Beyond the Artifact: Power as a Lens for Creativity Support Tools

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ABSTRACT

Researchers who build creativity support tools (CSTs) define abstractions and software representations that align with user needs to give users the power to accomplish tasks. However, these specifications also structure and limit how users can and should think, act, and express themselves. Thus, tool designers unavoidably exert power over their users by enacting a "normative ground" through their tools. Drawing on interviews with 11 creative practitioners, tool designers, and CST researchers, we offer a definition of empowerment in the context of creative practice, build a preliminary theory of how power relationships manifest in CSTs, and explain why researchers have had trouble addressing these concepts in the past. We re-examine CST literature through a lens of power and argue that mitigating power imbalances at the level of technical design requires enabling users in both vertical movement along levels of abstraction as well as horizontal movement between tools through interoperable representations. A lens of power is one possible orientation that lets us recognize the methodological shifts required towards building "artistic support tools."

CCS CONCEPTS

• **Human-centered computing** → *HCI theory, concepts and models*; **Interaction design theory, concepts and paradigms**.

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1 INTRODUCTION

A longstanding idea in the development of interactive computing is that computers enable their users to accomplish things they otherwise could not—in other words, that computers are *tools*. Recent review papers of creativity support tools (CSTs) [25, 42, 43], for instance, suggest that researchers develop novel tools towards enabling greater expressiveness, creating artifacts with less effort, and lowering the barrier to entry towards domain-specific making.

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These common goals fall under the broad value of *user empowerment*: a practical extension of a user's capability. For example, in *Design Principles for Tools to Support Creative Thinking*, Resnick et al. state, "Our goal is to develop improved software and user interfaces that *empower* users to not only be more productive, but more innovative" ([91], emphasis added).

However, as with past discussions that creativity support tools fail to adequately define "creativity" [43], or HCI's use of "agency" as an umbrella term [10], we think there is room to offer a more rigorous and precise definition of "empowerment"—and *power*, one's ability to affect, influence, and structure—in the context of CSTs.

Tools direct the attention of their users, yet users also guide their tools [74], extending their ways of working and thinking to be easier or more expressive than what was possible without the the tools. While this is how tools empower their users, it is also how tool designers have *power over* their users: tools mediate how users work [100], and designing a tool means structuring and bounding its users' ideas, goals, and intentions. These constraints construct a *normative ground*—how someone should or could think, act, and express themselves during use.

In HCI, researchers have responded to this power dynamic by closely investigating and collaborating with users to understand their needs and values [55], creating designs that match users' existing mental models [1] and ways of working [26], and introducing new methods to study the social impacts of computer technology [38]. These approaches focus on *aligning* the abstractions in computational tools with users' goals, mental models, and methods. However, for creative and artistic work, where the end goal is not predefined [11], where practices continually evolve [98], and where artists use tools in unpredictable ways [71], the ways CSTs project power relationships present additional and unique challenges.

As designers and developers of creativity support tools, we argue that our community should not solely be concerned with creating abstractions and software representations that empower users by *aligning* with their needs and goals. These kinds of tools often empower users by automating and making "invisible" [60] tedious tasks that are not considered a part of "creative" work. On the flip side, these tools may also fail to support creative and artistic practices that are purposefully effortful—practices that make the invisible visible, that intentionally resist established norms and aesthetics, and that instill a sense of pride through craft [96]. By building end-to-end systems whose goals are to automate tedious work and prevent breakdowns, CST researchers have implicitly defined "creativity support" as aligning abstractions. We believe, instead, that supporting "artistic" goals could open up the scope for what CST contributions could be: possibilities for artists to define and redefine abstractions, flexibly navigate and compose parts of software tools, or resist and refuse tools altogether—possibilities that mitigate power imbalances between designer and practitioner.

