WePaint: A Cooperative Painting Game

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Abstract
In this paper we describe our design and prototype of a full-body, collocated, cooperative digital painting game for two players we call "WePaint". Our goal for the WePaint system is to offer an engaging, low-pressure environment in which children with developmental disorders, such as those on the autism spectrum, can reinforce the social skill of cooperation. We describe an observational study that informed the design of WePaint, and discuss how we employed two game mechanisms (resource limitation and requirement for concurrent action) to encourage cooperation in WePaint.

Keywords
Ubiquitous computing, computer games, autism spectrum disorders, social skills development

ACM Classification Keywords
H5.3. Information interfaces and presentation (e.g., HCI): Group and Organization Interfaces – *computer supported cooperative work*

General Terms
Design, Human Factors, Prototyping

Introduction
The developmental disorders that comprise the autism spectrum disorders (ASD) are marked by impairments

in social interaction and communication, and by restrictions in an individual's range of activities and interests. Of particular interest to our work is the delay in social skills acquisition observed in many children with an ASD (e.g. difficulties in imitating other children). This delay can have a negative impact on the later development of higher-level social and communicative behaviors [5].

The goal of social skills therapies for individuals with an ASD is to teach a baseline of social knowledge that enables the individual to better handle daily social interactions. Within the autism community there is a desire for software and technology that can aid in the learning and practicing of critical social skills [4]. WePaint is a digital painting game that is designed to reinforce the high-level social skill of cooperation, which we define as working with others toward the completion of some task. It encourages cooperation through a number of computer-enforced rules, such that failure to cooperate leads to failure in the game. WePaint can complement existing therapies by allowing users to practice this skill in a low-pressure environment. In this paper, we describe an observational study that informed the current design of WePaint and discuss how we employ certain game mechanisms to encourage cooperation.

Previous work

A number of studies have demonstrated the benefits of using games to augment social skills therapies. One such game was developed after it was observed that a number of clients at the author's clinic shared a common interest in LEGO [2]. In this study, play consisted of two or more children working together in order to build a structure out of LEGO pieces. Each player was assigned a role: one as a director and the remaining as builders. Only the director knew the structure's target shape, and would need to communicate this to the builders. Such play, in conjunction with one-on-one therapy, was found to increase *social competence*: (1) the motivation to initiate social contact with peers, (2) the ability to sustain interaction with peers for a period of time, and (3) the overcoming of the symptoms of aloofness and rigidity.

Computer games have also been used to augment social skills therapy. The SIDES system was designed to encourage collaboration between adolescents diagnosed with Asperger's syndrome by having them construct a path in order to help a virtual frog cross a pond [3]. The game was designed for the MERL DiamondTouch table, a multi-touch system that can distinguish between users. Players could build the path so that the frog would collect flies, adding points to the final score. This game included two important mechanisms for encouraging cooperation. The first was that of *resource limitation*: players were given only a limited set of tiles for constructing the path. Since no player would be given enough tiles to individually construct the path, she would be required to collaborate with other players to do so. The second game mechanism encouraged *consensus building*: all players would vote on whether or not to use the final constructed path.

The "StoryTable" project was another system implemented on the MERL DiamondTouch. It was designed to encourage cooperation between children with high-functioning autism in the creation of a narrative [1]. The game used the DiamondTouch's

capabilities to distinguish between players to require that certain game actions be done concurrently. For example, specifying the setting of the narrative required both players to touch and drag a scene to the main work area. This requirement for concurrent game actions had a positive impact on players, with subjects demonstrating: (1) an increase in the initiation of positive social interaction, (2) an increase in the level of shared play, (3) an increase in the level of collaboration and (4) a decrease in the frequency of autistic behaviors during use.

Observational study

Although painting is generally considered a solitary activity, it is often used in primary schools as a medium for collaboration. To understand how cooperation plays out in collaborative painting, we designed an observational study to explore several questions: first, we were interested in how individuals paint; second, what is their subjective experience of painting, and finally, how does cooperating with others impact this experience.

The study is open in structure: study participants are given the opportunity to paint whatever subject matter they desire using a canvas, a variety of brushes, and acrylic paint. We asked participants to paint at least two pictures, as we noted significant improvements between the first and second paintings. During this time, we collected field notes of their actions, and their interactions with one another. Finally, we prompted them with questions in order to understand their painting experience and to understand their thought process as they paint.

To this point, we have recruited six adult participants (five females, one male): two as individual painters, and the remaining four participants as pairs painting collaboratively.

We made two important discoveries that have informed the design of WePaint. First, most participants emphasized the role of *multiple modes of feedback* in creating an enjoyable painting experience. Tactile feedback was mentioned the most, with one participant stating that their favorite paint color was purple due to its "viscosity". Similarly, the participants discussed the importance of the resistance between the brush and canvas. A second form of feedback mentioned was *audio*: one study participant noting in particular the sound the brush makes during a brush stroke.

Figure 1. Study participants playing a painting game where one participant creates paint drips and the other attempts to stop them.

A second discovery came during one of the group sessions. Here the participants *spontaneously and*

independently created a painting game centered on halting the progress of dripping paint: one participant would create drips of green paint at the top of the canvas and the other would attempt to stop them by placing a glob of purple paint in its path, as seen in Figure 1. This form of play proved engaging, lasting over ten minutes. Participants also personified the drips, stating they were "invading" and that there was a "struggle" between the two colors. In our analysis we felt such play would create a compelling game challenge and included it in our design.

