition and interaction for the communication of historical information. We motivate each aspect of our design with the need for engaged interaction, spatial and temporal situatedness, and social interaction. Our design model is based on extensions of the hyper-narrative with the concept of the 'happening' that occurs in place and is presented in the form of a dramatic scene. We further enhance the concept by situating the user in the context of place by use of a tangible tracked game board. We discuss the implementation of the system, highlighting how each system component is realized in hardware and software. As a first step to determining how well such a system might provide embodied access to historical information, we performed an evaluation of the system to determine how well users can engage with the system. Our pilot study shows the promise of our approach, while highlighting elements of our system that need improvement.

Keywords: Context, Embodiment, Tangible Interaction, Game, History, Insight formation, Hyper-narrative

INTRODUCTION

Docudramas, textbooks, museums, and historical narrative serve the common purpose of conveying historical information. The differences lie along several dimensions depending on medium. In this paper, we present a system, named STAGES, for the communication of historical information in a novel combination of the hyper-narrative, the animated drama or play, and tangible game-pieces on a horizontal display as a game-board. The purpose of our system is to explore a new means of engaging the recipient of the historical information in an interactive way by placing her in the context of the history. In this work, we engage subjects with historical information relating to the Underground Railroad [22] in Virginia by which slaves fled north from the Tidewater region of southeast Virginia.

Our approach is motivated by the premise that humans are 'embodied cognizers'. By embodied, we mean that the human mind is inseparably associated to our physical being, social context, and our situation in place and time [1-3]. It involves the combination of physical action, social action, and the setting in which these actions take place [4, 5]. In '*The Tacit Dimension*', where he explores the substance of human knowledge, Polanyi's asserts that knowledge is 'in the body' [6]. Polanyi begins with the axiom: "*we can know more than we can tell*" [6] and proceeds to argue that human knowledge is ultimately contained in the unutterable vaults of our embodied experience. He contends that "we are *relying* on our awareness of contacts of our body with things outside for *attending* to these things. Our own body is the only thing in the world which we normally never experience as an object, but experience always in terms of the world to which we are attending from our body." [6]

The presentation of historical information in a non-linear fashion as to facilitate better comprehension of key elements of the history presents the designer with significant challenges. These elements include the facts that events have causes and consequences, and that people's reactions to events and their consequences are often causes of subsequent events. One key to understanding the context of historical information is to know how these elements are related (e.g. why one action/event caused another). Our system presents information in such a way that connects a cause to an event and an event to a consequence [7]. Our approach is to use embodiment concepts to create an interactive hyper-narrative game that portrays the circumstances surrounding particular situations. Our work in presenting the history of the Underground Railroad in Virginia serves as a case study for the approach presented here.

In this paper, we overview our approach for embodied communication of historical information and our extensions to the hyper-narrative to enhance embodiment, present our system implementation, discuss our user study with the system, and conclude with a discussion of future work.

AN EMBODIED APPROACH

In accordance with our discussion on embodiment, we surmise that a vivid presentation of historical information to the degree that the communicator engages the communicant in understanding of the social context, immediacy of the events, the consequences of choices, and the situatedness of historical actors in place and event.

The Hyper-Narrative

To achieve this goal, we chose to implement the hyper-narrative. The hyper-narrative is the natural extension of hypertext and media to narrative [8, 9].

Traditionally, historical information is presented linearly in text based media, such as books or in video, such as the docudrama. The concern is that a component of understanding history is the ability to establish relationships between discrete historical information. Because such media are conceived linearly, people tend to consume them in the order that the author presents the information, limiting the recipient's ability to reference information across domains, and obscuring connections between discrete historical information.

As a departure from the age-old linear storyline, hyper-narratives entertain multiple threaded stories in which the 'reader' participates in the 'storyline' selection. This enables information to be presented non-linearly, and gives the user control of the information they see and the order in which they see it. Hence, hyper-narratives permit the author to create virtual worlds full of characters, places, and events that interact in time and space as they would in the real world. This allows the reader to explore this world, choosing their own paths to create their own personal experiences [10]. Hyper-narratives also provide implicit structure because it flows in a logical order. Hence, they are able to communicate cause and effect by enabling the reader to make decisions that affect the outcome of the story.

