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# **Supporting Reference Imagery for Digital Drawing**

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# Abstract

There is little understanding in the challenges artists face when using reference imagery while creating drawings digitally. How can this part of the creative process be better supported during the act of drawing? We conduct formative interviews with artists and reveal many adopt ad hoc strategies when integrating reference into their workflows. Interview results inform the design of a novel sketching interface in form of a technology probe to capture how artists use and access reference imagery, while also addressing opportunities to better support the use of reference, such as justin-time presentation of imagery, automatic transparency to assist tracing, and features to mitigate design fixation. To capture how reference is used, we tasked artists to complete a series of digital drawings using our probe, with each task having particular reference needs. Artists were quick to adopt and appreciate the novel solutions provided by our probe, and we identified common strategies that can be exploited to support reference imagery in future creative tools.

# **1. Introduction**

Reference imagery is any image an artist might refer to in order to assist the creation of an artwork. The reason reference is used varies from artist to artist and from artwork to artwork, and is usually integrated into the artist's workflow through ad hoc means. It might be viewed in a web browser, imported into image editing software directly and placed on or around the digital canvas, traced, viewed on a mobile device while drawing in a sketchbook, and so forth. Reference is not only used to recreate details of an unfamiliar subject; it can also act as a form of inspiration before the artist's brush hits the canvas. The use of reference is a natural and exciting part of the creative process. Today, when many artists are working almost exclusively with digital tools, we wonder: **how do artists use and access reference images while drawing digitally?** 

Capturing how artists use their tools is challenging because of the diversity of tools and workflows they adopt. It



Figure 1. Artists adopt a variety of strategies when using reference imagery during the creation of drawings. We design and deploy a technology probe to log how artists organize and access their reference imagery, while also exploring design solutions to address limitations described in our formative artist interviews. Our probe identifies common strategies artists adopt relative to why they are using reference, and artists responded positively to the just-in-time presentation of reference it provides.

is perhaps even more difficult when reference is involved, as some might view its use as taboo, where the artist's output might not be viewed entirely as an original product of their imagination. In *Secret Knowledge* [6], painter Hockney reveals how optical technology has long supported artists, usually under a cloud of secrecy, and we see similarities with how artists use reference, "*I know artists are secretive about their methods—they are today, and there's no reason to suppose they were ever any different. They were probably even more secretive in the past...*"

An interesting facet of the space surrounding the use of reference imagery are the possible effects of *design fixation*. Defined by Jansson and Smith [11] as "*a blind adherence to a set of ideas or concepts limiting the output of conceptual design*," or more simply put in the context of drawing, the inadvertent over-copying of source material during the design process. Our goal is not only to understand how reference is used by artists, but also to learn the contexts where fixation concerns are most prominent. How do artists manage using reference imagery, ensuring their creative output is an authentic representation of their artistic voice?

We first conducted formative interviews to understand how and why artists use reference in their day-to-day work (§3). We identified a variety of ad hoc strategies artists use when integrating reference into their creative workflows and learned about where reference images are placed, how long they are visible, if they are imported into image editing software or viewed side-by-side in other software, and so forth. Our goal is not to provide a full reference solution for artists, but to capture how reference is used to inform future design.

Our formative interviews inform the design of a technology probe [7] in the form of a digital sketchpad to capture how reference is used during the task of digital drawing (§5). Technology probes are not used solely to log how users interact with a system, but also to explore design solutions. Our probe provides a few improvements to address the limitations and ad hoc repurposing of software that our interviewed artists described. We recruited artists to create drawings using our probe and we identified common strategies used when placing and accessing their reference images (§6). Our probe reveals that artists' ad hoc strategies when using reference can be better supported with minimal design intervention.

# 2. Background

We identify a gap in this research space and look at related research in sketch-based interfaces and design fixation to inform our approach to gathering insight into reference usage. For a more thorough background on the history and uses of reference, please see our supplemental material.

