# SonicDraw: a web-based tool for sketching sounds and drawings

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## ABSTRACT

*We present SonicDraw, a web browser tool that lies in between a drawing and a sound design interface. Through this ambiguity we aim to explore new kinds of user interactions as the creative process can be led either by sound or visual feedback loops. We performed a user evaluation to assess how users negotiated the affordances of the system and how it supported their creativity. We measured the System Usability Scale (SUS), the Creativity Support Index (CSI) and conducted an inductive thematic analysis of qualitative feedback. Results indicate that users find SonicDraw a very easy and intuitive tool which fosters the exploration for new unexpected combinations of sounds and drawings. However, the tool seems to fail in engaging high-skilled musicians or drawers wanting to create more complex pieces. To infer knowledge about user interaction, we also propose a quantitative analysis of drawing dynamics. Two contrasting modes of interaction are likely occurring, one where sketches act as direct controls of sonic attributes (sound focus), and the other where sketches feature semantic content (e.g. a house) that indirectly controls sound (visual focus).*

## 1. INTRODUCTION

Sound and image expressions are deeply related both in scientific and artistic creative processes [1]. Moreover, our mental ability to map sound features (time, pitch, loudness, among others) into space coordinates, allows creators and scientists to transform sounds (or music) into visual patterns and vice versa [2]. This two-way relationship has been a strong source of fascination and creation since the antiquity and it has yielded fruitful bridges between sound/music and architecture [3], design [4], data science [5], among others [6]. However, this coupling is often uneven, as one of these two forms of expression tends to lead in terms of the creative process, relegating the second one to a more complementary function. A good example of this unevenness are music scores, where the visual part plays a pure functional purpose - i.e. to help in communicating the music - while sound is in the aesthetic and creative centre. We can also have the opposite case, where music or sound plays an auxiliary role related to an image - take, for instance, well-known image sonification techniques where visual parameters are directly mapped into sound parameters [7].



In the context of music creation software we can also find this dichotomy. Typical Digital Audio Workstations include intuitive and appealing visual objects and cues (sliders, knobs, plots, among others) to guide user interactions [8]. However, when the goal is centered on sound and music, these visual objects are fundamentally functional, and they are tipically subtended to the representation of sound aspects.

We can also find highly simplified music generation apps such as Brian Eno's Bloom and Scape apps [9,10]. In these cases, abstract and visually appealing interfaces (not necessarily related to any musical concept) allow non musician users to easily generate musical pieces through generative algorithms or scale constraints. Although such apps can be great for musical experiences, a creative drawback is that the underlying algorithms or processes take away autonomy from users, as they lose control over sound parameters, thus hindering the creation of more complex sound structures.

In this work we present SonicDraw, a music-drawing application that aims to put both drawings and sounds at the same level. The visual component is not an extended music score with informative purposes, but it rather becomes a central part of the creation itself, with aesthetic value and centrality. This would not only foster interdisciplinary artistic creation but it would support new users of the tool that go beyond (but include) the traditional electroacoustic music composers or digital visual artists. We adopted three main design goals for SonicDraw, each of which aims to conciliate two seemingly incompatible features. The interface aims (i) to be *intuitive and vague*, (ii) to focus on *freedom and mapping*, and (iii) to be engaging to both *beginner and expert* music and visual creators.

The design strongly relies on the idea of sound sketching [11], where sketching is taken not only as a way of portraying mental representations, but as a way of actively creating new unexpected ideas [4]. Through this, we aim to obtain a cyclic relationship where sounds and strokes act as both new elements of the piece and as feedback for the subsequent adding of new sounds and strokes.

The remainder of this paper is organised as follows. In Section 2 we review related work regarding sound sketching tools. Section 3 outlines the design process, with proposed goals and their subsequent solution. In section 4 we detail the qualitative and quantitative evaluation methods for SonicDraw. We show the results of these evaluations in Section 5. In Section 6 we discuss the accomplishment of the the proposed design goals. Finally, in Section 7 we draw conclusions and some suggestions for improvements and extensions of SonicDraw.