Employing the hyper-narrative provides the embodiment dimension of participation with the environment [5].

Embodiment Extension 1: Animated Happenings

Our first extension to the hyper-narrative model to enhance the embodied experience is to embed an animated drama into each node of the story grid. We call the content of each node a 'happening'. Each happening is presented as a simple 'drama scene' involving a place (represented by a backdrop as stage plays are), animated graphical actors that move on the 'stage' and speak to each other and the communicant to make her privy to the events that take place in the happening. Hence, the 'telling of a story' involves the development of the threaded hyper-storyline and the happenings in each hyper-linked story node that take the form of digital animations of characters, place, and scenery. The happenings are presented as an animated simulation to the communicant on a handheld tablet PC.

In the current version of our system presented here, each happening involves a single character that speaks to the communicant.

Embodiment Extension 2: Tangible Game board

A significant weakness of hypertext systems is the lack of readily perceptible structure. Without the aid of perceived structure, readers who are unfamiliar with the concepts of the text may become overwhelmed and find it difficult to maneuver through the links. This brings forth confusion about where they are in the network [11].

The concomitant concern with hyper-narratives is that they tend to result in disembodied presentation with respect to place because context is easily lost. Hyper-narratives lack the relationship between the environment and the physical and social interactions that take place within it. Until this relationship is made, the reader cannot completely understand the context of the information. One may think of this as the loss of situatedness in place and a lack of contextualization.

To remedy this, we introduce our second enhancement to the hyper-narrative. To help the 'reader' to be situated within the story grid, our model employs a game-board that represents the context of the story. The player/reader navigates through this game-board by moving a 'game piece' through the board (e.g. the board may depict the map of a town through which the player moves). The story nodes are associated both with the location of the game piece and the state of the story line (more than one hyper-narrative node may be associated with a contextual location depending on the preceding story path). The player/reader may navigate the hyper-narrative by making logical choices/decisions within a happening (e.g. by multiple choice) or by moving her game piece to a legal position (e.g. within a distance or pathway) on the story grid. Since the game piece is tracked in our system, the system can interpret this as a user 'choice' of destination.

The tangibility interaction represented by the game board and game piece extends our theme of embodiment. Tangible interaction can be viewed as the physical representation and manipulation of digital data, bodily interaction with objects resulting in the formation of meaning, and the coupling of physical space and objects with virtual displays [12]. The combination of these views forms a framework that includes tangible manipulation, spatial interaction, embodied facilitation, and expressive representation. Tangible manipulation is when the body interacts with physical objects. Spatial interaction is interaction that occurs in the physical space, enhancing spatial cognition. Tangible interaction systems provide the embodied facilitation by providing the procedural, physical, and spatial structure in which people act. Expressive representation is the physical representation of virtual data that communicates meaning [13].

Our game based approach becomes embodied by having people participate in contextualized situations. Games make use of physical objects, our sense of space, and spatial relations [14]. When playing games, participants physically interact with playing pieces and socially interact with each other in relation to a shared space. According to

Klabbers, "… games help in understanding the relationships between content, process and context of a subject matter. Emphasis is on handling concepts, relations, and sharing of explicit and tacit knowledge." [15]. People tend to engage in games as they do in the world.

Our application of a physical game board with game pieces to contextualize the information displayed in the handheld tablet PCs can be though of as an Augmented Reality (AR) presentation of history similar to Kretschmer et al [16]. The difference is that Kretschmer employ AR to contextualize history with a physical tour, while our game board and hyper-narrative form the context out of which the happenings occur.

