Empainty - A Tool for Collaborative Painting

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ABSTRACT

Attempting to tackle fixed-mindsets around the creative process and to lower barriers to entry, Empainty is a collaborative painting tool that encourages a growth-mindset by bringing painters together in an activity that focuses on the creative process, rather than the outcome of the process. In this collaborative setting, painters are forced to confront their constraints and make deliberate creative decisions by making note of each others gestural styles, which involves challenging their own creative boundaries.

INTRODUCTION

Painting is largely an individual exercise (in contrast with other creative practices such as dance or music). For novices, the individual experience can feel stagnant and limiting as there aren't opportunities to learn from or play off the creative inspiration of others (an act more prevalent in dance and music). Additionally, individuals can be impeded by design fixation: where they narrow in on a single vision due to bias, resulting in unchallenged and diminished creativity. This is compounded with cultural celebrations of beautiful artistic masterpieces developed from a fixed-mindset, as opposed to a growth-mindset creative process, the former of which being discouraging to the novice painter. By encouraging a growth-mindset and introducing interventions known to mitigate design fixation, we hope to (1) demolish barriers to entry that individuals may have that preclude them from engaging with the creative process in the first place, and (2) empower them to create down the line.

In this work, we encourage painters to listen to one another - as musicians and dancers do - as they create collaboratively. Through this process, we aim to shift fixed-mindsets toward growth-mindsets and bring focus to the creative process, rather than the product. Our tool, Empainty, serves as a mediator for the painters, indicating collaborative similarities and differences in gestures, prompting each other to engage in a dialogue about their process. By working together to achieve mutual goals given constraints, we believe painters will push the bounds of their creativity.

RELATED WORK

With regard to using tangible user interfaces in a creative setting to facilitate dialogue and discussion about the creative process, I/O Brush has seen similar results in that they "found that children not only produced complex works of art... but they also engaged in explicit talk about patterns and features available in their environment" [5]. Another example of a creative process mediated by design artifacts occurs through Concept Posters, which are identified as "props for encouraging and supporting design moves" and "catalysts for discussion," allowing for "ideas [to] emerge" [1]. Within the realm of gamification, WiiArts designed a creative, collaborative experience that "promote[d] collaboration between people rather than leading them to have competitive feelings" [3]. Our tangible user interface differs from the aforementioned examples in the following ways, respectively: (1) the interaction is explicitly collaborative (whereas I/O brush had the option of involving other individuals), (2) our TUI is responsive to the behaviors of the users, engaging them in a dialogue (whereas Concept Poster props were static), and (3) the artboard is sensitive to the nuances of their strokes (whereas WiiArts has predefined settings and imagery to uncover).

DESIGN

Figure 1: The iterative design process of our prototype, beginning with a cardboard rendition (right) with a living hinge mechanism, to a laser-cut wood rendition (bottom) with an unsuccessful living hinge mechanism (center), and our final, functioning laser-cut wood rendition with servo-motor mechanisms (left).

For novice painters, a belief that arts value rests purely in the beauty of the finished product can be intimidating and discouraging. In the terms of Activity Theory [2], Empainty is a tool that allows the subjects (a pair of painters) to achieve the object of the process of painting, encouraging a shift away from the final piece. Situated in a collaborative painting environment so as to encourage learning and discovery from a partners processes and mistakes, Empainty places constraints on the medium that fluctuate based on the synchronicity of

each painter's brush strokes. This gamifying of the painting experience liberates the novice painter from feeling overwhelmed by the open-endedness of the task at hand, allowing them to explore and learn with the medium and tools. Furthermore, Empainty externalizes ones painting process allowing for collaborative discussion between partners.

Empainty is primarily designed for watercolor and includes a palette box of red, orange, yellow, green, blue, and violet (ROYGBV) paints along with two paint brushes for the pair of painters. The palette box has lids on each of the ROYGBV paint wells, which move up and down allowing some colors to be available for usage (lid-up state), and other colors to be restricted (lid-down state). Each of the paint brushes has an accelerometer on the handle sensing x, y, and z position acceleration. With machine learning techniques, brush stroke gestures are detected for each of the painters. If the two people have similar paint strokes (i.e. they are painting synchronously) then the warmer paint colors of red, orange, and yellow will be available to use (with the cool colors restricted). If the two people have differing paint strokes then the cooler paint colors of green, blue, and violet will be available to use (with the warm colors restricted).

Watercolor was chosen (as opposed to acrylics or oils) given the inherent loss of control, consistent with our design to implement constraints outside of the painters control. Given our aim is ones process and encouraging a painter to explore and become more familiar with the capabilities of a tool, we elected to detect gestures (as opposed to sensing emotions of a painter). Inspired by the basketball game HORSE, where partners encourage each other to explore unique basketball shots at the hoop, the painters influence one another to try new strokes outside of their comfort zone. An accelerometer was used to detect brush strokes as it is a common sensor for gesture detection.