## 2. RELATED WORK: SOUND SKETCHING

A music score is, in its original meaning, a representation of the actual music, with much information left ambiguous, specially regarding timbral variation or sound texture specifications [11–13]. Modern composers such as Xenakis, Cage and Feldman, among others, were the first to explore new kinds of visual representations that would take into account these musical subtleties [11, 14]. These new initiatives motivated the integration of user-specifiable graphical representation in programming languages dedicated to music [15]. Xenakis not only developed a whole framework which sets the foundations for electroacoustic music graphical interfaces that will be detailed later, but also put these visual representations in the center of the piece. The score is no longer a mere representation, but it has an aesthetic value by itself. We can see the relevance of the visual aspect in his famous Metastaeisis work, where the visual score tightly relates with Xenakis' architectural works. The idea behind, as Xenakis explains, is that "we are capable of speaking two languages at the same time. One is addressed to the eyes, the other to the ears" [16], situating these two languages in a complementary fashion rather than thinking of them as a translation from one to the other. [3]. This idea of complementarity is further supported from a cognitive point of view, as combining visual and auditory stimuli can enhance human perceptual processing, when compared to unimodal stimuli [17, 18].

Xenakis' UPIC (Unité Polyagogique Informatique du CeMaMu) machine sets the foundation of modern computer GUIs for sound and music composition [19]. In particular, UPIC emphasises the role of sound sketching as a method for electroacoustic music composition [11]. Sound sketching refers to the enhancement of the creative and thinking process when creating a sound through the use of drawing sketches. Just as it happens with architecture or design, sound sketches operate through a cyclic feedback process, where the sound designer first listens to an already sketched sound, then moves (to "draw" a new sound) and then she/he listens to the resulting sound [4]. Interestingly, this process often leads to new meanings that can be extracted from the sketch, positioning sketching as a way of thinking, rather than just a way to represent pre-conceived ideas in our minds [20].

Since UPIC, a series of music composition software focusing on the advantages of sound sketching has emerged, such as Methasynth [11], Iannix [21] and Hyperscore [22] (see [11] for a more extended list and comparison). In most of them, the interface design differs significantly from traditional Digital Audio Workstations (DAWs). Instead of notes placed in a quantized time-pitch space, melodies are represented in a less restricted fashion, such as continuous lines or curves, where time is not always represented in an absolute or linear way (see, for instance, IanniX [21]). In this way, the resulting sound turns into something dynamic and often surprising, where rapid sketching is a fruitful way of trying new things. However, the function of sketching in these software is mostly music centered, and the visual scope still plays a secondary role.

## 3. DESIGN PROCESS

### 3.1 Design goals

Our aim was to build a sufficiently ambiguous interface that lies between sound composition and drawing, but that, at the same time, is engaging to users that have interest in these areas (e.g. both novice or expert musicians and drawers). In order to do this, we followed three design goals for SonicDraw:

(i) *Intuitive and vague:* The visual interface should be easy to use and intuitive. Though, it should look neither as a sound design tool - or more generally, a music creation software - nor as a standard drawing tool. It should maintain its generality through some kind of vagueness in its design and it must let users to decide (while using it) whether it will be the drawing that leads the sound, or if they will rather think of a sound and then sketch it accordingly.

(ii) *Freedom and mapping:* The tool must encourage free expression and creation of shapes and strokes, but at the same time it has to give a clear musical meaning and mapping to those shapes.

(iii) *Beginners and experts:* The tool should be playful enough to allow non expert musicians/drawers to use it, but at the same time, it should enable the creation of complex sounds/drawings from it.

### 3.2 Design proposal and implementation

Figure 1 shows a display of the SonicDraw interface. The general display has a naive/minimalistic style, aiming to simplify the interaction and to avoid overwhelming users with a more professional DAW-style interface. Through the right-side menu users can pick the tool they want to use in the drawing canvas, while the bottom-bar allows them to select the color of the stroke. There are two possible tools: pencil or airbrush. Pencil strokes will map to melodic (monophonic) sounds produced by a single oscillator. There are four different oscillators - sine, saw tooth, triangle or square wave - one for each stroke color. Airbrushes, instead, map to different kinds of filtered noises, also with four possible options - pink, brown, white-low pass and white-high pass - each one coupled to a specific stroke color.