SYSTEM DESCRIPTION

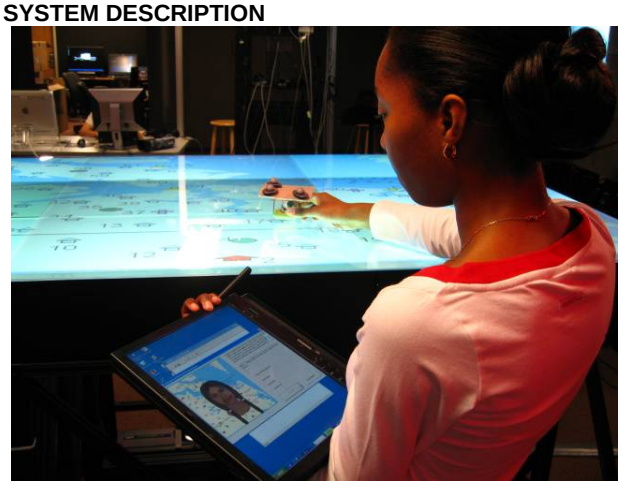

Figure 1: STAGES in operation

Figure 1 shows our embodied hyper-narrative system in operation. The player holds a tracked game piece on the game board presented on the horizontal display. She holds a tablet PC presenting the happening in the form of the animated drama-scene.

Hyper-Narrative Structure

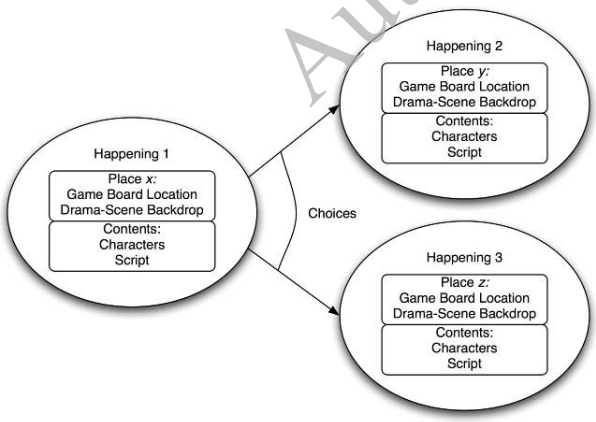

Figure 2: The hyper-narrative schema.

The roles of historians are to populate the system and create a hyper-narrative game. To construct a game, the hyper-narrative structure, the contents of each 'happening', and game board are created to convey historical information. The diagram of the hyper-narrative schema is shown in Figure 2. Each node of the hyper-narrative, a 'happening', contains the elements of a place, people, and events. Events occur when people interact with each other in a place. This is described in the happening script. Historical people can communicate with participants through talking (represented in 'talk turns' in the script). Historians can also populate the system by providing the background information associated with each happening (e.g. by describing this in the speech of an animated 'narrator' character, or more skillfully through the dialog of the animated actors). The game enables the creation of these historical figures, places, and events in their context.

Hardware

Horizontal Display

Figure 3: Visblock Horizontal Display

In our current implementation, the game board is displayed on a large horizontal display. This display is made up of 9 Visblock rear-projection monitors from Visbox Inc. [17]. Each block presents a WXGA (1280 × 720) display on a 24" × 13.5" surface. These Visblocks are placed on their ends (see figure 3) in a 3 × 3 grid to yield an approximately 6 feet, 3840 pixel × 2160 pixel horizontal display surface. Since these displays are rear-projected they require some stand-off between the projector and the display surface. The devices we use are 3' 10" deep, giving us a table whose display surface is 3' 10" off the ground. The Vizblocks are driven by a grid of computers running under the Fedora Core 5 version of Linux.

An advantage to using Visblocks is that there are no borders between the blocks, creating a seamless display. We placed a sheet of plexiglass over the 9 Visblocks display to produce a rather robust table that supports use as a regular table (e.g. users can lean over it, put objects on the surface, and even place beverage cups on it). As we will discuss in our user study results, the height of our table, standing 3' 10", posed a problem for some users.

The high resolution supported by our horizontal display allows the game board to include detailed map information such as geographical coordinates, terrain elevation, and other details right on the game board. The expanse of the table also allows the presentation of a playing surface that is well suited to supporting the development of a sense of spatial situatedness by game players.