The restriction of paint colors on the warmer-to-cooler spectrum was inspired by a metaphorical sense of closeness to another individual, as exemplified in the game Hot-And-Cold where one person helps another person find something by giving clues like 'you're warm, you're warmer, you're boiling, you're burning'. The hot state represents closeness (being warm toward one another), while the cold state represents distance (being cold toward one another). The Empainty has 'warmest', 'warm', 'cold', and 'coldest' states mapping to ROYG, OYG, YGB, and YGBV, respectively. When moving between states, the box flutters on the next extreme state taunting the painters to keep moving in that direction. For example, if the two painters gestures are similar but not perfectly similar, the box will first quickly reveal the 'warmest' state as a temptation and then settle on the 'warm' state. The fluttering instills a sense of life into the palette box.

The materiality of a wooden palette box was chosen due to a desired patina. With significant usage of some colors versus others, over time participants can glean the general warmth of their collaborative relationships. Additionally, residue of color-mixing or accidental gestures onto the box transforms the box into a means to capture unexpected actions and moments. Over time, the patina upon the box can be used as a tool for reflection on interpersonal relationships as well as a persons creative process.

Figure 2: Watercolor palette box with lids moving from 'warm' state to 'cold' state where the orange paint is being covered while the blue paint is opening up, because the two painters are using very different strokes. Each paintbrush houses an accelerometer on top of the handle.

IMPLEMENTATION

Brush stroke recognition

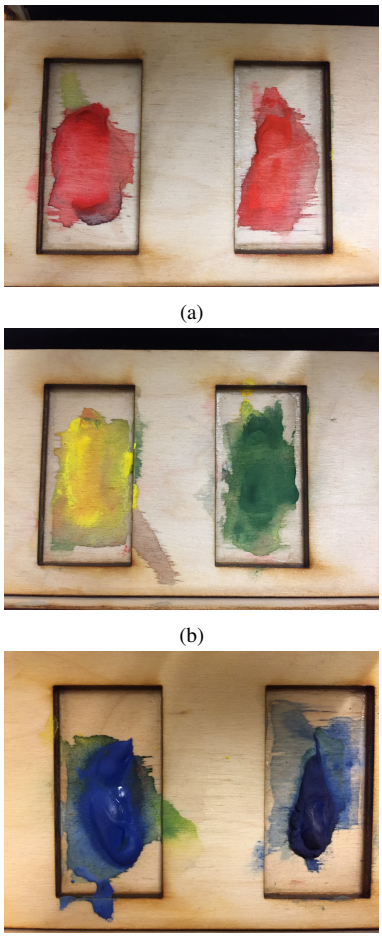
Each brush has an accelerometer on the handle reading in x, y, and z acceleration data in g's. After reading in the data, we relied on David Mellis's Example-based Sensor Prediction (ESP) software [4] and trained three distinct gestures - a stroke to the right, stroke to the left, and short poking motion on the tip of the paint brush. Note, we indicated on the brush handle where the user should place their fingers to ensure a consistent orientation. The ESP tool employs a naive-bayes classifier and a dynamic time warping algorithm to read in new data and predicts when a certain gesture is detected.

Animated palette box

The palette box relies on 6 servo motors controlling each of the lids over the ROYGBV paint wells. The whole watercolor palette is controlled by a custom C++ class, which has member functions that correspond with desired degree positions, including 'warmest', 'warm', 'cold', and 'coldest' states and speed inputs to control how quickly the lid moves to the desired position. Each lid, controlled separately steps its way to the desired position.

As the Arduino code controlling the state of the servos loops through, it records the latest gesture from the two brushes (so as to avoid a queue of gestures, maintaining the real time feel). A similarity measure is then captured based on the most recent eight gestures captured. The next state of 'warm', 'warmest', 'cold', and 'coldest' is determined based on the number of similar gestures out of the eight.

Note that due to unresolved hardware issues, we were unable to control 6 servos in fluid motions, so we elected to control only 4 with the middle two controlling lids for the yellow and green wells remaining static. Specifically, the servo motors were drawing too much voltage from our Arduinos 5V port, causing the Arduino to repeatedly reset.



(a)

(b)

(c)

Figure 3: Close-up photos of the residue from after the pilot demonstration. (a) We can see hints of yellow in the red well; (b) dirtied water trailing away from the yellow well; and, (c) green paint mixed in with the blue well.

Communication across devices

Arduino sends running accelerometer data to ESP (in Processing or Xcode) over the Serial Port. We were restricted in sending data from two accelerometers over the Serial Port to two ESP modules, so we elected to have each brush with separate accelerometer data hooked up to two separate computers each running their own ESP modules. ESP returns predicted gestures via a TCP server to a third computer controlling the servos.

