Musical Brush: Exploring Creativity in an AR-based Tool Combining Music and Drawing Generation

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Abstract
The 21st century’s economic growth and social transformation are hardly based on creativity. To help with the development of this skill, the Creativity Support Tools (CST) concept was proposed. Here, we introduce Musical Brush, an artistic-based CST mobile application for music and drawing improvisation. We investigated different types of interaction designs and audiovisual feedbacks, measuring their impact on creativity support. A user study with 26 subjects was conducted to verify the Creativity Support Index (CSI) score of each design. Results showed the suitability of the association of Musical Brush with Augmented Reality (AR) for creating new sounds and drawings.

Index Terms: Human-centered computing—HCI design and evaluation methods—Interaction devices—Sound and Music Computing;

1 Introduction
Digital tools, nowadays, play a crucial role in the most creative practices of our daily life. From young children playing on smartphones to create simple drawings to professional design artists, who depend on advanced graphical interfaces to accomplish their creative works. This growing link between digital instruments and creativity culminated in the emergence of a new subfield of Human-Computer Interaction (HCI), known as Creativity Support Tools (CST) [11]. More specifically, the research on CSTs focuses on the development of interfaces that aim not just the productivity of users but also the enhancement of their innovative potential, with the primary goal to support users on being more creative more often. The study of this subarea has leveraged based on the idea that computers have the potential to enhance human creativity [4].

In this paper, we introduce “Musical Brush” (MB), an artistic application that enables novices to improvise music while creating drawings in AR. Being an application for mobile devices, we exploit the widespread smartphones capable of sound synthesis and equipped with other basic components such as accelerometer, or pressure sensors. We start by detailing the design and development of MB. After that, once we are particularly interested in exploring how the application of different features enhance creativity, we propose a practical user study that evaluates the potential impact of such features on the creativity of individuals.

We identify the central contributions of this project as the conception of a new CST focused on supporting users in artistic improvisation, along with the assessment of the tool key characteristics regarding the enhancement of creative skills. While we are aware that the achieved results are particular to our tool, we argue that many of the design choices could easily be extended to other audiovisual drawing-based tools. Moreover, we provide the overall creativity-related application scores, thus encouraging comparison with future works.

2 Related Work
Since early works, a large number of different interactions and technologies were explored on the conception of new musical interfaces [8]. Among the many possibilities, we highlight the concept of combining drawings with music. These tools generally present a highly visual aspect, benefiting from the degree of expressiveness that the drawings representations offer. The UPIC System [7] presents a very early work in this direction. Composed by a digitizing drawing board and a pen, the system generates sounds according to the shapes created. On another recent similar work, [6] presents Articulated Paint, an interface for non-musicians that explores the use of a physical brush and a canvas to produce sound based on the drawing properties. A common approach is to correlate the characteristics of the sound with the visual aspects of the sketches. For example in MicroJam [10], an application for improvising short audiovisual performances in a mobile screen, the stroke color is related to the sound timbre that is being played.

Still, most of the research on drawing-based musical interfaces focuses only on 2D interfaces. Regarding this, immersive technologies have been explored in order to bring more freedom and expressiveness for musical tools [9]. Due to their capability of creating scenarios not feasible in the real world, new experiences that are not possible through traditional instruments can be created. In Reflets [1], performers, and spectators experience a mixed-reality environment for musical performances. Among the proposed scenarios, we highlight SoundPaths, where performers make use of a Wii Remote to draw 3D sound paths. Differently from previous work, MB was developed as a portable AR experience, thus lacking any overhead needed for setting up environments. Through only motion and touch interactions on a smartphone, performers can compose audiovisual pieces. In order to investigate its potential capacity on supporting creativity, we compare the tool with different variation sets of its own features.

3 Design and Implementation
The essential operation of MB consists of mapping different user interactions into sounds and drawings. By moving the device, the
application leaves a visual trace along the traveled path while generating sound. Both sound and visual feedbacks are controlled and shaped based on user interactions and device motion characteristics. The composition is an incremental process and the visual strokes act as a way to represent the performance structure. The synergy between user input and system output is crucial for its better understanding – direct correlation between gesture and sound reduces cognitive processing load and enhances performance [5]. The extraction of parameters from the smartphone sensors is forwarded in real-time to both the sound and graphics modules. The first makes use of a Pure Data (Pd) based engine \(^1\) which allows the mapping of input parameters to a wide range of audio synthesis techniques. Pd audio engine gives a high degree of flexibility to the sound generation module in MB and provides an easy and fast way to further extensions of the proposed tool. Aiming to have a better-controlled testing environment, we have developed four different sound timbres using additive synthesis designed with oscillators based on siren, triangular, sawtooth, and square waveforms. The graphics module is responsible for creating the 3D virtual strokes in real-time. We opted for using ARKit together with the low-level Metal API to anchor and render the 3D virtual elements.