Vicon Tracking System

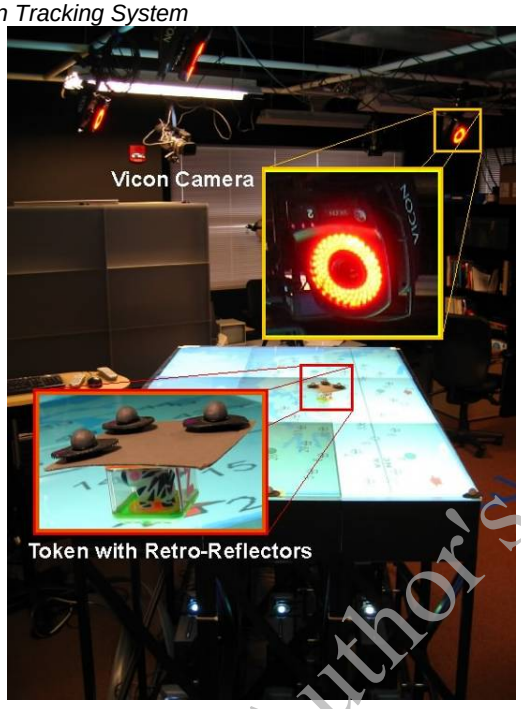

Figure 4: The hyper-narrative schema.

Figure 4 shows our tracking system for the game piece that sits on our horizontal game board. We use a Vicon motion-capture system [18] to track the actions of the players. The system tracks infrared retro-reflective markers using near-infrared cameras. We employ a system with 8 high resolution cameras that is able to determine the location of markers within a millimeter's accuracy. While we do not expect a practical system to be deployed using such an expensive tracking system, the Vicon system allows us to prototype tracked systems rapidly for experimentation. A myriad of lower cost technologies (e.g. tracking motes [19], or ultrasonic devices) may be employed.

As shown in Figure 4 (inset), we attach retro-reflective markers on our game piece to track its' position as a user moves it across the horizontal display. During game development, the specific locations of the game piece on the display are logged to represent discrete places on the game board of significance to the hyper-narrative.

Tablet PC

The Tablet PC is used as a tangible piece for each user to communicate the historical information. A user can hold it or put it on the table. It is also used to display the events that occur within places. We here refer to it interchangeably as the client.

In Figure 1, the game player is holding a tablet PC on which the 'happenings' are presented. The portability and hand-held nature of the tablet PC's enhances the perception that the player is intimately involved with the goings on in the happening, and that the historical characters are interacting with them individually. It also permits the player to move around the game board and view it without disengaging with the temporal events presented in the happenings.

Game Server System

The game server implements the game rules and controls the entire process of the game. It maintains the game database and keeps the state of player in the hyper-narrative. It is the 'nerve center' of the system, maintaining communication with the Vicon motion tracking server, the client tablet, and the game table. For example, it sends the appropriate operation to the client tablet to load the correct scripts from the database for the happenings.

Software

People Putty

The happenings presented in the tablet PCs take the form of animated dramatic scenes (somewhat like a series of one-act plays). In our prototype, we employ People Putty, software developed by Haptek, to model and render realistic animated virtual humans as the characters in our hyper-narrative [20]. We take the 'stage play' model where the 'acting' is largely presented in dialogs among the characters of the play – and the player/audience is brought into the story by interacting with the play. An example of the virtual human on the tablet PC is shown in Figure 1. Haptek's lip-synching capability technology enables the avatar's lips to sync with sound, recorded speech, or textual input. Our prototype stores character dialogs in text in the script database, and the speech is rendered using Microsoft's TTS (text-to-speech). The avatars also gesture as they speak. These virtual humans are used to represent various people in history and interact with the players.

Database

The schema of the STAGES database is based on the conceptual model of historians. It stores people, places, events, and background information which are characteristics of any piece of history. These are organized in terms of the elements of our hyper-narrative and the script content of each happening.

Hardware and Software Interaction

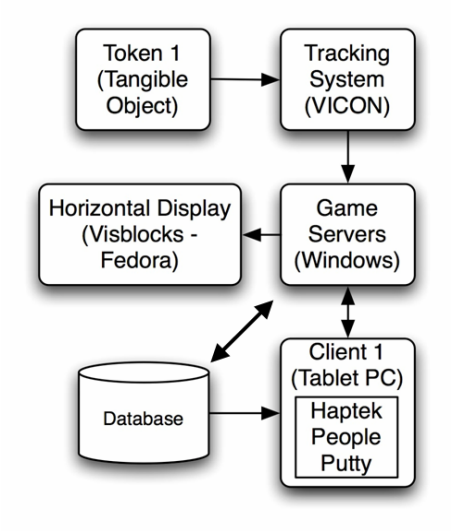

Figure 5: The system overview.