The play head is represented by a vertical bar that moves from left to right of the drawing canvas with a user-defined speed controlled through the slider at the bottom-right. As soon as the play head meets a drawn object, it activates the corresponding sound. The $y$ coordinate of each pencil or airbrush stroke is mapped to the frequency of the oscillator or to the cutoff frequency of the filter, respectively. The

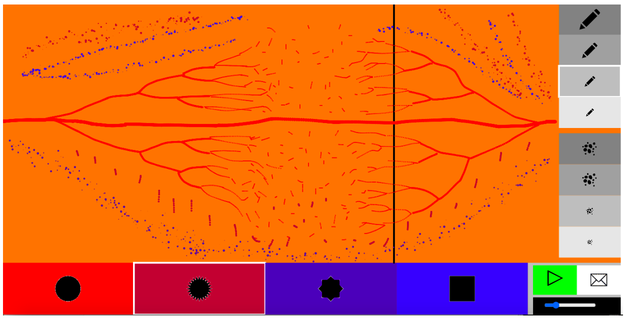

**Figure 1**: An example of a visual/sound sketch, showing a combination of pencil and airbrush strokes. The black vertical bar represents the play head.

thickness, instead, will map to the amplitude of the sound.

SonicDraw can be accessed directly through any web browser (e.g. Chrome, Firefox, etc), and it is written in *Javascript*. In particular, we made use of *p5.js*, a library for implementing *processing* visual sketches in *Javascript*. Additionally, *p5.js* includes a sound library, *p5.sound*, that allows the creation and manipulation of oscillators, noises, filters, among other sound objects. *p5.sound*, in turn, uses the Web Audio API for sound generation.

SonicDraw is available at:
https://forkingpaths.intersections.io/Sonicdraw

Also, its source code can be found at:
https://github.com/teo523/sonicDraw

## 4. EVALUATION METHODS

### 4.1 User evaluation

We performed an online user evaluation of SonicDraw and a subsequent survey in order to assess its usability and how much - and in which ways - it was supporting creativity. This study was approved by QMUL's Research Ethics committee (reference: 2456).

#### *4.1.1 Procedure*

We asked participants to access the SonicDraw website - through a desktop computer or laptop - where the instructions were given. We firstly asked them to explore the interface and functions of SonicDraw for about 5 minutes. Then, they were asked to create a piece with the tool and send it by simply clicking the envelope at the bottom right corner of the interface (figure 1). After sending the piece, users were taken to an online survey.

#### *4.1.2 Participants*

We recruited participants by emailing graduate students of the Media and Arts Technology Programme at Queen Mary University of London, as we were interested in users that could have an interest and some expertise in either drawing or music. We also asked them to forward the invitation to their design and music-related contacts.

#### *4.1.3 Survey*

The survey included four parts: a series of open-ended questions regarding their interaction with SonicDraw, a System Usability Scale (SUS) assessment [23], a Creativity Support Index (CSI) assessment [24] and, finally, basic demographic information (gender, age, level of expertise both in drawing and music, among others).

The open-ended questions part concerned the general experience of the user with SonicDraw. Following Houde and Hill's model for an integral evaluation of a prototype [25], we asked questions regarding the look and fill aspects (e.g. *What did you enjoy the most about SonicDraw?*), the role that the tool could play in their lives (*Do you think you could use SonicDraw in specific context(s) and if so, which ones?*) and finally, specific implementation or technical details (*Please report any bugs (errors) you experienced while using the tool.*). We subsequently performed an inductive thematic analysis [26] on the given answers in order to obtain the most salient themes that reflected repetitive patterns in the survey [27].

The SUS technique aims to obtain a simple quantitative assessment of usability in different contexts [23]. SUS is composed by 10 different items that reflect different positive and negative aspects of usability. Each item is simply assessed through a Likert scale (from 1 to 5).

The CSI assessment aims to evaluate the level of creativity support provided by a specific interface or tool [24], and it proposes six orthogonal and creativity-related factors to assess: results-worth-effort, exploration, collaboration, enjoyment, expressiveness and immersion. Both SUS and CSI translate into a single value that ranges from 0 to 100.

### 4.2 Direction of movements

We analyzed the sound/drawing pieces generated by participants. In particular, one of our objectives was to assess to what extent the drawing process was led by musical concepts. We foresaw two likely limit cases. In one extreme, users could be completely absorbed in the music task. This would mean that the resulting drawing would merely represent a music score. For these cases, the most likely shapes to be found in the drawing would be horizontal lines representing melodic lines. Moreover, if participants were centered in representing melodic variations over time, then strokes are expected to be drawn from left to right, following the direction of time increment. The opposite case would be when the sound is just a consequence of drawing. Lines and shapes are drawn freely without taking into consideration any music concept. In this case we wouldn't expect melodic or harmonic patterns, neither the predominance of horizontal lines. Instead, multi-directional lines or even closed shapes as circles or squares could be found.