### 2.1. Sketch-based drawing assistance

Relevant systems incorporate reference imagery support in some shape or form [3, 8]. *iCanDraw* [3] provides novice artists with feedback on correct proportions based on some reference photo when drawing portraits. *The Drawing Assistant* [8] extracts and emphasizes the *structure* of a reference image, and provides guides to assist the artist.

Sketch-cleanup research has a strong history with reference imagery, and we are interested in how, at a lowerlevel, input images for these systems are created. These past works are filled with drawings or artifacts created using some form of reference, such as the *Benchmark for Sketch Cleanup* by Chen et al. [19], *StrokeAggregator* by Liu et al. [13], and *Bendsketch* by Li et al. [12]. Reference imagery is an almost guaranteed part of the creative process for many artists, and we promote further research in this lower layer to inform future tools and study.

Much of the previous research that grazes the use of reference is intended for those learning how to draw, and provides visual feedback to assist them in this task. We however are not concerned with only the beginner artist but also the working professional artist. We assume that artists want *full* creative authorship over their work and desire no sketch feedback or image processing to be applied to their drawing at hand. Artists enjoy the act of producing their own drawings, and we do not want to take that away from them.

#### 2.2. Commercial Tools

There exists commercial software to support reference imagery: *Pureref* and *Kuadro* [9, 5]. These present imagery in floating windows, ensuring they are always visible. At the time of this writing, the popular iPad drawing application Procreate [16] announced reference support in its latest update. Though artists have technically always been able to import reference images as individual layers (similar to other image editing software), in Procreate reference images have now been given a special home, separate from the art layer stack, in an always-visible floating window; an indication that artists desire more nuanced support for reference. A limiting feature with all of the above applications, and how reference is digitally presented in general, is the *always-visible* nature of the reference unless manually toggled by the artist.

#### 2.3. Design fixation

Youmans et al. [20, 21] explore a set of factors affecting how much fixation occurs during the creation of new works and how to potentially mitigate it. They suggest that group work, physical interaction with prototypes, and task interruption can limit the effects of fixation. We are interested in interruption's ability to mitigate fixation by interrupting the task of viewing reference (not the task of drawing).

We also note that fixation concerns might not always be clear when using reference in the creative context, and at times could be more akin to priming. As Colin Ware states in Visual Thinking for Design [18]: "Priming is the reason artists and designers often prepare for a particular creative bout by reviewing relevant images and other materials for a day or two. This gets relevant circuits into a primed state."

# 2.4. Usage

The missing piece in our background of reference is *how* it is used by artists working digitally. We have knowledge of past technologies helping artists bring imagery closer to their canvas — from camera obscura to photography (see supplemental material for further background) — but today many artists are working in entirely digital, and unique, workflows.

Our work seeks to fill this gap and provide a more concrete understanding of how artists integrate reference imagery in today's digital environment.

# **3. Formative Artist Interviews**

We conducted interviews with 14 artists to learn about their use of reference. Participants ranged from professional studio animators and illustrators, recent illustration and design graduates, illustration/art instructors, and freelance illustrators and designers. They self-reported experience creating art digitally as "Intermediate" (n=6) or "Expert" (8).



Figure 2. Reference usage in the wild. Artists use a variety of ad hoc approaches when integrating reference imagery into their workflows.

We conducted semi-structured interviews over video chat. Interviews were recorded and transcribed. Artists were also asked to demonstrate the context in which they use reference imagery via screen sharing, providing photos of their physical workspaces and/or screenshots of their digital working environment (see Fig. 2).

# 3.1. Why do artists use reference?

Artists predominantly describe using reference imagery to help them create something they are unfamiliar with or have not drawn before. However, reference also fulfills other creative roles beyond recreating unique details from a photograph, artists also describe using reference as a source of inspiration or guidance for *color* or *style*.



It is not uncommon for artists to use other artworks as reference material. In this image of a digital workspace from our interviews, **P7** has placed many other artworks as style reference on the right side of their artboard

in Adobe Illustrator. The reference material has distinct graphic shapes and particular color palette qualities the artist is trying to instill into their work. Reference is also used commonly for color selection and establishing color palettes. Recounting their experience using reference for color, **P1** said, "Sometimes I'll steal colours from a photograph. I may open it up in Photoshop to grab the five-color scheme from it ... It's like a color reference."