The parameters extracted from the smartphone sensors act in a way of shaping the audiovisual output. Sound characteristics such as amplitude, timbre, and reverberation effects are controlled by the device 3D position, the pressure of the touch gestures, and the device acceleration. The same happens for the visual aspects like stroke colors, animations, and thickness (see online video \(^2\)).

## 4 Validation with Users

To explore the effectiveness of our implementation regarding the support of creative characteristics, we propose a targeted user study. More specifically, we are interested in three main topics: (1) Is the design of MB successful in supporting creativity? (2) What aspects of creativity are impacted the most? (3) What are the key features that impact substantially on this support?

Measuring creativity is not trivial since the concept is ill-defined, with its measurement being approached in distinct ways by the community [2]. However, independently of the creativity definition, the Creativity Support Index (CSI) measurement tool [3], a psychometric survey specially designed to measure the capacity of CSTs on supporting individuals engaged on creative works, brings the evaluation of attributes (e.g. exploration, immersion, etc.) that indirectly express fundamental qualities inherent to the majority of the creative processes. In our context, creativity is quantified by the CSI scores measured during the user’s interaction with the MB module while composing artistic pieces. We compared four different variations of MB (AR, Sound Only (SO), 3D, and 2D) with 26 subjects to measure how the different interactions and visualizations may affect creativity. Table 1 summarizes the main differences between the versions, while Table 2 brings the CSI results for each of them.

Among the key findings, we discovered that the visual drawings are crucial for a significant enhancement of users’ creativity. By providing visual feedback to the interactions, the drawings were mainly responsible for improving the participants’ expressiveness and exploratory capacity, as well as providing greater satisfaction. Furthermore, the presence of visual feedback was also highlighted for increasing the perception of immersion due to its surrounding 3D drawings. Although not presenting significant statistical differences on creativity support aspects, the comparison among the 2D and 3D versions produced interesting results. From our experiments, it is clear that all types of interactions can be somehow useful for applications that integrate music with drawings. However, the choice of this specific interaction is, in fact, a tradeoff between controllability and expressiveness. Feedback indicated that the 2D was preferred for rapid and efficient control of sound parameters, while the 3D preferred for freedom, and exploration of different possibilities, space, and ideas.

### Conclusion and Future Work

In this work, we proposed Musical Brush, a drawing-based musical application that allows novices to improvise music while drawing in a portable AR experience. Through a comparative study, we discovered that the tool drawings are crucial for enhancing creativity while composing musical pieces. In the future, we intend to explore collaboration among participants while experiencing the tool.

### Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

### References


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\(^1\)https://github.com/libpd

\(^2\)https://vimeo.com/313557959

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**Table 1: Application Versions - Real Env. (Real Environment), Fake Env. (Fake Environment), Black Img. (Black Image)**

<table>
<thead>
<tr>
<th>Version</th>
<th>AR</th>
<th>SO</th>
<th>3D</th>
<th>2D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Feedback</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Interactions</td>
<td>3D</td>
<td>3D</td>
<td>3D</td>
<td>2D</td>
</tr>
</tbody>
</table>

**Table 2: CSI scores for each compared version. Bold values indicate the highest average value. (R.W.E = Results Worth Effort)**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>AR</th>
<th>SO</th>
<th>3D</th>
<th>2D</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.W.E</td>
<td>7.59 ± 2.5</td>
<td>6.61 ± 1.7</td>
<td>7.17 ± 2.0</td>
<td><strong>7.65 ± 1.7</strong></td>
</tr>
<tr>
<td>Exploration</td>
<td><strong>8.03 ± 2.1</strong></td>
<td>6.61 ± 1.9</td>
<td>7.5 ± 2.1</td>
<td>7.76 ± 1.7</td>
</tr>
<tr>
<td>Immersion</td>
<td><strong>8.13 ± 2.3</strong></td>
<td>7.51 ± 2.0</td>
<td>7.96 ± 2.1</td>
<td>7.94 ± 1.5</td>
</tr>
<tr>
<td>Expressiv.</td>
<td>7.76 ± 2.3</td>
<td>6.21 ± 2.1</td>
<td>7.21 ± 2.1</td>
<td>7.21 ± 1.9</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>7.65 ± 2.2</td>
<td>6.59 ± 3.2</td>
<td>7.25 ± 2.4</td>
<td>7.55 ± 1.7</td>
</tr>
<tr>
<td>CSI Score</td>
<td><strong>78.4 ± 20.6</strong></td>
<td>66.4 ± 17.8</td>
<td>74.1 ± 19.3</td>
<td>76.4 ± 14.1</td>
</tr>
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