Towards this goal, this paper proposes a practical lens for understanding power relationships embedded in creativity support tools. We conducted 11 interviews with CST practitioners who are creative professionals, tool designers, and researchers—often in overlap. While our analysis is informed by existing academic and theoretical perspectives, we focus on how interviewees think about, negotiate, and act upon power relationships in their everyday lives. Through these interviews, we define empowerment in the context of tool use and synthesize three dimensions for CST researchers to understand power relationships in their tools: *normative ground*, *vertical movement* through different levels of abstraction, and *horizontal movement* through ecosystems of tools in response to breakdowns.

To demonstrate how our lens can be practically applied, we analyze literature in CST development and exploratory digital fabrication. We show that computational scaffolds for novices further normative assumptions of what "good" art is, and that, compared to end-to-end fabrication pipelines, practitioners prefer composable primitives which enable horizontal and vertical movement. Bridging critique and construction [9], we present low-level technical and methodological recommendations for *artistic support tools*: that CSTs are meant to be inspected, retooled, and repurposed to enable user empowerment through vertical and horizontal movement, and that seeing CSTs as *probes* [109] to study creativity can be a site of normative, cultural, and political work and possibility.

It is our hope this paper may scaffold emerging conversations around how the tools we design and build unavoidably create and shift power relationships, and for researchers to recognize that while we cannot control every external factor that determines the power relationships surrounding our tools, we *do* have control over the low-level technical decisions that structure them.

2 RELATED WORK

Social theorists, philosophers, and anthropologists outside of HCI have developed many distinct conceptualizations of power [3]. We report on and draw from their intellectual genealogy in the context of our interview findings in Section 3. Below, we focus on the conversation within HCI on power: frameworks to understand it, and tools that give users power to accomplish their goals.

2.1 Empowerment frameworks in HCI

While not specifically grounded in CSTs, HCI scholars have had long-standing discussions of empowerment and agency. "Empowerment" and "agency" differ in that empowerment usually means a state of having power, while agency refers to a feeling of being in control of deliberate actions, though both have been used as umbrella constructs [10] that subsume a diversity of theoretical underpinnings. In their framework of empowerment in HCI [95], Schneider et al. define two concepts of power prevalent in the long-standing literature: *power-to*, the ability to do something, and *power-over*, a relationship between multiple actors. CST research has historically had a strong focus on giving users the power-to, but often does not consider power-over relationships between the tool designer and user.

In addition to concepts of power-to and power-over, the framework of empowerment [95] also looks at the psychological component of empowerment (doing/feeling/thinking) [121], the duration of empowerment (during technology use/persistent), and the design mindset that created the technology (expert/participatory). The authors then map HCI literature that claims empowerment to their proposed framework. While CSTs may broadly slot into categories of empowerment through enabling power-to, doing, during technology use, and a mix of expert/participatory design methods, we believe that analyzing general properties of tools is less fruitful than specific contexts of their use. Bennett et al. also map literature to four aspects of autonomy and agency: self-causality and identity, experience and materiality, time-scales, and independence or interdependence [10]. In addition to people researchers have also discussed how *materials* might have agency in how they "talk back" to influence design processes [104]. Constaza-Chock uses Collin's matrix of domination (which describes the interlocking and systemic forces of race, gender, and class [27]) to explore the ways people might resist powerful AI systems at the personal, community, and institutional levels [28]. Lastly, data feminism [34] and critical race theory [84] also outline ways to address unequal power relationships in HCI. These above frameworks are helpful for understanding ways technologies can both enable and oppress people; however, they do not address how low-level engineering decisions around abstractions and representations manifest as power relationships, nor do they specifically examine CSTs.

Despite using different terminology, past HCI scholarship has also addressed concepts of "normative ground." Pierce proposes a framework comparing conventional design to frictional design, arguing they are both prefigured, similar to our concept of how every tool unavoidably enacts normative ground [86]. The constructionist idea of low floors, high ceilings [51], and wide walls [91] identifies how tools may effectively constrain novices yet allow them to grow. Classical HCI research rooted in cognitive science also offers explanations for how interfaces structure how users act and think. For instance, Norman highlights how an object's physical, semantic, logical, and cultural constraints guide users in thinking about and interacting with it [83]. Cognitivist frameworks, however, assume a "problem space" users interact in, while creative tasks often involve discovering that space through material explorations [59]. Material interaction [90] emphasizes that goals and materials are reciprocally discovered through local explorations—explorations we argue are difficult to pre-design into tools. More recently, Davis reframes the cognitivist notion of affordances to talk about *how* affordances shape politics and power [29].