# 3.2. How do artists use reference?

Artists described a variety of ad hoc approaches when integrating reference into their unique workflows. They provided photos and/or screenshots of their creative environment to demonstrate the context in which they use reference imagery (Fig. 2). One artist described digitally collaging reference to use as a mood board. Another reported viewing reference images on their mobile phone while drawing in a sketchbook. Some described using reference imagery predominantly for tracing, while others avoid tracing reference entirely. Some artists indicated that they look at reference imagery as inspiration, before any brushstrokes are put to canvas, where others begin with exploratory drawing and introduce reference imagery later in the process. Nearly all artists described having no consistent plan when using reference imagery and simply respond to the creative needs of the moment.

Within this variety of approaches, we identify commonalities. Most common was viewing reference alongside image editing software, e.g., viewing reference in a web browser alongside the image editing application's window, echoing the traditional observational drawing technique of alternating between looking at a subject *there* and drawing it *here*. Many artists describe importing reference directly into their creative software when they desire control over the reference (e.g. adjust opacity, size, sample color), but this comes with challenges which we discuss below (§3.3).

Interviewees using a single display tend to view reference imagery beside their creative software. **P14** described a common downside to this approach when trying to view reference and the canvas simultaneously: "*My canvas becomes so much smaller and it also means the reference image is small too.*" See Fig. 2c for trade-offs in canvas vs. reference image size for artists using tablet devices.

When artists desire more control over their reference image, such as resizing, altering transparency for tracing, or perhaps to sample colours from it, importing it into their software is the way to go. As **P11** said, "[Normally] I'll just do a Google image search and look at [reference] on the web, but if it's more complicated, I'll actually save the images and open them into Photoshop."

# 3.3. On challenges when using reference

As described in the previous section, one of the primary challenges interviewees describe when using reference is screen real estate availability. **P9** described the broad sentiment felt by our artists that "*there are always screen real estate issues*." Another concern is the *always-visible* na-

ture of reference, and the management of reference visibility during the creative process. As **P14** stated, "*I don't like importing [reference imagery] as a layer because I have to keep turning it on and off, and that's inconvenient.*"

Other challenges mentioned relate to importing reference directly into image editing software, as its own layer, or in the space surrounding the current canvas/artboard (if applicable), and the visual clutter that ensues. **P3** says, "*If I'm not tracing images, they're all shoved onto the side of my artboard and in a disaster, rather than having to go back and forth from Pinterest and have multiple tabs open at a time.*." Depending on the software used, reference imagery might exist *within* the bounds of the canvas dimensions, e.g., Photoshop, effectively occluding the artwork. Some artists mention not mixing reference imagery in their layer stack because it becomes difficult to keep the current project organized, occludes their current artwork, or it becomes too easy to blindly copy reference.

#### 3.4. Fixation concerns and strategies

Artists reported concerns relating to design fixation, such as the risk of copying reference imagery too closely once imported into image editing software. A common strategy described by our interviewees to mitigate fixation was by reminding themselves to disable/hide the reference after it fulfilled its purpose. Some went further, such as P3, who described avoiding importing their reference into image editing software altogether: "I tend not to import them into my actual artwork, because it would be so easy to just literally [trace] over it ... " Others tell of intentionally searching for low quality images to limit the amount of details they could potentially fixate upon. P8 says "The lower resolution the better, because that represents an abstraction [to the reference image] already." Some artists describe introducing reference later in the creative process to mitigate fixation. **P1** said, "I'll try to draw out of my head initially... And then once I've dialed something in I might go and seek out reference that will help boost the next layer of drawing."

### 3.5. Commercial software used

Interviewed artists predominantly described using their primary image editing software for reference if not viewing reference via web browser or image viewer. They mentioned being aware of other software that caters to some form of reference content, like the pose-able 3D mannequin found in Clip Studio Paint or Poser [1, 2], but none use these tools. Some artists reported using tools to organize mood boards of reference imagery, such as Go Mood Board [14]. None of the interviewees used or were familiar with previously mentioned software specializing *exclusively* in the support of reference imagery (Kuadro or Pureref [5, 9]).