On the third computer, we had a Processing sketch to read in the gestures from each brush (via two TCP servers) and then sent the detected gestures over the Serial Port to Arduino. Note that without extra hardware, Arduino cannot read incoming data from TCP servers. The Arduino sketch then calculated the similarity of the gestures as described above and set the degrees of the servos accordingly.

Note that when everything is set up, debugging cannot be done by printing to the Arduino Serial Monitor as it is in use by Processing. So the built in LED on pin 13 of the Arduino can be turned on/off for debugging purposes.

Schematics for box dimensions, circuit design, ESP code with the trained gestures, Processing and Arduino code, along with set up instructions are available on github: https://github.com/AGagliano/empainty.

PILOT EVALUATION METHOD

Initial watercolor participant-observations

Prior to the launch of our pilot, we conducted a set of participant-observations, in which we set up stations for collaborative watercolor painting in South Hall. We provided a 12” x 16” watercolor paper pad, two water jars, two types of brushes (sponge and traditional), and a watercolor palette. Initially, we imposed no additional constraints to the collaborative painters, as to observe what their unadulterated behaviors would be like. All we instructed them to do was to paint.

Partway through the experience, we began to impose restrictions on the painters, as to simulate our palette boxs mechanized behavior. At the time, we believed we would have two palette boxes available, one per painter, and so we restricted one painter to one set of colors and the other painter to the remaining set of colors upon the same palette. Some immediate reactions were of surprise, confusion, but in all cases a dialogue occurred between the two painters something that was not evident in all pairs prior to the imposing of constraints. It was this aspect of engaged dialogue that we wanted to expand upon in the development of our prototype, as it made evident what the users were thinking, as well as prompted negotiation and resolution to achieve desired outcomes.

Showcase interviews, surveys, participant-observations

At the showcase itself, we presented two sponge brushes, two water jars, one communal palette box, and one communal 18” x 24” canvas for painters to paint on. We asked each painter a set of questions to understand their preconceptions surrounding creativity, the creative process, and art-making, as well as their experience with watercolors. Then, they were instructed

Figure 4: An instance from our pre-pilot participant-observation (*without* Empainty), in which one painter reaches toward the end of the canvas furthest away from her (but closest to her partner).

to "have fun painting," the palette box responding to their gestures immediately. At times, painters would ask us how the palette box was deciding which colors to conceal or reveal; we did not answer, wanting to see how their behaviors transformed as their interactions continued.

During the showcase, we attempted to take video and photography of the experiences unfolding; however, the noise level in the room was quite high and so it became difficult to hear what the partners were saying at times.

PILOT EVALUATION FINDINGS

During the pilot, all pairs engaged in some dialogue with their partner: some pairs creating hypotheses about how the palette box works and some pairs recognizing that the box's movements were introducing constraints on their creative process. In many cases, the focus of the painting exercise shifted away from the piece itself, but the process instead:

> *P1a: "I stopped caring about making a good painting."*
> *P1b: "I did not try to represent real objects. Our art evolved more organically."*
> *P4: "Till the end, I didn't know what I wanted to paint. I was just exploring different colors and strokes and having fun."*
> *P5b: "Colors tell a nice story of what happened abstractly."*

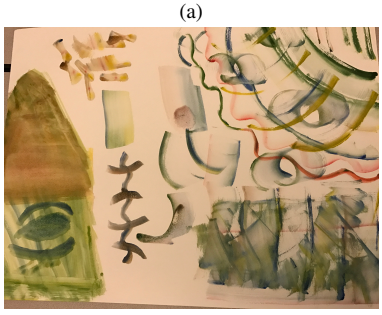
With regard to purely interacting with the box, some reactions we anticipated to occur, but were still surprising to our users. For example, users attempted gestures that we did not train our gesture-mapping software with yet, expecting the box to react to them. Specifically, we hadn't mapped dabbing on both corners of the brush, but just one, resulting in user-confusion. Additionally, the rate at which the palette box opens and closes a lid is a bit quick to react to if you are not expecting it. Surely enough, some users found their brushes

(a)

(b)

Figure 5: Collaborative paintings *without* Empainty. Note, there appears to be a vision for the pieces.

(a)



(b)

Figure 6: Collaborative paintings *with* Empainty. Note, there is exploration of strokes, as opposed to a vision for the pieces.

being closed upon, or otherwise knocking into the lids as they moved unexpectedly.