Our overall block diagram of our system is shown in figure 5. The system consists of mainly five subsystems, which are 1) client, 2) game server, 3) Vicon tracking system, 4) display, and 5) database. The client subsystem takes an interactive role between a player and People Putty, who provides the historical information to the player. The server's main role is to make the game proceed by checking the location of a token placed on a horizontal display and communicating with a player based on their chosen path. The tracking subsystem sends to the server the position data on the display in real-time. The display subsystem will consist of two displays, the horizontal display for the player and the vertical one for audience. However, in our first version, we just use the horizontal display due to time constraint. As of now, our horizontal display shows the map with places where all historical events happened. The database subsystem stores all text information, such as the narration for the human avatar, historical background, place information, etc. based on the game scenario.

EVALUATION AND DISCUSSION

Game scenario

The horizontal display shows a map of Hampton Roads[1] along with icons that represent various places. The user will move tokens to different locations on the map. Each user takes the role of a runaway slave traveling through the Underground Railroad. As the user travels from node to node, she views each happening as an animated dramatic scene displayed on her tablet PC that acts as a window to her personal experiences. Historical figures take the form of People Putty animated characters and are able to interact with the subject. The scenes in the tablet PC provide information to the user such as her current location and give the user the options of the paths that she can take. People Putty characters acts as narrators, fellow runaway slaves, agents, station masters, stockholders, abolitionists, conductors, slavery supporters, etc.

The game starts with an introduction of the scenario given by the narrator. The user departs from a slave house in the area and moves to a safe place or an unsafe place. If the user moves to a safe place, she will meet up with its inhabitant (agent, fellow slave, stockholder, etc). The inhabitants will give the user a description of who they are and a piece of information that could lead the user one step closer to freedom. Then the user will be able to choose where she wants to go next. If the user enters an unsafe place, she will be caught and will have to return to a slave house and start over[2]. The game is completed once the user reaches a ship[3].

For example:

> Stockholder (character): *Hello, you are about one mile away from the ship. Here are some clothes to help you disguise yourself. I hear that traveling the road is dangerous but it will get you to the ship faster. Do you want to take the road or the woods to the ship?*
>
> Player (slave): *I am going to travel through the woods.* [dialog segment selected by multiple choice]
>
> Stockholder character: *It is nice to meet you and I wish you luck. Move to the tree.*
>
> <Player moves game piece to the tree on the game board>
>
> Fellow slave (co-traveler): *Hello, I have been on the run for one month. I am currently waiting for my wife to arrive so we can get on the ship together. I see lights in the distance. Do you want to stay in hiding with me or make your way quietly to the ship?*
>
> Player (slave): *I am going to make my way quietly to the ship.*
>
> Fellow slave: *Proceed to the nearest ship and I will see you up North.*
>
> <Player moves token to the ship>
>
> Narrator: *Congratulations, you have made it safely to the ship and are on the way to freedom.*

Pilot Study

A formal pilot study has been conducted to evaluate the system. The main goal was to observe how much users (i.e. non-historians) can be engaged in such an embodied

[1] Hampton Roads in the Tidewater region of Virginia is the starting point of many runaway slaves on their journeys on the Underground Railroad.

[2] Historically captured slaves were beaten, and put on auction or returned to their original owners. They were seldom killed because they were viewed as valuable property. If sold, they continue life in another slave house.

[3] The Underground Railroad through the Tidewater region often involved a trip up north on ships departing from Hampton Roads.

interface that provides contextual historical information. We designed a historical game scenario (with the aid of historians from Norfolk State University) like the one described in the previous section. The game begins with a happening in which a narrator character gives the subject some background information about the Underground Railroad, and initializes the participant at some slave house. For the pilot study, we provided pre- and post-questionnaires. Since this study is conducted as a pilot to see how users use our interface system, it does not include objective measurements.