### 3.6. Upshot

Our artist interviews confirm the obvious: how artists find reference (image search), why it is used, and screen real estate concerns. The interviews also reveal the non-obvious such as artist concerns over the manual management of reference visibility, the intentional sourcing of low-quality of imagery, and why they decide to import reference it into their creative software or avoid it altogether.

# 4. The Spectrum of Reference

Our formative interviews emphasize the potential placement of reference material in relation to the artist's intent. We propose the concept of the Spectrum of Reference (Fig. 4) to loosely categorize the reasons why and how reference is used and inform the design of our study with artists using our probe.

On one end of this spectrum the goal is detail recreation, such as tracing an image, where the artist will place their reference material on the canvas itself. A step or two away from this end, and we might see an artist working from a photograph placed beside the canvas. On the other extreme end of the spectrum, reference is used for more interpretive purposes; where an artist might use reference for inspiration in style, mood, or color selection.

In the middle we have a mix of the two extremes. Imagine an animation studio artist painting a background for a scene taking place in a fictional town. They might look at images of previously created backgrounds for style reference and to ensure continuity in the scene. They might add new objects to the scene requiring reference for technical detail recreation, such as an elaborate park bench or an intricate carriage wheel. Though this creative task is full of different reference needs, looking at each reference image individually, the goals become more clear: some images might only require a glance, others might be brought closer to the canvas, others could get traced, and so on. The artist requires a lot of reference management.

# 5. Technology Probe

We designed a technology probe [7] to log how artists use and access reference imagery while also exploring new design avenues to support reference in creative software. Capturing how artists use reference in the current state of the world is challenging considering the range of ad hoc strategies and software artists use, and we are not interested in baseline comparisons. As Dourish [4] said, "*data generated by probes are intended to provide inspiration rather than the basis for analysis.*" To this end, we want to deploy our probe to observe if artists develop interesting patterns when offered different, novel ways of using reference, and view a technology probe to be the ideal tool for the job. Our probe provides the following opportunities:



Figure 3. Our technology probe provides the ability to create reference regions on a digital canvas (a). Images can be associated with regions (b), allowing for automatic just-in-time presentation of reference when drawing (c, d). Images can also become transparent automatically to enable tracing (e).



Figure 4. The Spectrum of Reference. How might an artist adapt their digital workspace to fit the reason why they are using reference?

#### Integration affordances:

- **O1** Allow artists to have a seamless way to integrate and view reference, while accommodating their creative process.
- **O2** Allow reference material to automatically present and hide itself to artists via just-in-time and in-context situations.
- **O3** Allow flexibility in supporting the variety of ways artists might use reference, as described in the Spectrum of Reference.

#### **Fixation mitigation affordances:**

- **O4** Mitigate fixation by interrupting how long an artist is exposed to their reference.
- **O5** Mitigate fixation by allowing images to be presented with less clarity.

#### 5.1. Functionality

Technology probes should be functionally minimal [7]. Ours is a simple sketchpad intended for use with a pen stylus and allows for drawing, the ability to undo/redo, and sample colours. It does not provide the ability to create layers, make selections, or other actions commonly found in image editing software.

Our interviews suggest reference images can be more seamlessly integrated, so we designed our probe to provide automatic just-in-time presentation of reference imagery via the use of **reference regions**, Fig. 3a. An artist can create these rectangular regions on the canvas and associate an image with it via simple drag and drop. When an artist's cursor/stylus enters or exits one of these reference regions, the associated reference image(s) appear and disappear, respectively (**O1**, **O2**). Regions can be repositioned, resized, disabled, or deleted entirely by entering **edit** mode.

Our probe also includes a variation of the reference region we call a **global reference region**. When a global region is entered, *all* reference images associated with the canvas are displayed, similar to a mood board, as was commonly described in our interviews.