Despite that, people engaged in a dialogue with the box as if it were alive, but separate from their partner ("Is it giving contrasting colors when we're working?"; "Now it lets me use blue.") Nevertheless, the reaction to the box introducing constraints on color choices was received more positively than when our team simulated the boxs behavior in our initial watercolor study, in a way where it felt fun to the users:

P1: "It was more fun for us to work together than to compete."
P2: "We were focused on changing the color boxes rather than focusing on the painting."
P5: "I think it is encouraging me to try different patterns and different textures."

With regard to their own sense of creativity (which participants defined as "uniqueness of expression," "expressiveness," "imagination," "unlimited thought," "thinking outside the box," "freedom of speech," "how you express yourself," "different for different people," and "having constraints and figuring out something interesting to do with it,"), most people felt their creative boundaries being pushed either by the presence of their partner, or by the palette box's communication. The below quotes are in response to the following survey question post-activity: "Describe a moment, if any, that pushed your sense of creativity."

P1: "Discovering a way to paint what we wanted while maintaining the motions necessary to get the colors we wanted [pushed my sense of creativity]."
P2: "Yes, once they told us the gesture changes the colors available [my creativity was pushed]."
P3: "The drawing part reminded me of my childhood days :)"
P4: "Using different colors on the side of the brush."
P5: "I saw my partner was working abstractly so I tried to fit into that aesthetic more (P01). I saw my partner make dots and thought 'I can do that' (p02)"

While several painters interacted with our palette box over the course of the demo session, we believe that the patina effect we seek is still possible. As an extension of our palette box shared over time with at least one common user, the canvas reflects the interpersonal dynamics after one session. In response to what surprised them about the activity, one pair in their survey reflected on the colors of their painting as opposed to form:

P2: "Its really red/warm toned."

DISCUSSION

Potential improvements, elaborations, and future iterations of Empainty:

The machine learning tools for gesture recognition could be improved and made more complex. As of now, the ESP gesture recognition software serves well, but only three gestures have been taught. Work could be done to expand the array of gestures that Empainty can recognize by teaching the software more sophisticated and specific gestures.

Another notable limitation of our current use of the ESP gesture software is the fact that it is necessary to pre-program gestures ahead of the painting activity. It would be ideal to find a way to personalize the gesture training to individual painters (i.e. one painters leftward swipe gesture might be different from anothers). It would also be interesting to establish personalized gesture definitions in real time as painters begin to use Empainty, to give the users control over the gesture types instead of the designers. It would be good if the raw accelerometer data could be processed in a way that recognized left-handedness and adjusted for it, and allowed users to grip the brush at any orientation.

In the future, the paintbrushes themselves might be designed differently. A brush with bristles (instead of foam) might allow for more flexibility in the strokes that painters are able to make. Right now, gestures are recognized by processing the x, y, and z direction acceleration data. It follows that our machine learning software could process a fourth or fifth piece of data when recognizing gestures as well. Conceivably, a flex sensor or force sensitive resistor in the brush would allow for more exact and distinguishing differentiation between gestures.

Additionally, some users expressed concerns about their motions with the paintbrush to either dip for paint (in the palette) or water (in the jar) being falsely recognized as actual painting gestures. In the future it would be useful to have a way to tell whether gestures are being picked up as a result of painting strokes on the canvas, and to discount anything else.

Future research could focus on the way that our users engage with Empainty and looking closely at what aspects of the tool do the best job freeing and encouraging the creative process. A mode of exploration would be to emphasize a game-like interaction with Empainty, where users are encouraged to push the limits of their own painting habits in order to unlock color access, or given feedback on different techniques in the form of gestures that gradually increase in difficulty or complexity.

Along these lines, further research into questions that are central to our hopes for how Empainty affects its users approach to painting could be helpful. Below is a brief listing of research questions that are relevant to these hopes. The important comparisons to make are between traditional painting and painting with Empainty.

- To what degree do users vary the style, length, and intensity of their brushstrokes?
- To what degree do users engage each other in dialogue about the creative process?
- To what degree do users overlap where they've painted on the canvas (as opposed to staying separated on the canvas in a way that divides up the area between collaborators) as a way of depicting interpersonal intimacy?
- To what degree do users report feeling satisfied with what they've painted?

CONCLUSION

Empainty aims to alter the painting process in a way that lowers barriers to entry perceived by newcomers to the painting world. By making painting more collaborative, and encouraging a growth and process driven mindset, we hope to make the creation of visual art a more accessible, less intimidating practice. This way all people, those that do and do not identify themselves as having artistic talent and inclination, can reap the emotional, intellectual, and social benefits of creating. In its initial demonstration, Empainty helped less experienced painters approach the creation process in a process-oriented, collaborative way. Empainty was able to help users engage in supportive and constructive dialogue with their partners by opening doors to candid conversation, and by challenging the limits of the painters creativity. In the future we hope to fine tune Empainty so as to make these goals as universally reachable as possible.

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