Procedure

We recruited a total of 10 students (both graduate and undergraduate) from various backgrounds. The participants signed an informed consent form and filled out a pre-questionnaire, providing their background information. Each participant played the game individually. The total time to complete the game varied from 15 min to 30 min, depending on what path the participant chose. After completing the game, the participants filled out a post-questionnaire designed for subjective measurements. The investigators asked the participants follow-up questions based on their answers.

User Feedback

Our goal for this pilot study was to test for user engagement with the system. Since 'engagement' has many factors that contribute to it, we tested for engagement based on satisfaction. In this section, we give the quantitative results of the questionnaire as well as the participants' comments about the system.

According to the pre-questionnaire, forty percent of the participants had no prior knowledge of the Underground Railroad[4]. Although over half of the participants knew something about the Underground Railroad, all of the participants learned something new as a result of playing the game. One participant said that they got some knowledge from the questions but had no idea about the real historical information. This reflects that fact that most of the participants were international students. The participant also suggested that the game should have different levels of difficulty and more paths to choose so that they could learn more history.

The post-questionnaire, with a total of 13 items, is divided into three sections, "Satisfaction with Interface", "Satisfaction with Game Context", and "Tiredness". Items are scored on a seven point Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). As previously mentioned, we used "Satisfaction with Interface" and "Satisfaction with Game Context" to measure engagement. We also measured "Tiredness" because it could affect the user's engagement/satisfaction with the system. The tiredness measure is also important because we want people be able to use the system over an extended period of time. The graphs below show the average score for each item.

Figure 6 shows how satisfied users were with various components of the system's interface. It is divided into four categories that we believe contribute the users' satisfaction with the interface: Token, Horizontal Display, Voice Synthesizer, and Graphical User Interface. The data shows that most of the participants had trouble recognizing the TTS-generated synthetic voice. Some participants complained that the horizontal display was too bright and too high to look at the map as shown in Figure 7. This is because the depth of our Visblock rear projection system placed the tabletop at nearly 4 feet. For a 5-foot tall person, for example, this will place her eyes less than a foot from the display surface. A participant also mentioned that the token was too big to grab in their hand and sometimes, it covered a place icon on the map.

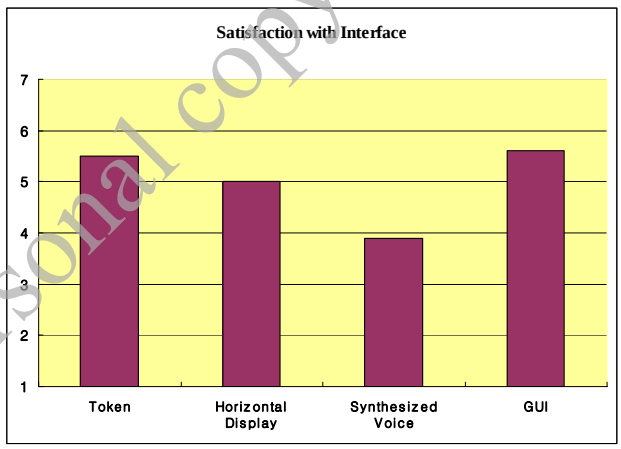

Figure 6: Satisfaction with Interface

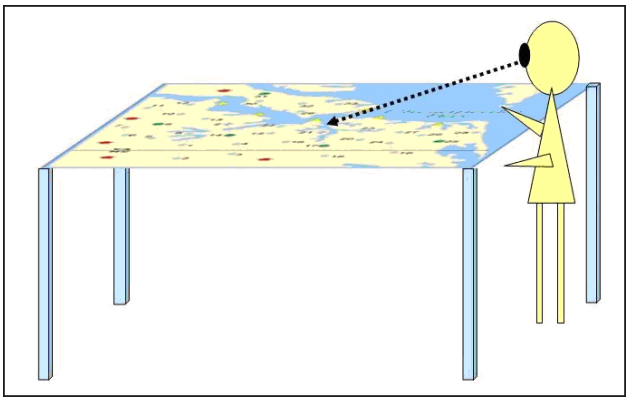

Figure 7: A snap from the user feedback: The horizontal display is too high to look at the map for a certain user

[4] A good number of our subjects are foreign students to the United States, with very little of the cultural and American history instruction typically received in American schools.