Our probe provides the option of adding a **timer** to reference images. Images with a timer will automatically hide after their timer expires (**O4**). This is inspired by interruption's ability to mitigate design fixation [20]. Some artists interviewed reported searching for intentionally low quality images as a mechanism to prevent fixation. Similar to the timer feature, our probe allows artists to easily **distort** imported images via a slider: at position 0, the middle of the slider, the image is left as is. Moving the slider to the left applies a pixelation filter to the image; to the right, the image is blurred, making details less clear.

To quickly enable **tracing** of reference images in our probe, images can become semi-transparent automatically (see Fig. 3e). Image opacity is automatically reduced when an image is placed such that its rectangular bounds intersect the bounds of its associated region (O3). Transparency can be further adjusted by the user. Refer to the supplemental video (at 2m21s) for a demonstration of this feature.

If an artist wants to sample a color from their reference, a shortcut key reveals an eyedropper tool (**O3**). Establishing satisfying color palettes is an interesting problem of its own. We imagine other work like *Color Builder* [17] can fit into this socket to improve the experience.

As Hutchinson et al. [7] state, "a deliberate lack of certain functionality might be chosen in an effort to provoke the users." We design our probe to feel natural to draw in for those familiar with professional tools, but intentionally limited its functionality to see how artists use reference in an open-ended sandbox.

# 6. Study: capturing reference

We conduct a self-administered user study to capture how artists use and access reference images while creating digital drawings. The goal of our user is to quantify and analyze how reference imagery is used and laid out digitally by artists, and to determine the effectiveness of the novel features our tool provides, such as just-in-time image presentation, automatic transparency, as well as the built in design fixation features.

# 6.1. Participants

We recruited 13 participants in total (6 also took part in our formative interviews). When asked about their experience creating art digitally, 5 artists identified as "Intermediate" and the remaining 8 as "Expert." Participants identified as studio artists, post-secondary instructors, freelance illustrators, and recent art school graduates, and hobbyist artists.

Participants downloaded a package containing all required study material (see supplemental material) and were asked to screen capture their desktop and to "think aloud" during the tasks, but this was not a hard requirement. Poststudy interviews were conducted within 1–2 days of task completion.

# 6.2. Task design

A series of drawing tasks were designed to represent different use-cases of reference imagery commonly found in the wild, with each task sitting at a particular point along the Spectrum of Reference ( $\S$ 4). We are not interested in the quality of art created for these tasks, and instead are interested in the process of completing tasks using reference, including the organization of regions/images, and workflows adopted. We asked our participants to:



**T1: Draw a portrait** of the provided subject, trying to match likeness. In the Spectrum of Reference, this task would sit on the extreme end of *detail recreation*.

**T2: Draw an imaginary machine** using any of the provided images. This task would sit somewhere in the middle of the spectrum.

T3: Draw a sofa in the same style as the unique furniture depicted in the provided images. We imagine this *interpretive* task would sit on the opposite end of the spectrum compared to the portrait task, T1.

Artists were given the same set of reference images and were not required to use all provided images. Artists were not expected to create fully realized and finished artworks in such a short amount of time; if they spent more than 15 minutes on a given task, they were welcome to stop and move on to the next task.

# 7. Findings

Our goal is *not* to determine a statistically significant correlation, but rather qualitatively observe some common usage patterns, and unique ones as well. We show a selection of drawings and reference region layouts in our supplemental material, revealing how participants placed and used reference over time within the context of their display.

### 7.1. Image placement

For **T1**, which requires the participant to draw a portrait matching the subject's likeness as closely as possible, 6 participants adopted a **tracing strategy** by sizing their reference image appropriately, dragging it into their primary region, and tracing it. Once initial tracing was satisfactory, these participants then moved the image away from the associated region, and opted for a side-by-side viewing of the reference in order to introduce more of their own artistic touch to the drawing. Participants opting not to trace tended to place imagery outside of the canvas bounds or overlapping it slightly, and did not size images up as much as those tracing.

