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Wabi-Sabi in Virtual Reality Sketching

Toward a Digital Creator's Posture Change

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ABSTRACT

Traditional design promotes abundant, inexpensive, and disposable ways to create that are not compatible with sustainability. The authors explore alternatives to this paradigm by comparing a virtual reality sketch method with a new approach inspired by the traditional Japanese concept Wabi-Sabi. An experiment limited users' amount of virtual paint and removed users' ability to erase, and while participants' creative approaches and processes changed, they were satisfied with the results. Combining Wabi-Sabi with digital technologies provides a concrete opportunity to "go forward" by incorporating sustainable considerations in practice and in the development of tools for digital artists and creators.

WABI-SABI AS AN ALTERNATIVE PARADIGM IN DIGITAL CREATION

In the context of sustainability, while artists and creators are increasingly using technologies [1], they also tend to be more aware of the energy impact of their digital tools [2]. This paper investigates how to complement digital creation with ecological awareness.

From early research on sketching using technology of Ivan Sutherland's Sketchpad (1963), which allowed hand sketching with a light pen [3], to modern immersive tools, gesture analysis facilitates 3D sketching, which is ideal for spontaneous ideation [4]. Bhamra and Hernandez note that over the last thirty years [5], measures to address environmental damage resulting from the creation process were mainly corrective. We propose that environmental concerns be addressed from the beginning. In this early phase, the dominant model for sketching, as formalized by Buxton [6], promotes "abundant, inexpensive, disposable" properties for "effective" design practices. This idea is inherited from Modernism, which emphasized logical, absolute control, without any tolerance for ambiguity or consideration of usability (see Table 1 in the supplemental material). Other components could, for example, rely on theories of perception in order to optimize the creative process as seen in Gestalt theory [7], although at the risk of being too reductive.

To implement these principles, Buxton's design theory implies that a good sketching tool allows users to redo and correct as many times as possible to make each action quick and easily modifiable to stimulate creativity. Promoting a positive attitude toward error means improvement, but conversely, Buxton urges that errors be erased or corrected as fast as possible.

This perspective as a "main design paradigm" is implicitly accepted and not necessarily questioned [8], and many recent digital sketching tools are based on natural gestures and offer the possibility to modify, delete, and redo [9]. Undoing is also considered an important criterion for usability of digital technology [10]. In regard to this question, we seek alternative and more durable solutions for the utilitarian and aesthetic ends of the undo function.

VR drawing tools such as Quill or OpenBrush (formerly TiltBrush) target creative tasks and have been used by artists such as animator Glen Keane and illustrator Goro Fujita. However, according to our analysis, they are developed around modernist design principles (see Table 1 in the supplemental material).

At the same time, the undo function is increasingly questioned, as it tends to homogenize creativity and produce the "too polished" effect of digital art [11]. Some digital artists, such as Cedric Babouche [12], recently adopted the radical posture of working without the undo option in 2D creation software to integrate the "imperfections" of hand gestures

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[13,14], to get a "rougher" result, in addition to stimulating their creativity. This has not yet been experimentally evaluated.

We propose a reconsideration of the notions of errors and corrections by revisiting Wabi-Sabi, a traditional Japanese aesthetic. According to Koren's artistic approach [15], Wabi-Sabi's core principles are founded in tea master Sen no Rikyu's work, which was an alternative to the dominant 16th-century opulence in Chinese art. Nowadays, it is viewed as "a counterpoint to Modernism," since it emphasizes impermanence and imperfection. "Nothing lasts, nothing is finished, nothing is perfect" [16]; the philosophy also emphasizes harmony with nature. It is traditionally experienced in a tea house, a rustic hut based on a typical Japanese farmer's house, which offers tranquility and simplicity.

One of Wabi-Sabi's artistic forms is Japanese calligraphy, a traditional craft that conceives of errors as impossible to correct. Following this idea, the concept of "error" has no reason to exist.

We found a similar definition of error in the field of improvisational theater. Here, error is the "subjective impression of not having achieved the desired objective." In the case of improvisation exercises like the failure bow, failure is celebrated as a victory and therefore relativized [17].