We then propose a way to measure the overall and individual average direction angle of strokes. As shown in figure 2, for each two consecutive points of the trajectory (stroke), we can find the instantaneous direction of the move-

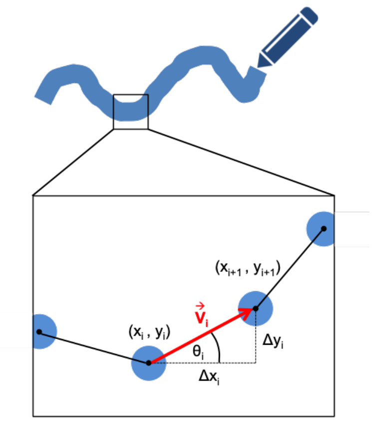


**Figure 2**: Every stroke made by the user corresponds to a series of points representing it (blue circles). We can obtain the instantaneous trajectory of user movements by calculating the vector between two consecutive points (red arrow).

ment users made while drawing. In particular, for a point with coordinates $(x_i, y_i)$ that belongs to a stroke, then the vector $\vec{v}_i$ that gives the direction of movement can be defined by the angle formed with the horizontal axis $\theta_i$, and its magnitude $r_i$. Both quantities are obtained, according with figure 2, from the relations:

$$\theta_i = arctan(\frac{y_i}{x_i}) \qquad r_i = \sqrt{x_i^2 + y_i^2}$$

For a complete stroke - in SonicDraw, defined since the user clicks the canvas and until the click is finished - we can calculate the relative frequency of each direction, by weighting each angle by the corresponding magnitude of the vector. Thus, for the $j$th stroke of participant $k$, and given an interval $I = [\theta_1, \theta_2]$, with $0 \leq \theta_1 < \theta_2 < 2\pi$, we obtain the relative frequency of angles in this interval as:

$$p_{jk}(\theta_1 < \theta < \theta_2) = \frac{\sum\limits_{i,\theta_{ijk} \in I} \theta_{ijk} r_{ijk}}{\sum_i \theta_{ijk} r_{ijk}}$$

Note that this is the relative frequency of angles in the range $I = [\theta_1, \theta_2]$ for a specific stroke and participant. For obtaining the overall relative frequency of a participant we simply have to include a sum over the $j$ index (adding all corresponding strokes), and for obtaining the relative frequency over all participants we have to sum over the $k$ index.

## 5. RESULTS

### 5.1 User evaluation

A total of 23 users participated in the test, 15 females, 7 males and 1 preferred not to reveal their gender. Participants ages ranged from 22 to 45 years old (mean=30.22), with variable expertise in music and drawing (self-reported, for each case, in a scale from 1 meaning no experience to 5 meaning an expert). The quantitative assessment resulted in a SUS of 77.6 and a CSI of 71.3. Figure 3 shows the SUS average evaluations for each of the 10 questions. As shown in the figure, participants found SonicDraw easy to learn and use, while they didn't show particular interest in using the tool frequently. Figure 4, in turn, shows the raw values of the six different creativity support factors, exploration being the highest evaluated factor and collaboration the lowest one - as can be expected since we were not assessing collaborative factors in this study.

The evaluation scores were not even across groups of different levels of expertise both in drawing and music. As figure 5 shows, intermediate levels of expertise, both in music and drawing, showed the highest scores. Interestingly, this happened for both the CSI and SUS evaluations.