The most dynamic use of reference imagery occurred during **T2**. Here, participants were often switching between side-by-side observational use of their reference and tracing. This makes sense considering the task sits somewhere in the middle of the Spectrum of Reference. The artist is creating something new from their imagination and likely using reference to inspire and prime themselves. At the same time, they are pulling in reference to help recreate particular details. This approach was adopted by 6 of the 13 participants. The remaining organized their reference in the early stages of the task and never touched them again for repositioning.

For **T3**—draw a sofa in the same style — reference material was nearly always placed outside of the bounds of the canvas. Visualizing results from this task shows some reference images placed within the canvas bounds, but the time stamps of these events reveal they occurred in the initial set up phase of the canvas (see supplemental material). For the duration of this task, images were generally placed beside the canvas. This is not surprising; this task requires artists to internalize and interpret style before producing their drawing. We do not see much reason to trace over the source material in this task, and think back to Ware's thoughts on creative priming ( $\S$ 2.3).

All participants began the tasks by organizing and setting up their regions and images before drawing. This contradicts some of the responses in our interviews, where interviewees stated that they introduced reference into their workflow later, after some initial drawing has already been





completed. Adjustment events (such as resizing, repositioning of regions, images, etc) tended to occur in the early stages of task time (see Fig. 5). This agrees with our study participants' self-reporting of the organizational benefits of our probe; once the artist has organized their reference material to fit their needs, they are free to focus on the act of drawing, and not on the management of their reference materials.

# 7.2. Region placement

We also identify four common region layout strategies adopted by participants using our probe. The provided examples were selected from **T2**, emphasizing that strategies are not necessarily task specific. In the following visual examples, blue rectangles in each drawing represent where artists placed regions in their canvas. Pink rectangles are global regions. To the right of each drawing we show where artists placed their reference images in context of their display device; images are tinted to emphasize their associated region.



**Region over subject:** The most common strategy adopted in our study was the placement of regions in the same portion of the

canvas the artist intended to draw in, resulting in imagery being presented *while* drawing. In many of these cases, artists placed their reference images outside of the canvas space or along its edges, as we can see in the adjacent figure. See a larger version of this strategy in Fig. 1.



**Region away from subject:** In this strategy, regions are placed *away* from the canvas area the artist intends to draw in,

allowing reference to be viewed temporarily with only the flick of a wrist. This strategy comes with some built-in fixation mitigation as the image can only be presented while the artist is *not* drawing, forcing them to internalize their reference. See this strategy in our supplemental video (3m38s). **Tracing:** If an artist desires to trace an image, it is simply a matter of repositioning it such that it intersects its associated region,



which automatically makes the image semi-transparent. And if the artist desires to see their drawing without the reference image they are tracing overlaid on their drawing, it's simply a matter of moving their stylus out of the region. Many artists adopted the tracing strategy for those tasks that existed on the detail recreation end of the Spectrum of Reference, (**T1** and **T2**). In the example here, participant **A8** placed many images *inside* or intersecting their associated regions, revealing the participant was tracing their reference imagery.

**Global regions:** Another common strategy was the use of global regions. Artists place regular regions in a manner that



fits the artist's needs, and a single global region is added to the canvas. In our study, global regions were usually placed along the edges (e.g. pink rectangle in the adjacent figure). By hovering over the global region, *all* reference imagery associated with the canvas is presented, providing the artist with a quick mood board view of their imagery for reference or inspiration.

### 7.3. Fixation mitigation

No participants used the timer feature to automatically hide reference images, nor the distortion feature to perturb images during their tasks. Participants were not explicitly required to use these features as part of the tasks. Many described having no need for the timer, suggesting the automatic presenting and hiding of images was adequate. A3 said, "I didn't really feel like using it because gliding over [the regions] felt like it was timer enough. Like I would just pull away if I didn't want [to see my reference images] anymore," and A9 said, "I didn't notice that [timer feature] because just using the basic features was enough for me". In our study, fixation mitigation is in the hands of the artists. Though the timer and distortion features were not explicitly used by participants in our study, fixation mitigation still comes built-in to the probe depending on how it is used. The region-away-from-subject strategy, for example, ensures that reference is not visible while drawing. When tracing — an act of high fixation — the participant can quickly move their stylus away from their drawing/region to quickly see their drawing without reference, giving them a chance to see how their work stands on its own.