Beyond a tool-specific instrumental lens [8], Suchman [101] and Dourish [35] emphasize the situated and embodied aspects of interaction, emphasizing the coupling of intentional actions and contexts. To study situatedness, these schools of thought embrace "thick descriptions" of emergent interactions, which we also believe are necessary to adequately capture and understand situated power over relationships. Other analytic devices like activity theory, which has historically been concerned with studying tools [12], and actor network theory, which highlights the agency and power of non-human relationships [67], also are helpful in understanding the institutional influences of power relationships not captured by an instrumental lens. These methods may also be well-suited to studying power relationships, and we offer a discussion relating them to CST research.

2.2 Tools towards empowerment

Much work in systems building has focused on increasing the power a person has to accomplish their goals. Early contributions in computer science aimed to empower people through augmenting their memory, as imagined with the Memex [17], or through flexibly modifying abstractions, as with the SmallTalk [64] programming language. In a 2022 retrospective, developer Goldberg said, "We had the live flexibility to change things, and we were saying, 'How can we empower you to have what you want [19]?' " More recently, domain-specific tools like the VocalChorder [107] seek to empower domain experts (i.e., opera performers) through enacting custom constraints that match with user goals.

While fewer creativity support tools have been built to address power-over relationships, researchers have studied how tools affect feelings of power. For instance, many professional artists learn to code as a form of gaining power [71]. Researches have applied the multidimensional framework of power [50] to study open source software contributions [87], as well as compared bottom-up versus top-down approaches in data visualization to show that, while more tedious, bottom-up approaches resulted in a greater feeling of agency [76]. The UTOPIA project collaborated with typesetters and labor unions to increase workers' power over the activities and conditions of their work [15] through participatory design (PD). However, PD has also been criticized [52] in not actually remediating power relationships between researchers and design partners. This paper offers both technical and methodological recommendations for mitigating power dynamics in CSTs, complementing the analysis and critique offered by PD and alternative design.

3 UNDERSTANDING CSTS AND POWER IN PRACTICE

We conducted interviews to develop a practical understanding of how CST designers, researchers, and practitioners perceive and respond to the power relationships surrounding their tools, and the effects of these relationships on their work, practices, and lives. Framing our interview findings through a lens of power reveals that practitioners respond to power asymmetries from a new *normative ground* in part by navigating up and down the abstraction ladder (*vertical movement*) and by leveraging interoperable or functionally equivalent tools (*horizontal movement*). Figure 1 shows an example of these concepts. This lens also reveals how factors like values, economic and cultural situations, community support, and documentation can play a central role in supporting power relationships with creative tools. Finally, we put these findings in conversation with the constraints and motives of CST designers and researchers.

3.1 Methods

We conducted interviews with 11 creativity support tool practitioners: a mix of professional artists, tool designers, and CST researchers, with 8 participants falling into two or more categories (Table 1). Participants came from the authors' existing networks or responded to calls advertised on social media and were selected from screening survey responses for a diversity of mediums, tools, and creative skill level. Interviews occurred in early 2023 over video call and lasted on average one hour; participants were compensated for their time and the study was IRB approved. We used provisional coding [94] to analyze interview transcripts. Prior to the interviews we had defined a vocabulary around power, abstractions, interoperability, and institutional influences to structure our questions; our interview data allowed us to refine and develop these codes into the six subsections below.

3.2 What is empowerment?

Talking about, recognizing, and analyzing power can only be done within the context of actual situations, not as abstract, blanket statements [16]. Extending this argument with Foucault's belief that "power exists only when it is put into action" [41], we initially place power not as a static *property* of a CST, but rather something which emerges out of its situations of use. Thus, we report on interview findings of *power-to* and *power-over* (as earlier defined in Section 2.1) within specific contexts of use.