With this relationship to errors in mind, we investigate how design could help in the adoption of sustainable digital behavior in the long term. We propose using Wabi-Sabi as a lens to reconsider people's creative processes.

AIM(S): TOWARD MORE SUSTAINABLE DIGITAL CREATION

Creation and Experimentation in Virtual Reality

We focused on virtual reality (VR) since it is an efficient tool with creative potential that aids in creative spontaneity [18]. It shows much potential to improve early phases of prototyping [19].

It is increasingly used by creators, replacing physical tools that consume material. Considering the overall expansion of digital tools, which, in turn, increases energy consumption as well as the primary resources needed [20], the direct ecological impact of creation in VR needs to be addressed.

Since our practical usage focuses on creativity using digital tools, we developed a VR sketch creation task. We consider a VR sketch a drawing in a virtual space, in 3D, enveloping the user while offering the possibility to move freely. We identified different creative tasks using sketching in VR:

- a creative problem-solving task; for example, Fleury et al. asked participants to design a workstation for a wheelchair user. They noted that the virtual environment improved creativity by inducing soft fascination and "attention restoration" in the participants [21];
- an idea generation task; for example, the participants are asked to sketch original dresses [22].

This paper explores creative idea generation through the design of a hut, without any specific constraints. As mentioned above, the hut refers to a teahouse where Wabi-Sabi is typically experienced [23] , and this prompt allows for more creativity than standard reference models like the Stanford bunny [24].

Problem

Our research questions how to get creators to adopt an attitude rejecting the notion of "error" and constraints in the digital creative process.

Following Wabi-Sabi principles, the tool should encourage imperfection. To that end, we challenged the concept of "error" as previously defined in order to change the perception of correcting imperfections during the creative process.

Since it is difficult today to find tools for ideation or design that consider sustainability, we propose a custom tool that encourages users to adopt a Wabi-Sabi approach.

Hypotheses

We propose adding Wabi-Sabi-informed creative constraints to VR sketching software for creators. In fine arts education, adding constraints helps stimulate creativity, the "poetic constraints" of the *OULIPO* literary association being a representative example [25].

As a theoretical hypothesis, we suggest that questioning the notion of error through Wabi-Sabi will allow the VR approach to become more sustainable. We expect the study of users'/artists' creative behaviors, stimulated by "sustainability constraints," will give way to a new framework of digital tools designed with ecological awareness in mind.

As an operational hypothesis, due to Wabi-Sabi's relationship to errors and to Metayer et al.'s conclusions [26], we expect that adding creative constraints, in our case, inspired by Wabi-Sabi, will allow creators to adopt an attitude oriented toward sustainability by accepting—even embracing—what initially may have been considered errors. To explore this theoretical hypothesis, we include here a list of operational sub-hypotheses to check the evolution of participants' creative practice and expected results for sketching in VR while removing the ability to erase. These operational hypotheses correspond to items in a quantitative questionnaire:

A. Change posture of creation;
B. Imply an economy of virtual paint;
C. Less rejection of the experience;
D. Feeling more spontaneous;
E. Feeling more freedom;
F. Feeling more present;
G. Feeling more guided by sensation than intellect.

Regarding the qualitative approach, we hypothesized that we would observe a change in creative attitude during the interview phase. We posed an open question to participants about their relationship with the notion of error within their creative process both before the experiment and after.

METHOD

Participants

The study involved 28 participants (19 males and 9 females), ranging from 21 to 34 years old, with an average age of 28 years old. As they were students in VR development and

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Fig. 1. Two participants performing the VR sketching task. (© Gaëtan Henry)

3D art, we expected their points of view to be diverse. Also, we expected they would be future users of VR digital creation tools, and interested in sustainability. All participants were volunteers and unremunerated.