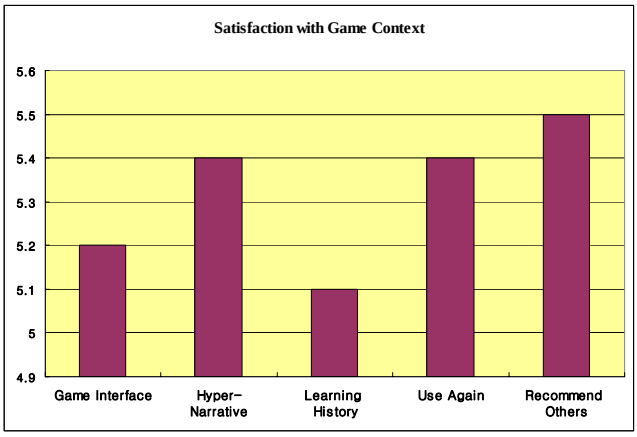

Figure 8: Satisfaction with Game Context

The game context ratings are shown in Figure 8. The game context consists of the following: Game Interface, Hyper-narrative concept, ability to learn history using the game, probability of using system again, and probability of recommending the system to others. As Figure 8 shows, the game interface, which is the combination of the look of token, the tablet PC, and the horizontal display background image, was not highly rated. One participant suggested that the game should be more interesting, so that users can be engaged in the game. They also said that the map is too simple to gain historical knowledge about the geographical location of historical places. Nevertheless, the hyper-narrative game approach may be quite effective because most of users said that they would like to use it again and recommend it to others for learning other history.

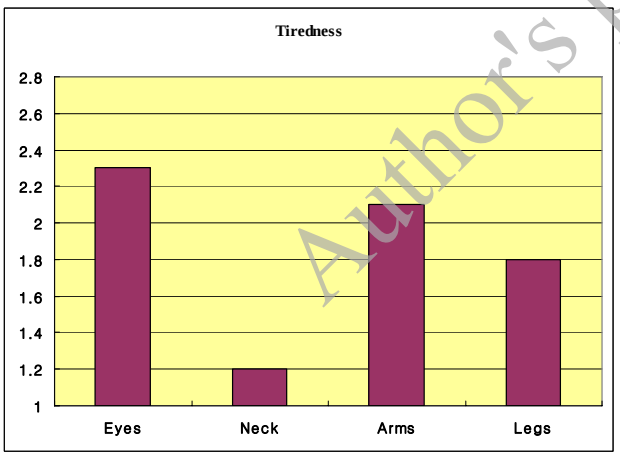

Figure 9: Tiredness

Figure 9 shows how tired the participants felt while playing the game. Tiredness was divided into sore eyes, neck, arms, and legs. Thirty percent of the participants agreed that looking at the horizontal display made their eyes sore. Holding the tablet PC hurt some participants' arms to the point that they had to put it down. Most of the complaints about hurt legs came from participant who had to play the game longer due to choosing wrong paths. We did not receive any specific feedback regarding neck strain. The results of the "Tiredness" ratings show that we should redesign some physical properties of interface.

Discussion

The results of the pilot study give us some direction for future work, and what aspects of our interface tools and game context we need to refine for users to better engage in the history that the game is presenting.

Based on user feedback, we realize that prior knowledge of the subjects needs to be taken into consideration. Future implementations should embed more background information in the form of narration or through the communication of the actors. An advantage to using a hyper-narrative approach is that some nodes can provide more background information than others. Therefore, students with prior knowledge can skip over unnecessary nodes or go to other nodes so that the game can be more challenging.

Several components of the system's hardware can be altered to improve the user experience. For example, the size of the token should be big enough, so that several reflective markers can be attached to the token and the Vicon system can correctly recognize it. The size of the token could be reduced if we use different tracking systems, such as ultrasonic devices and sensed objects, so that several markers need not to be attached to the token. Since we used a projection-based display as a horizontal display, the table's height depends on the distance between a projector and a screen block. A platform could be built around horizontal display in the future such that the table top will be closer to the height of a typical desk with respect to the user. The synthesized machine voice can be improved by using better hardware (the speakers on the tablet PCs were a little weak), using earphones, or by changing the settings of the voice by modifying the settings with Haptek's People Putty software. The discomfort of holding the tablet PC can be reduced by using a smaller tablet or by using a handheld device such as a Pocket PC. These changes can decrease the "tiredness" the participants may feel while interacting with the embodied system.