Artists and creative practitioners are not a monolithic group. For production artists whose economic means were tied to fulfilling client constraints, empowerment meant they did not have to think about their tools while drawing (P1), they had mastery over higher level abstractions that sped up their workflows (P3), and, practically, the software was capable of handling their large files without crashing (P3 & P10). Hobbyists felt empowered when learning new skills and expanding their knowledge of what was possible to create (P2), while others felt overwhelmed when presented with too many options (P6). These points are aligned with the implicit arguments of user empowerment CST developers have been making: giving users the *power-to* have greater control, more efficient practices, and "removing obstacles," as one researcher (P8) put it.

For artists whose creative practices were not constrained by external clients, however, empowerment was not tied to harnessing efficient forms of automation, but creating art to make the invisible visible. For instance, P5, a creative coder, purposefully misused tools, saying "the interesting things are doing what [tools] are not designed for," citing that "appropriation and remixing" were core to their process and conceptual pieces. P6, a hobbyist illustrator, shared, "When I draw a picture of something, it's also time I get to spend looking at it and thinking about all the little objects in it, just reflecting a little bit, and spending time with that picture and all the memories I associate with it." Making art let P6 intentionally structure their time towards specific objects and memories. P6 went on to describe feeling empowered by the "microcommunities" that formed around their illustrations, such as comments on a social media post about their mother's grief at the passing of her father. P4, whose art intentionally "directs the gaze on the powerful rather than the marginalized," said that creativity was "trying to authentically capture my kind of subjectivity and worldview," and that they also felt empowered when their art could get others who interacted with it to see their perspective. Empowerment to these artists meant a creative practice that revealed something new about how they saw the world, and their *power-over* others who interacted with the art to adopt that viewpoint as well.

P#	Occupation	Current tools used (years experience)	Tools built
P1	Freelance artist	Adobe Creative Suite (14), Blender (5), CSP (8)	None
P2	Software engineer	Adobe Creative Suite (5), Figma (5), DALL·E (1)	One CST
P3	Digital illustrator	Adobe Creative Suite + Lazy Nezumi (5), Procreate (4)	None
P4	PhD candidate	Adobe Creative Suite (6), Sketch (6)	Several visualization tools
P5	Freelance artist	Adobe Creative Suite (5), Blender (2), Processing (12), AR studios (1), AI tools (5)	Custom software and UI as needed
P6	PhD student	Adobe Creative Suite (10), Procreate (2)	Graphics tools, custom brushes
P7	PhD student	Drawing tools (10)	AI-based drawing tools
P8	HCI research scientist	Fusion 360 (6), Figma (2)	Digital fabrication tools, custom actions/menus in Fusion and Creative Suite
P9	HCI research scientist	CSP (5)	3+ CSTs
P10	Concept designer	Adobe Creative Suite + Lazy Nezumi (7), Blender (2), Procreate (2), Krita (1)	PS and Blender plug-ins
P11	Artist, software developer	"Most of them" (20)	"Too many," including VR painting app

Table 1: Self reported participant demographics.

To clarify, this type of empowerment is not due to a mismatch between the needs of "production" artists who value efficiency and "fine" artists who value idiosyncrasy. Both sets of users engage in personally meaningful creative practices, though the former often feel that there is limited scope for their own interpretations given the constraints of their jobs: for instance, P3 mentioned clients would often choose versions of works they personally thought were visually weaker. Rejecting this dichotomy of user needs (and using "creative practitioner" to mean both groups), we instead argue that the logic of automating work does not fully allow for personally meaningful and empowering creative practices.

Takeaway: Beyond removing obstacles, creative practitioners are empowered by their tools when they can intentionally harness them to capture and interpret their perception of the world and share their unique perspectives with others to affect change.