Task and Experiment Environment

We asked participants to draw a hut from their imagination, in reference to the Wabi-Sabi teahouse, with a sketching tool using a VR headset (Oculus Quest 2) (Fig. 1). The sketching experiment was conducted individually, but two participants did different experiments at the same time in the same room. The sketch was in 3D and free from specification, without any problem-solving prompts. The experience ended when the participants themselves considered their drawings finished. We did not impose a time limit for the experience, and the average sketching time was about 7 minutes.

The software used, called TimeToSketch, is based on the Unity3D engine and allows users to draw lines with 4 different brush sizes and 17 different colors (Fig. 2a).

Virtual paint is usually an infinite resource in digital creation tools. But in comparison with the real world, material is limited in the same way as primary resources and energy needed for technology. To reflect that, we decided to limit the virtual paint quantity to provide a biomimicry context.

We choose to focus on the undo function since it doesn't exist in the physical/natural world. The undo function usually removes the most recent part of the creation process as if it never existed. We kept the eraser as a correction tool but we aimed to find a relevant analogy for material behavior in the real world, and we were inspired by how material can be removed and reused in ceramics. Following the principles of craft and material (such as clay), we decided that erased virtual paint would return to the gauge to be reusable.

Finally, we wanted the participants to have a more accurate perception of the virtual sketch's original scale and of the virtual paint quantity. To ensure this, participants were not able to scale the virtual environment while sketching.

a

b

Fig. 2. (a) TimeToSketch menu. (b) Gauge for limited virtual paint connected to the virtual controller in TimeToSketch. (© Gaëtan Henry)

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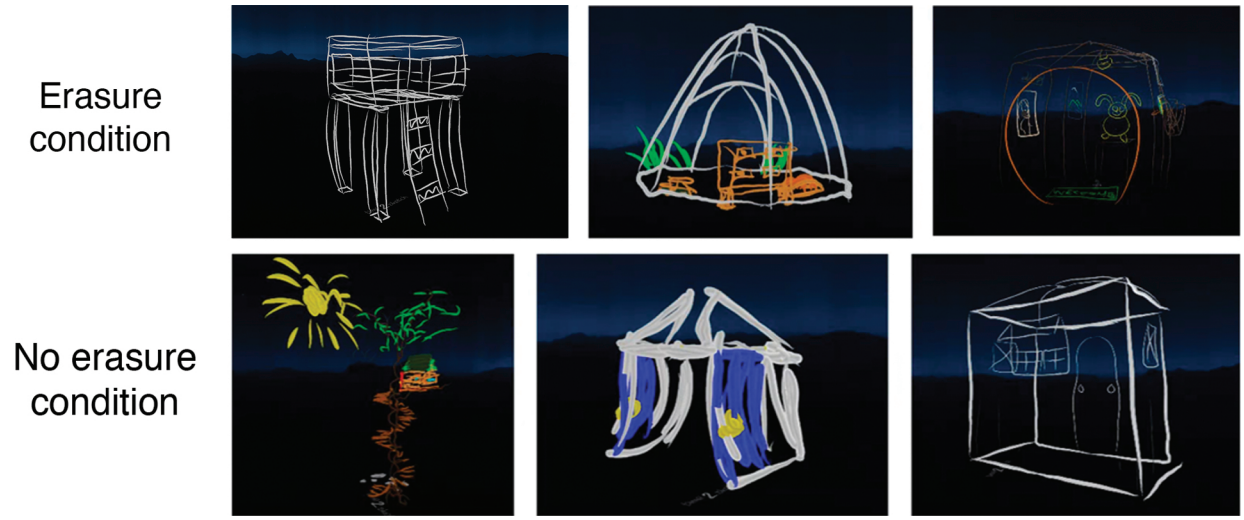

Fig. 3. Examples of huts drawn in TimeToSketch. (© Gaëtan Henry)

We asked that the participants follow four rules that aligned with physics in the natural world:

1. While sketching, a gauge in the participant's field of view shows the amount of "virtual paint" left to underscore the limits of the resource (Fig. 2b)
2. Since undo does not exist in nature, it is unavailable in this experiment
3. The eraser remains for corrections, and the paint erased is returned to the gauge of available material (Fig. 2b) as in ceramics
4. The environment scale function is locked to keep the sketch at human scale

Experimental Conditions

This study compared the experience of creating the hut with the following two conditions:

1. Erase condition: The erase function was allowed and the virtual paint erased returned to the gauge to be reused
2. No-erase condition: The erase function was removed

The experiment (Fig. 3) was conducted in within-subjects design: Each participant performed the task twice in two different experimental conditions, with the possibility in the first condition to erase strokes made by clicking on them (erase condition), which was not allowed in the second condition (no-erase condition).