In our next user study, we will test to see if the game enables the participant to understand relationships between people, places, and events. Since very little research has been done concerning evaluation criterion for insight formation, we have to research ethnomethodology in order to develop our own evaluation criterion.

CONCLUSION AND FUTURE WORK

We have presented a system that is founded on principles of embodied cognition and interaction. We motivated each aspect of our design with the need for engaged interaction, spatial and temporal situatedness, and social interaction. Our model is based on extensions of the hyper-narrative with the concept of the 'happening' that occurs in place and is presented in the form of a dramatic scene. We further enhanced the concept by situating the user in the context of place by use of a tangible tracked game board.

We discussed our implementation of the system, highlighting how each system component is realized in hardware and software. As a first step to determining how well such a system might provide embodied access to historical information, we performed an evaluation of the system to determine how well users can engage with the system. Our pilot study shows the promise of our approach, while highlighting elements of our system that need improvement.

Apart from the improvements mentioned in our discussion of our user tests, there are several fundamental research directions that this work suggests. We divide these future directions under four separate headings.

First, the authoring of the STAGES hyper-narratives requires significant research. Such authoring includes the creation and management of hyper-storylines, content creation for the happenings (to include definition of place, people, and event scripts), end-user graphical editing (e.g. for character creation by historians and other non-graphic designers), end-user specification of animations (to present character actions in the dramatic scenes), and implementation alternatives for the tracked game board.

Second, our interaction with history instructors in the course of this research has made us aware of the need of new pedagogy for the training of historians. History is not just a collection of facts. The historian needs to engage factually guided imagination. A system like STAGES can be used in instruction where history students construct plausible hyper-narrative scenarios that depict their understanding of the people, places, and events that constitute the history. Such research will open the doors to better understanding of pedagogy for the development of future generations of historians and the use of new media for the communication of historical imagination.

Third, much research is needed to understand how a system like STAGES can engage the broader cognitive and perceptual resources associated with the 'embodied mind'. The engagement of these resources may result in better understanding of, and insight to the subject matter presented. The evaluation of such understanding and insight formation requires that new methodologies such as the application of ethnomethodology (not for design but for understanding changes in information uptake) to be developed.

Fourth, our current STAGES implementation engages a single player in the exploration of historical information. We would like the system to enable collaboration between players in the sense that the actions of one player can affect that of the others. An example of this in relation to the Underground Railroad is that the action of one player can cause everyone in a station to get caught and sent back to slavery. Another example is that slaves could meet up at a particular location and consult with each to gain broader insight to the historical environment, increasing their chances of success and moving the next safe station. Players may have competing goals where some players may even play the role of slave holders to gain better understanding of the historical context. Such collaborative game playing requires that the system be able to handle many 'clients' and to be able to resolve more complex decision configurations. It also requires that the system be able to maintain and enforce game rules involving multiple players.

In addition to these major themes, several minor research directions relating to design improvements in STAGES may be engaged. For example, we could investigate the incorporation large vertical displays in our system to show dynamic public information (analogous to having a 'blackboard' display of contextual information). This may show where the game narrator will appear to inform the players the global historical context. The vertical display may also show the player's progression along the game. Such displays may also permit 'onlookers' and 'side participants' to share create and maintain common ground with the primary players [21].

ACKNOWLEDGEMENTS

This research has been supported by NSF grants #0551610 "Interacting with the Embodied Mind" and #0624701 "Embodied Communication: Vivid Interaction with History and Literature"

We also acknowledge our collaborator, Cassandra Newby-Alexander, Professor of History, Norfolk State University for providing guidance and materials for concerning the history of the Underground Railroad, and Crandall Shifflett, Professor of History, Virginia Tech with whom we interacted concerning History instruction.

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