3.3 Normative ground

We have previously offered a definition of normative ground as the way a tool structures its practitioners' ideas, goals, and intentions, shaping how someone thinks, acts, and expresses themselves. We now offer concrete examples of how establishing normative ground influences and shift power relationships. P5 described that any choice of tool or platform was "working within these walled gardens [...] and a lot of the funny, interesting pain points aren't about the art object, or creation, at all," but about the different mental models, aesthetic norms, and practical constraints that each tool's normative ground enacted. P6 said, "I would like to explore more of the features and different ways of hacking things in software to get what you want, but I've generally been able to make do with what's immediately available, so I tend to go down that route." Aligning abstractions to user needs creates smooth operations, but does not challenge pre-existing normative ground. While P6 has been able to "make do," a concept of normative ground reveals that what abstractions make visible to practitioners often ends up being *just what they make do with.*

As a positive example, both P1 and P3 recounted "learning how to think" (P1) in Adobe Illustrator, which provided them more

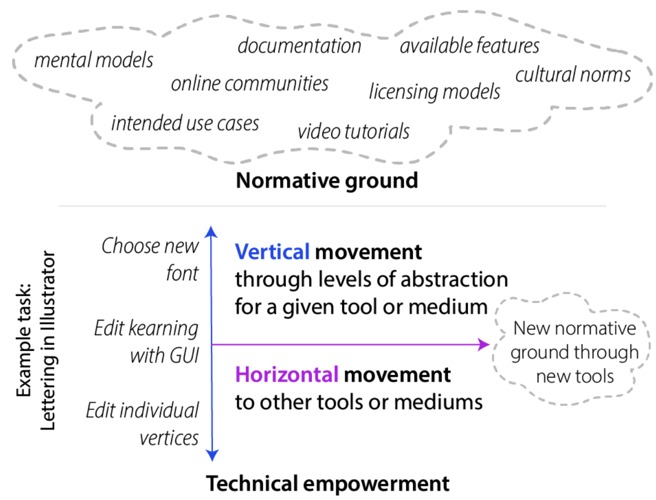

Figure 1: Top: A tool's normative ground incorporates many factors that shape how creative practitioners think about and use the tool, such as features, communities, and cultural norms. Bottom: We argue vertical movement through levels of abstraction and horizontal movement to other tools are crucial for technically empowering creative practitioners.

power to execute different kinds of art, such as using shape boolean operations that were not available in Photoshop (PS). While they were more familiar with PS due to its raster-based, rather than vector-based, ways of working that more closely resembled drawing on paper, they adapted to Illustrator's normative ground once they "spoke its language" (P3). P10, a concept artist for AAA games who uses PS for "anything and everything drawing," said it was because PS was the industry standard: even though other tools like Clip Studio Paint (CSP) may have offered better drawing features, since all their coworkers used PS and would send PS files back and forth, or tell each other new tricks in the software, it was more powerful to stick to its normative ground.

The ways tools establish their normative ground is not entirely within a designer's control. For instance, P1, P2, and P6 all mentioned watching YouTube tutorials to learn how to think about and use Blender; P3, P9, and P10 mentioned learning from their friends and co-workers. P5, a creative coder, said that the *documentation* of Processing became the style of the tool because that was how practitioners first got started. They lamented the aesthetic uniformity of generative art, saying, "peeling back the layers reveals getting to interesting, unique stylistic variations just following the docs won't." Furthermore, as a conceptual artist who found encoding the process behind a piece to sometimes be the artifact itself, they were "always fighting the tools because they try to strip all of [the process] away by the nature of being coding based." While Processing gives many coders the power to create art, it also constrains them to a particular kind of symbolic expression and abstract aesthetic. This is the contradiction tool designers need to contend with: the decision to make certain operations easier with a tool may actually result in uninteresting art. Thus, by dictating what should be made easier—by building a tool and enacting a new normative ground—CST designers and researchers shift power towards themselves and away from creative practitioners who are left trying to uniquely make sense of, and situate themselves in, this new normative ground.