To avoid order bias on the results, the order of the conditions was counterbalanced (half of participants followed the experimental conditions in one order and the other half in the other order). Before the experiment and after each sketching session, participants answered quantitative questionnaires about their feelings while sketching (for instance, satisfaction, if the sketch is finished or unfinished, relaxation, spontaneity, comfort, calm, presence, freedom, instinctive, conscientious, surprise, need to adapt or correct, and so on). They were also interviewed about their relationship with the notion of "error" in creation to observe whether their personal vision and creative process had changed.

Quantitative Measures

The TimeToSketch software used for the experiment allows recording of many different user data, such as the scene volume, the number of dots of each virtual paint curve, the number of color changes, and the head pitch, yaw, or roll. We cross-referenced those elements with questionnaire answers to analyze the results.

Questionnaires

We had to design a questionnaire based on Wabi-Sabi characteristics. As far as we know, there is no formal categorization of the analysis of experimental results based on Wabi-Sabi. We asked quantitative questions based on tables comparing Modernist thought and Wabi-Sabi in Koren [27] to establish a set of categories for analysis of the quantitative questionnaire.

Because Wabi-Sabi is transversal, its formalization is difficult, so we used specific elements in our questionnaires. Participants answered 21 questions about their feelings during the experience. We had them chose a number from 1 to 7 to allow for nuance. Example: Was the experience satisfying (rated 1) or unsatisfying (rated 7)? Were your gestures large (rated 1) or small (rated 7)?

We also interviewed participants about their relationship with "error" before and after each experiment.

RESULTS AND ANALYSIS

We were not analyzing the VR sketches themselves; we were simply checking that participants understood the task objective and the rules. We chose to focus on the creators' emotions during the experiment.

Quantitative Results

Figure 4 presents the means and standard deviations for user responses to the questionnaire. As anticipated, it appeared that this creative constraint in VR changed users' relationship with the notion of error and their creative attitude (Hyp. A). We noticed that participants felt the need to adapt to their creation rather than to correct it.

Inferential comparisons indicated a significant shift in satisfaction (Hyp. C, $p = .008$). This was an unexpected positive

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Fig. 4. Means and standard deviations of the scores for the quantitative questionnaires about the participants' feelings.

result. We imagined it would be positive from a sustainability perspective but not from the user experience point of view, as we thought users would feel constrained. This satisfaction result is important for the generalized adoption of this idea. The eraser condition existed to ensure rigor, since they had a correction tool. The organic rendering of the VR hand-drawn lines and the feeling of not having enough virtual paint to finish the sketch did not create dissatisfaction as we thought (Hyp. C). On the contrary, it seems that the sense of work unfinished brought the user a feeling of presence inside the VR creation.

Differences are also significant for feelings of presence (Hyp. F, $p = .045$) and of freedom (Hyp. E, $p = .040$), but not for spontaneity (Hyp. D, $p = .511$) nor for feeling guided by sensations (Hyp. G, $p = .332$). Regarding the participants' creative attitude (Hyp. A), "feeling the need to adapt" was higher in the no-eraser condition and the "feeling the need to correct" was higher in the eraser condition ($p < .001$).

Finally, regarding the limiting of virtual paint (Hyp. B), the number of dots in the sketch was higher in the no-eraser condition ($p < .001$), and the number of color changes was higher in the eraser-enabled condition ($p = .039$). This reveals an "adaptability of our participants using different means to achieve the same effect," regarding the constraint as also noted by Christie et al. [28] in their studies which compared the paper drawing's erasure rate with the digital drawing on tablet's erasure rate.