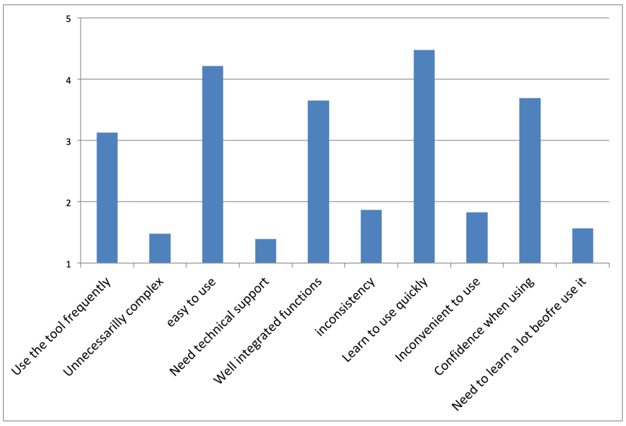


**Figure 3**: Results of the SUS evaluation

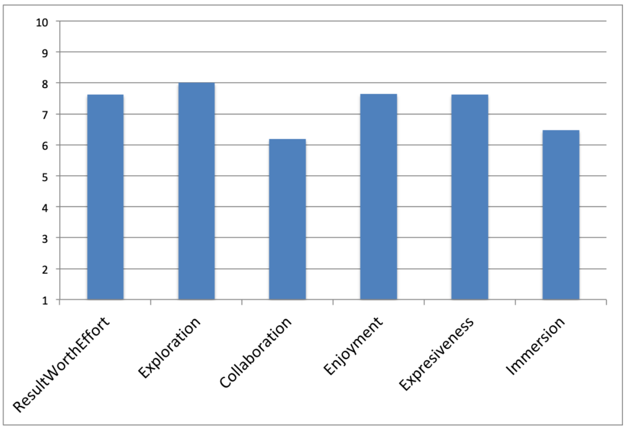


**Figure 4**: Results of the CSI evaluation

### 5.2 Thematic analysis

The inductive thematic analysis led to 5 main themes:

1) *Erase tool:* 15 participants pointed as a drawback the lack of an erasing tool.

2) *Sound design:* 9 participants said that SonicDraw could be useful in the sound design process. This could be divided in three subgroups. A first group pointed out that they would be interested in using SonicDraw as a tool or patch embedded in some other

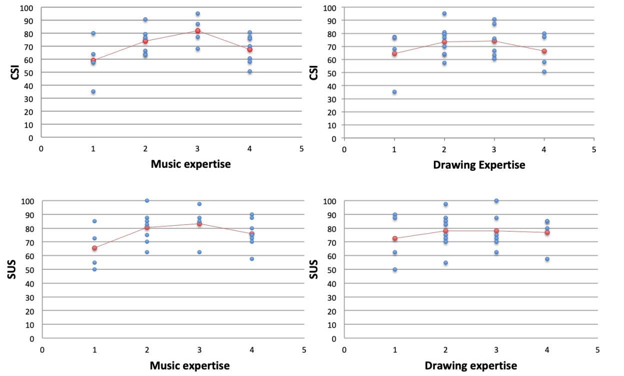


**Figure 5**: SUS and CSI scores depending on self reported level of expertise in music and drawing

software (e.g. Ableton Live, MAX/MSP). A second group envisioned SonicDraw as a tool for sketching new ideas in the beginning of the music composition process. A third sub-group described a more general use to explore easily - for musicians and non-musicians - new unexpected sound textures.

3) *Teaching purposes:* 8 participants suggested that SonicDraw would be useful in a pedagogical context. Because of the playful character of the tool, they said it could help children to learn often difficult-to-grasp concepts such as pitch/frequency and timbre features. Some users even suggested the exercise of sonification of images as a good exercise for children: “it would be very nice to hear the sound of particular images or drawings, like an exercise of translation...what sound would have a tree, a flower, an animal, etc”.

4) *Intuitive:* 5 participants said they liked the intuitiveness of the tool given by the mappings between shapes and sounds and because of the proper feedback: *“you can quickly sketch and hear the result”*.

5) *Freedom and exploration:* For 6 participants, the fact of having a continuous 2-dimensional space, plus the possibility of thinking both in the sound and visual aspects at the same time, created a sensation of free interaction and flexibility in participants. 3 participants explicitly said they enjoyed exploring the tools and how drawings interacted with sounds.

### 5.3 Direction of movements

In figure 6, a polar histogram shows the overall angle frequency obtained for all participants. We can appreciate a significant deviation to the positive part of the x axis. In the histogram, the maximum relative frequency is in the $[-10°, 10°]$ interval, with a value of $0.111$ for $[0°, 10°]$ and $0.107$ for $[-10°, 0°]$. As well, the interval $[-90°, 90°]$ accumulates the $76.9\%$ of the relative frequency, meaning that more than three quarters of movements where directed to the right (though not necessarily horizontal).