Design

The WePaint game is designed to include game mechanisms that encourage cooperation between players and to include a game challenge that makes play engaging. To this end, we drew on prior work, employing the game mechanisms of resource limitation and the requirement of concurrent actions in our design as cooperative elements. We also drew on our own research, including the game challenge of halting the progress of paint drips.

Resource limitations

As illustrated in Figure 2, player resources are limited through the concept of a "palette". Each player is given a *subset* of the primary colors, with one player being given red and yellow, and the other being given red and blue. A player can only access those colors on their palette, enforcing resource limitations as no one player has access to all of the paint colors necessary to address the game challenge.

Concurrent actions

In the WePaint game, though, the possible colors extend beyond just the primary ones of red, blue, and yellow to include the secondary ones of purple, green, and orange. If players desire to use these colors, they must mix the colors on their palettes in a central mixing area. This action must be concurrent, in that the second color must be added to the mixing area within a given period of time (indicated by a timer). Each player must independently contribute a color, such that the player who controls both red and yellow cannot make orange; she must contribute yellow while the other player adds red to the mix.

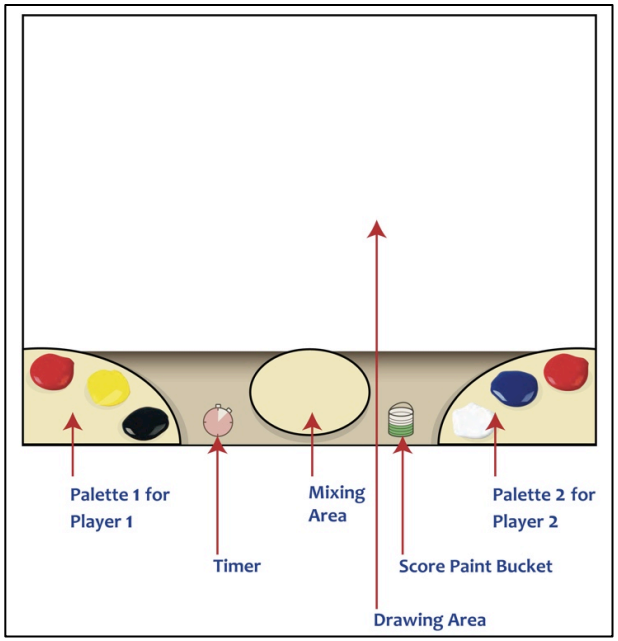

Figure 2. A wireframe mock-up of the game screen. In the lower corners are the palettes of the two players, each with a subset of the primary colors. In between the palettes is the mixing area, indicators for the amount of time left to play and the players' score.

Game challenge

For our second goal of designing a game that would be engaging, we created a backstory involving an alien race known as the "Drip Invaders". Their goal is to ruin the players' picture by leaving drips of paint all over the canvas. Drips begin at the top of the canvas and slowly fall to the bottom, but players can work cooperatively to stop these drips. Drips appear in any of the primary or secondary colors, and can only be stopped by a glob of paint in their path of the same color. Players are thus forced to perform the cooperative mixing action to prevent the drips from ruining their picture.

Prototype

We implemented a functional prototype of the WePaint game using the Processing programming language, the Glove Programmable Input Emulator (GlovePIE) and two Wii Remotes. Game logic and visuals were accomplished using Processing, a programming language designed to support the rapid development of digital media projects. GlovePIE was used to read sensor data from the Wii Remotes and make it available to Processing. The Wii Remotes enabled remote operation of the game. This is important to our efforts, as a goal of the project is to create a full-body gaming experience, which would not be possible using a keyboard and mouse. In one of our group painting observations, we also noted that the participants had issues with sharing physical space at the canvas. When later asked about creating the painting remotely, one participant stated that they would have "more real estate" and "won't be tripping over each other".

We have implemented all of the game features: players are restricted to only accessing the paint colors on their palettes, the creation of secondary colors is accomplished by both players concurrently mixing colors from their palettes, and the "Drip Invaders" periodically drop a drip of paint of a random color on the canvas in an attempt to ruin the players' picture. In the next phase of the project, our goal is to observe our target population playing the WePaint game to determine if it is engaging and encourages cooperation, while working with therapists and teachers to determine how the game could be incorporated into social skills therapies.

Conclusions and future work

Our WePaint system offers a collocated, interactive digital painting game that promises to encourage cooperation between players in an engaging way using Wii Remotes to enable distant interaction. Through the game mechanisms of resource limitation and the requirement for concurrent actions, we force players to perform cooperative actions, and so implicitly reinforce this important social skill. However, the Wii Remote has failed in one important way: it does not require full-body interaction. A player can simply move their wrist to accomplish the same result as moving their entire arm.

In future work, we plan to first perform formative studies with neurotypical adults to determine if any of the game mechanisms are lacking or if a critical usability element, such as sufficient feedback, is missing. We then plan to conduct summative studies with both neurotypical children and our target population, children on the autism spectrum. The goal of these studies will be to answer the following questions: (1) does the game properly engage our target population and (2) does play actually encourage cooperation between the players?

While we believe that our current system is sufficient for answering these questions, we also desire to explore other methods of system interaction, such as using the Microsoft Kinect, to determine which one best affords a truly full-body, collocated, interactive experience with the WePaint game. Unlike the Wii Remote, the Kinect should afford a true full-body experience, requiring non-trivial player movement to reach different areas of the virtual canvas. The Kinect also has the ability to measure object depth, providing a richer set of potential interactions.

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