Qualitative Results

Before the experiment and after setting each of the two conditions, we asked an open question about each participants' relationship with the notion of error to determine whether there was a shift in their creative attitude.

We categorized each answer and then analyzed those categories with an intersubjective validation process with three judges who classified the participants' qualitative responses; then we compared. The similarity score was greater than 85%. The four categories of participants' relationship with error that emerged from the intersubjective validation process were:

1. Active use: acceptance and mention of personal use of the error, as if they use it to their advantage.
2. General acceptance: general mention of the fact that errors can be kept without mentioning a possibility to repurpose the error or use it.
3. Frustration: the error provokes emotional reactions;
4. Active rejection: the error is a problem and it needs correction.

After validating these answers' classification, we plotted the evolution of participants' relationship with error after each experiment (Fig. 5).

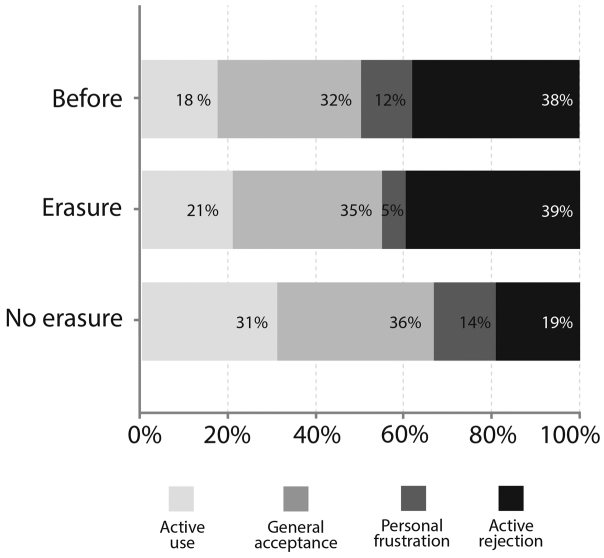

Fig. 5. Bar graph indicating participants' relationship with the notion of error before and after the experiment, as well as between the eraser and no-eraser conditions.

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The answers are considerably different before the experiment and after each condition. Before the experiment, we note active use (18%) and acceptance (32%) are the lowest; frustration is about 12%, and active rejection is high (38%).

When given the ability to erase, active use is slightly higher (21%) than before the experiment but lower than without the eraser; acceptance is higher than before (34%); frustration is the lowest (5%), and active rejection is the highest (39%).

Without the eraser, active use (31%) and acceptance (36%) are highest, while frustration (14%), and active rejection are the lowest (19%).

Between the no-eraser and eraser conditions in Fig. 5, we identified qualitative results confirming our hypothesis of change of creative attitude. We then refined this main hypothesis into four categories. The four categories identified in the intersubjective categorization process are further confirmed by the distribution of the answers:

- More use of error
- More acceptance of error
- Less rejection of error
- More frustration with error

According to the qualitative results distribution described above, we propose a double analysis: first, one of VR sketching in general, and second, one regarding corrections in VR sketching.

Regarding VR sketching generally, the acceptance of error changes between theory and practice. We deduce that the perception of error in the creative process is better after sketching in VR.

Regarding corrections in VR sketching, the relationship with error evolves:

- before the experiment, participants are more likely to reject error;
- with eraser: highest rejection, more acceptance and more use than before, lowest frustration;
- without eraser: highest active use and acceptance, lowest rejection, but highest frustration.

Removing the eraser function shows adaptation, which proves the possibility of a creative attitude change.

Some unexpected revelations included: During the intersubjective process of validating the categorizations for the qualitative questionnaire, we found four users were frustrated not with the error (which was the main question) but with the correction itself. Also, during the questionnaire after the experiment "with eraser," four users spontaneously said they were frustrated with the correction.

We assume some of them were in a state of acceptance, and some were rejecting the error, but their main concern was the frustration that comes with excessive correction, time, and effort invested in perfecting their sketching. The quest for perfection doesn't always bring better results. Those users appear to be frustrated by both error and by correction. In that case, could an attitude change help in managing frustration?