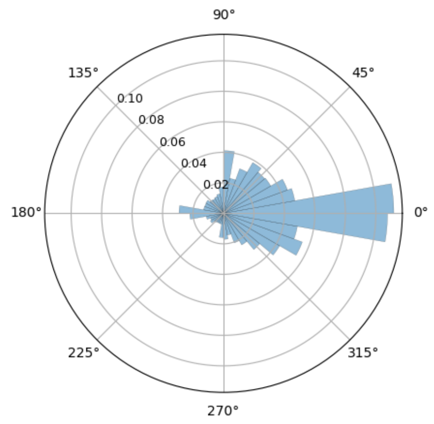


**Figure 6**: Relative frequency distribution for angles in stroke drawing. The radius of each angle interval corresponds to how frequent that range of angles was in participants strokes.

## 6. DISCUSSION

### 6.1 Types of interaction

Figure 7 reflects the two expected extreme cases of interaction discussed in Section 4.2. In the first case (left side) we can clearly notice the horizontal tendency of strokes, and closed shapes as circles are absent. We call this the “music score” limit case, as the visual part is merely functional, just as it happens in a music score. Also, the angle distribution displayed in the bottom of the drawing shows a marked tendency to horizontal lines drawn from left to right. In contrast, in the second case (right side) we can see that concrete or abstract drawings are the centre of the piece. As the sound that emerges is merely a consequence of the image, we call this the ”image sonification” case. This second case shows a more even angle distribution of movements, when compared with the first case.

Most of the interactions lay in between these two poles. As an example, figure 8 shows a typical interaction which combines both above mentioned strategies. Interestingly, we can notice both very concrete drawings like a house but also more abstract shapes. We also find soft straight lines which probably evoke a melodic intention, similar to the music score case. We can even notice music notation alike symbols (upper right corner, red shapes), reflecting the centrality of music and an explicit arrangement of objects in time.

The usual combination of drawing-centered and music-centered strategies suggests not only that there was a cognitive trade off in choosing between a musical and visual interaction, but also that this trade off was a successful mechanism of fostering new ways of creation and exploration, which is corroborated by the recurrence of the concepts “exploration” and “free” (interaction) in the thematic analysis. In support to this hypothesis, the best evaluated of the six factors in CSI was exploration. A good description of what this combination of strategies achieves for user interaction is given by a participant:

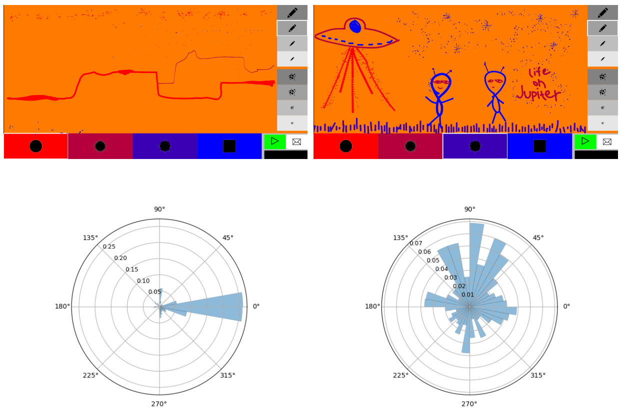

**Figure 7**: Two examples of drawings with their respective stroke angle distribution. Left: a participant who used SonicDraw as an extended music score, with significant awareness of the time-pitch dimensions in the canvas, and with stroke movements highly biased towards the right side. Right: a participant who used SonicDraw primarily as a drawing tool. Here, we note closed shapes and even figurative representations, with no specific bias in stroke directions

**Figure 8**: An intermediate case. This participant alternated across the drawing-centered and the music-centered strategies.

> *I enjoyed the mappings - some are very intuitive, others more surprising. I really liked the rhythmic effect created by acceleration/ fast strokes across the 'page'. It made me think a little differently about organising sound, more about gesture and concentrations of frequencies than notes and rhythm. I like that you see the entire piece at once because then overall shape and structure becomes big concern.*

We see an explicit account of moving from the usual time/ pitch domain to a more visual consideration of music notes.

### 6.2 Design goals

In section 3.1 we described a series of challenges to be taken into account. In the light of the obtained results, here we discuss whether they were successfully accomplished:

1) *Intuitive and vague:* Intuitiveness was a salient feature of SonicDraw, both in the SUS evaluation (figure 3, *easy to use* and *learn to use quickly*) and in our thematic analysis. We attribute this to the fact that users got the sensation that they were actually manipulating strokes and sounds, rather than clicking buttons that mapped to convoluted computational operations. This is in line with the design principle of direct manipulation [28]. Regarding vagueness, as shown in section 4.2, we noticed two extreme kinds of interactions: a first one that was led by musical aspects - the awareness of time and pitch axes was clearly reflected in the piece - while a second group centered the piece in the drawing aspects, relegating sound aspects as a mere consequence of the drawing.