Users control their tools but tools also influence users—any interaction is two-way [56]. P9 traced their "DNA heritage" from openCanvas to Paint Tool Sai to now CSP, saying their aesthetic—and the aesthetic of digital artists in the community they wanted to emulate—stemmed from each program's default brushes. Unavoidable power dynamics are not always a bad thing—as novices learn through examples and are shaped by their tools, this can also result in a sense of pride, like with P9 finding comfort in the anime art community. On the other hand, P6 mentioned preferring physical to digital drawing recently as they felt like their digital drawings were "falling behind" if they didn't include the most recent advancements and features. And as AI-generated art has become more mainstream, P2 said they were less interested in participating in it due to what they considered boring aesthetics. Finally, resisting the flat-pack aesthetic of most CNC furniture, P8 developed their own tool to make joinery-based furniture. As individuals situated in a larger culture, creative practitioners navigate the normative aesthetics and trends tools enact—while for P9 the drawing aesthetics of CSP represented a positive association with their community, we can see P6, P2, and P8 purposefully *refusing* the normative ground presented to them as a way of gaining personal power. Creativity is an exciting site to open up, challenge, and begin to refuse—while still being defined by—a normative ground.

Takeaway: The normative ground established by a tool not only affects how users can practically accomplish things (*power-to*), but also structures how they think and react. This represents a trade off by granting tool designers *power-over* creative practitioners. Creative practice is an opportunity to trouble power dynamics by proposing a new normative ground through making art.

3.4 Abstractions and vertical movement

A tool's normative ground is in part established through the design of its abstractions. But defining abstractions and constraints is not inherently harmful: building constraints is how tool designers enable *power-to* capabilities, and some level of abstraction is helpful (after all, software developers rarely write their tools in assembly). Graeber writes that "power is all about what you don't have to worry about, don't have to know about, and don't have to do" [47]: by structuring our attention and intentions, abstractions give us the power to focus on what is important.

P5 drew an analogy between different analog and digital levels of abstraction, saying manually mixing paints (low abstraction) is to photography (high abstraction) what coding is to text-to-image models like Stable Diffusion. "None of them are any less of an art, or less interesting. It's more of where an artist wants to put their creativity, and working within the constraints is a creative act in itself." P5 firmly believed, "at the end of the day it comes back to picking the right abstraction for you." In other words, to be empowered by a tool is to be able to freely choose an appropriate vertical position along the ladder of abstraction [108]. As we saw in section 3.2, making art is empowering when it enables artists to pay close attention and causes perspective shifts in others. This close inspection and guiding of audience intentions is the same process tool designers undergo when deciding on their tool abstractions.

Researchers in organizational behavior devised a multidimensional definition of power that considers mainstream (power is control over resources and decision-making), critical ("power is used to produce apparent consensus [by] replacing visible controls by hidden cultural forms of domination"), and Foucauldian perspectives (all knowledge necessarily embodies new forms of power) views of power [50]. While the broad values of user empowerment in the CST community generally align with the mainstream view, we believe that the critical dimensions of power also explain common effects of opaque abstractions: abstractions that users cannot inspect or modify are taken as natural, for-granted parts of either working environment. Creative practitioners being unable to "pick the right abstraction" (P5) is another way CST researchers and designers exert *power-over* them.

When pre-defined abstractions work for creative practitioners, they have no need to move vertically. For example, P3 praised the liquify tool because its behavioral abstraction—using a brush to warp underlying pixels—matched with their existing skills of spatial judgement and manipulation. They could efficiently tweak their drawings without redrawing every single pixel, retained fine-grained aesthetic control, and let the abstraction fade into the background [111] so their spatial judgement could take control. But during breakdowns, lacking the ability to further inspect or change how abstractions are represented leaves creative practitioners disempowered. P1 recalled feeling excited for CSP's mobile app that allowed them to map keyboard shortcuts to digital buttons in the iPad app, as they wanted to flip between animation frames (which requires pressing the left and right arrow keys), like on desktop. Flipping between frames, as opposed to relying on the onion skin feature, was important to their animation process to better perceive changes between frames. However, P1 soon discovered the UI buttons on the mobile app were so small they could not reliably press them without looking away from their animation. Because the representations of the abstractions—the digital buttons—that flipped the frames were at a fixed, pre-defined size, P1 had no choice but to revert back to onion skinning. Similarly, P3 recounted frustration at not being able to hide the mesh controls in the puppet warp feature, as it would occlude their artwork when zoomed out.