Discussion

This study sought the creator to adopt an attitude of accepting errors and what may have initially been considered errors, as well as constraints in the digital creative process. While an eraser function is considered central to maximize users' creativity [29], our results present a different view.

The environmental test used the software TimeToSketch, originally designed using Modernist logic, but we were still able to implement these new "sustainability constraints" easily without it being complex or time consuming.

We decided to remove the undo function as a rule and the eraser as a condition. However, the users could choose to use undo or the eraser. Is it possible to encourage users to adopt this posture naturally and to guide them in this personal choice? In that case, the software could suggest creative constraints the user could adopt to do so.

In this study, we chose to remove undo as a "sustainability constraint." But we also acknowledge that some artists, designers, and psychologists have questioned the undo function for creativity reasons [30]. Being able to undo is considered central to unleashing users' creativity [31], and designers often say that they need to use much "trial and error" in sketches to obtain a "perfect line." Given that existing VR drawing tools are mostly designed within a Modernist paradigm based on technological functions, the fact that we successfully proposed to remove an "important criterion" of usability reveals a process allowing for more freedom and resulting in a change in the creators' attitude.

CONCLUSIONS AND PERSPECTIVE

In this study, we investigated how to get the creator to accept errors and constraints in the digital creative process.

We conducted a sketching task experiment with a constraint questioning the notion of error and the possibility of correction inspired by Wabi-Sabi. This was a way to reconsider traditional design guidelines that promote a view of errors as problems to be erased or corrected as quickly as possible.

We observed that removing the ability to erase and limiting the quantity of virtual paint indeed changed the creative attitudes and processes of participants. Without the ability to erase or to undo actions, they tended to use and accept the error as an alternative way to create, reconsidering the notion of error and imperfection as natural.

The creative constraints we proposed appear to satisfy and to help creators in developing their creativity, opening the door to surprise, emergence, or serendipity. This indicates that there is an acceptable alternative sketching method. We interpreted our results as due to the more realistic material properties in the no-eraser condition (as in Japanese calligraphy).

We suggest another interpretation: that the impossibility to correct could cause more planning during the creation task. We expect the Wabi-Sabi paradigm to be an inspiring starting point for new ways of making, collectively, among researchers, artists, and designers.

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For many years, the Modernist paradigm of creation influenced creators and researchers. Our results offer an opportunity to think "outside the box" where interesting methods may remain unseen.

Buxton identified several characteristics that sketching requires in a design project in order to be "effective" from a productivity perspective. Based on his work, and Koren's comparison of Wabi-Sabi and Modernism, we are currently investigating how to use Wabi-Sabi as a new standard for sketches in a more sustainable digital form as a comparative table.

The Wabi-Sabi-inspired method seems to radically contradict Modernism's approach to sketching. That said, we did find convergences that require additional investigation. Meanwhile, it seems possible to combine the two methods in any creation process.

As a perspective, we propose a typology of "sustainability constraints" that could benefit creativity and explore the limits: How many new creative constraints can we put together without overloading the creators? Therefore, we propose the following future experiment conditions inspired by Wabi-Sabi:

- Unlimited virtual paint versus a limited gauge of virtual paint
- Undo enabled versus undo disabled
- Carving with virtual paint versus adding virtual paint (as a metaphor for sculpting)
- Virtual paint is lost when erasing versus virtual paint erased fills the gauge back to be reusable (as in pottery)
- Sketches remain permanent versus erosion of sketches over time during the experience (degradation, decay)
- Sketch rescale versus no rescale
- Virtual paint color change versus no color change
- Light environment and big virtual space versus small environment and dark virtual space

We realize while ideating and creating; since users don't have to think about undo/correct imperfections, they can focus on pushing creativity forward, by playing or improvising with the content. This refers to the concept of *poiesis*: "The task of the craftsman is not to generate the meaning, but rather to cultivate in himself the skill for discerning the meanings that are already there" [32]. Going forward instead of backward allows the conservation of energy, attention, and time that could be (re)used in the creative process, allowing ideas to infuse.

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