2) *Freedom and mapping:* Freedom of creation was also a salient feature for several participants in the thematic analysis. The mapping from these free forms to sounds was well understood and intuitive, as reported by participants. This was likely due to two main reasons. Firstly, the association of every sound with a specific color, and a marked difference between colors and their respective sounds. Secondly, a quick feedback both in the visual and sound scopes. Shapes appeared instantly as the mouse was dragged and sound started as soon the play head moved over the corresponding shape.

3) *Beginners and experts:* This was maybe the weakest point of SonicDraw. As shown in figure 5, the highest values both for SUS and CSI are found in intermediate expertise levels, both for musical and drawing expertise. Adding to this the fact that the immersion factor was the second lowest rated factor of the CSI evaluation and that participants were not particularly keen on using the tool frequently (SUS evaluation, first question), we conclude that SonicDraw fails in engaging for further expert usage. We hypothesize that this could be caused by two reasons. Firstly, although exploration is fostered in a first instance, in longer interactions users could feel limited, as sounds timbres are restricted to four, and the timeline is constrained to very short sounds. Secondly, when asked about possible contexts in which they would use SonicDraw, participants usually gave very general contexts such as "educational purposes" or "just for fun", but a real applied context within their own lives was rarely given.

## 7. CONCLUSIONS

In this work we have presented a browser-based application called SonicDraw, which allows the free creation of sound/visual pieces where users can choose how musical or how visual centered the piece is. We defined three key design goals regarding our tool: (i) to be easy and intuitive to use but also to not give cues that are specific to drawing or sonic aspects, (ii) to allow freedom in drawing but still allowing a clear mapping from visual to sound, and (iii) to be suitable for beginners, but that it also allows the further exploration of complex patterns by expert users.

Through the analysis of drawings, we found that participants used SonicDraw in very different ways. We found extreme cases where participants used the tool in an either purely drawing-centered or sound-centered fashion. We called these extreme cases the "music score" and the "image sonification" limit cases, respectively, as it is the metaphoric function they accomplish. Supporting design goal (i), most of participants used a combination of these two strategies, letting both sounds and drawings intermingle in a creative and interactive fashion. As was also outlined in other works (e.g. Xenakis' UPIC), we suggest that this combination led to fruitful feedback loops, as sketching is not only a way to translate our mental ideas to a paper or canvas, but it is rather an embodied way of thinking and create.

Participants found SonicDraw a very intuitive and exploratory tool. They emphasised the easiness to learn and use it, as well as the importance of an intuitive mapping from shapes to sounds, suggesting SonicDraw fulfills design goal (ii).

Goal design (iii), in turn, stays an open challenge. The tool showed to be interesting enough for participants with an intermediate level of musical or drawing skills, but it failed in engaging participants with more expertise or for longer times. Users seemed to rapidly find limitations both in the allowed sounds and in the time constrains of the canvas. This yielded several suggestions and ideas for further improvements and explorations. In the following we enumerate possible future lines of work that tackle these suggestions, and we invite others to contribute with, as the code of SonicDraw is open source.

Firstly, and quite unexpectedly, it seems that this kind of tool could be very suitable for teaching purposes, as suggested by several participants. Its simplicity is key for the direct manipulation and playful attitude which can be very useful for children engagement.

A second possible line for SonicDraw is sound design. However, converting SonicDraw in a sound design tool would need to add a substantial amount of sound features (e.g. advanced timbre features) that would hinder the intuitive use of the tool. As one of our aims is to engage also non musical users, a possible alternative would be to have a specific professional branch of SonicDraw that includes advanced sound manipulation features. A different approach would be to provide SonicDraw with a communication protocol such as Open Sound Control (OSC), which would allow to connect SonicDraw with professional DAWs or other music software, thus expanding its capabilities and possible uses.

Finally, we emphasise the low score that SonicDraw had in the collaboration factor of CSI assessment (figure 4). This is because SonicDraw is currently thought to be used at the individual level. However, extending SonicDraw to a collective used tool would be feasible thanks to its browser-based nature. This would allow two (or more) users in different parts of the world to instantly and collectively create a SonicDraw piece. The possibilities of these new features are wide and could lead to new unexpected ways of audiovisual creation.

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