Good abstraction design is often framed as "a main research contribution," as P4 described with their visualization tool that aimed to "minimize [its] conceptual surface area." While higher level abstractions do benefit creative practitioners if their goals are aligned with what the system enables, it comes at the cost of a narrower action space. P9, who worked on a tool that edits videos at the word level as opposed to the frame level, acknowledged that while editing transcripts was faster and easier, "of course, this limits the type of tasks you can do."

Takeaway: Creative practitioners are empowered when they are able to freely move up and down the abstraction ladder. Building tools at a higher level of abstraction enables greater *power-to* capabilities, but also narrows the *power-to* band.

3.5 Interoperability and horizontal movement

When CST practitioners lack the ability to accomplish what they want at the given level of abstraction and are also unable to vertically move, they often seek out other tools that are functionally or representationally equivalent.

For instance, P5 described wanting to make an app-based filter that replaced the audience's face with a circle to comment on the nature of facial filters, and choosing between creating the filter on Snapchat, TikTok, and Instagram. P5 initially chose Snapchat since it offered the most malleable abstractions, allowing filter creators to upload their own facial recognition models. However, they realized that Snapchat was more of a direct messaging app than a social network, so they moved to TikTok. As TikTok's facial recognition model failed to uniquely identify multiple faces, and, unable to open up the black box as to understand why, P5 finally settled on Instagram reels, which provided not only an aligned abstraction for creating filters, but also satisfied the social media constraint P5 self-enacted. Instead of compromising on self-enacted constraints, P5 exerted power by refusing Snapchat and TikTok and horizontally moving to Instagram.

In addition to choosing between many different tools, interoperable data formats also enable creative practitioners to chain tools together as part of a workflow. P10 said, "the most happy feeling I can get is when brushes and files are interchangable between software." Unfortunately, while practitioners could piece together tools to make long workflows *possible*, editing pieces was inconvenient. Both P1 and P3 mentioned doing extra work to convert artifacts collaborators had done in a different program to their program of choice. P8 described a workflow to create two-tone UI screens that displayed 3D models by exporting a 3D model from Solidworks in .dxf, using Illustrator to convert the .dxf to .svg to be able to import to Figma, designing the screen in Figma, and finally exporting as a .png to Photoshop, which converted the colored screen into a two-tone bitmap. When they had to make any changes, P8 felt disempowered, describing the inefficient import/export paradigm, born out of computing constraints, as like "threading a long needle."

We observed that developers of CSTs chose their new tool's data types by what was convenient for system engineering, and thus subject the entire tool to the normative ground enacted by the underlying library. For instance, P7 built AI tools on top of CLIP, P2 and P4 web apps in React, and P8 a fabrication tool in paper.js for its 2D vector math functionality. In response to the heterogeneous representations of charts and graphs online, P4 said, "all I do is write wrappers" to convert between representations for an accessible tool that worked with screen readers. Prioritizing engineering convenience over how data types constrain creative practices is another way CST developers exert *power-over* creative practitioners.

On the positive side, P1, P6, and P10 all praised Blender for its rich ecosystem of plug-ins. An open source software, Blender provides programmatic handles for every operation and data type available in the tool. By enabling community members to contribute extensions, plug-ins increase practitioners' *power-to* execute *within* the established normative ground of the original tool.

Takeaway: Creative practitioners are empowered when they are able to laterally compose tools in an efficient workflow, or refuse tools by replacing them with different ones. Plug-ins, as opposed to brand new tools, increase practitioners' *power-to* capabilities while mitigating designers' *power-over* them through working within the same normative ground.