### 7.4. Design impressions

**Ease of learning.** The concept of reference regions was well received by participants and described as easy to integrate into their drawing workflows. **A12** said, "*I was happy that I could jump into edit mode and tweak. And that was a very fast and easy thing to move around.*" **A9** said, "*I like the fact that I can place my imagery wherever I want [in or out of app]. If there are some parts I want to trace over, I could do that, and then move it away and come back to it. That was quite easy".* 

Automatic presentation of images. Participants reported being impressed by the convenience of automatic image presentation in our probe, preferring it over the "traditional" approach of managing reference manually in layers or windows. A5 said, "It's nice to keep your reference images in view while only having the [one] application that you have open." A12 said, "I do really like how the images disappear when you don't want them. You decide where they're useful and then they're gone [...] I don't have to, you know, make that layer invisible."

**Organizational tool.** Participants also described the integrated support for reference enables them to better plan and organize their reference. **A1** said, "*The other thing that I liked about it was as an organizational feature. I liked how this gives a place for reference to exist, and also makes it editable.*" **A6** said, "*It was really nice to be able to set up my screen as I liked and to be able to toggle it pretty easily.*"

**Novice-expert transition:** Participants identifying as experts described a more enjoyable experience than non-experts, perhaps from their previous experiences using reference imagery. Some experts were particularly excited about their experience with our system, provoking them to imagine new workflows in a studio pipeline, such as passing along art assets with prebuilt reference regions integrated into a working file. We view such imagined use-case as the byproduct of a successful technology probe, fulfilling Hutchinson et al.'s design goal of *"inspiring users and researchers to think about new technologies"* [7].

#### 8. Discussion & Future Work

Results from our study make a strong argument that reference regions are *one* possible solution to improving the integration of reference into the creative digital workflow. Artists interviewed described screen real estate as a primary concern, yet our study reveals they left large portions of their desktop empty. This suggests space issues are a byproduct of having to manually manage many reference images. As it stands now, artists are prone to placing and organizing their imagery so that it is all visible, resulting in a visually cluttered workspace that requires extra management of visual assets.

Though there are existing tools that specialize in supporting artists using reference imagery [5, 9], they are essentially image viewers that still require artists to manually toggle image visibility when working. From our study, the automatic presentation of images can remove this sense of clutter by presenting only what is needed on demand and just in time. This also allows artists to focus more on their own drawings and not get too caught up in their reference images. In particular, when artists adopted a strategy to trace reference imagery in our study, they were able to quickly hide the images by simply moving their stylus out of the region bounds, allowing them to focus on their drawing and not have to search through a layer stack to manually toggle reference visibility.

Perhaps this is too cumbersome a hurdle, fixation mitigation features must be *manually* applied by the users in our study. A longitudinal study using a similar probe without restriction in time or subject could help us understand if and how artists would adopt fixation mitigation features on their own.

The act of drawing is full of physical movement, and a proxemic interaction suits this space well [10]. The automatic presentation of imagery via reference regions is admittedly simple, but this simplicity is an effective solution that artists found intuitive to grasp and quick to adopt it. Echoing Myers et al. [15], the design principle of "*low threshold, high ceiling, and wide walls*" in our probe allowed artists to work in a variety ways. This versatility and simplicity shows that improving the support of reference in our creative tools is not waiting behind technically challenging barriers.

# 9. Conclusion

We built a drawing system with integrated support for reference imagery to address concerns raised in our formative interviews. We conducted a user study which allowed us to quantify and analyze how reference imagery is used and determine the preliminary effectiveness of the novel features in our system. Artists appreciated the spatial association of reference imagery on their canvas and common image/canvas layouts were identified. Automatic transparency of images for tracing was frequently adopted, but the design fixation features provided by our system (image timer and distortion) were ignored by users.

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