3.6 Freedom because and in spite of institutions

While institutions and society can shape and control our thoughts and actions, we nonetheless rely on institutions and society to exist in our world. Additionally, when practitioners interact with a tool to accomplish a goal, they also make decisions that are influenced by larger *institutional* factors such as communities, values, and economics [114]. Butler argues this position by positing "freedom, possibility, and agency" [18] as themselves reliant on communities, institutions, and cultures to support them, "always negotiated" within such power relations. While institutions that structure these power relations may create oppressive situations, it is through their existence that people can also develop a sense of self and a sense of freedom—in the context of the institution—in the first place. Greene echoes this reciprocal dynamic when she proposes freedom as a dialectic: freedom is not given or static, but constantly redefined and striven for [49]. To be empowered is to consciously direct one's actions with the implicit support of institutional and cultural life.

We noted examples of this dialectic playing out as CST practitioners chose tools not solely based on their features, but how they fit within the contexts of their larger lives. For instance, P1, P3, and P6 all transitioned from primarily drawing on a desktop to an iPad, with P1 saying it was better ergonomically and P3 and P6 saying they drew personal projects on public transportation as it was time they could carve out of their day. It is because practitioners suffer from joint pain or have long, non-driving commutes that the portability of the iPad became enabling and powerful. Similarly, P5 mentioned if their face filter was a physical photo booth in a museum instead of on Instagram, the art would no longer be about the "appness" aspect but about face detection models. We can understand P5's work as art only when we consider Instagram's constraints as platform, its highly curated aesthetic, and its push for reels. Likewise, P11 described how while it was a cultural norm for the URL in an NFT smart contract to point towards the same static content, nothing prevented a developer from incorporating ever-changing URLs into an art piece. While a normative ground enacts constraints, art that is culturally situated becomes powerful *because* it comments meaningfully on said normative ground.

Creative practitioners also described how tools took a long time—often years—to learn and master. Partially because of this time cost, practitioners universally disliked subscription-based models: P6, for instance, said "having access to your tools taken away from you not by choice feels disheartening," and P11 felt "trapped" in paying. These feelings of disempowerment did not stem from financial burdens; even though they could afford them, P1, P2, P3, P6, and P11 felt that subscription models were against their *values*. In this context, empowerment is derived from psychological ownership and the security of knowing one's skills and investments in a tool will persist.

Communities of peers and audiences are also social institutions which shape creative practitioners' work. P7 recounted gratitude towards users who volunteered to donate their own art as training data and others who maintained a community Discord for their AI tool. P11 described how NFTs were an easier way to make money in a community compared to selling physical art, saying, "I can't open an Etsy store... [NFTs] are as speculative as the high end market, but faster." P9, who participates in Vtuber fandoms, recalled drawing fanart to call attention to funny moments in Vtuber streams. "The image itself is not that special," P9 said, explaining they would not have drawn the moment if another community member already had—the art served to direct the fandom's attention. Sharing knowledge, wealth, and artifacts are all examples of how CST practitioners build culture through their work, and how their work reflects the culture—and power dynamics—they are embedded in.

Takeaway: While a tool's unique normative ground may challenge larger institutional factors such as communities, values, and economics, these same factors are what give the normative ground power.

3.7 Researchers' motivations

The idea that a privileged class designs for, and has power over, a "user" class is part of a long standing conversation. Illich, arguing that elite professional groups such as researchers have a "radical monopoly on knowledge," pushes for a "convivial approach" where tools should work *with*, rather than *for*, the common people [58]. Similar pushes critique how AI researchers should think not only about fairness but also how their systems shift power [63], how algorithmic systems cause harm when they are allowed to impact people who have little to no insight into or control over them [2], and how Ubicomp researchers spread the colonial enterprise of knowledge through assuming users come from the same contexts as they do [36]. Given the implicit claims of user empowerment in CSTs, we wish to use our interview findings with CST researchers to interrogate and potentially explain why our community tends not to explicitly address the power dynamics enacted by their tools.

First and foremost, every CST researcher interviewed expressed they had limited time. As past or current PhD students, the incentives of a successful computer science PhD (publishing papers, which often meant having a strong technical contribution) were already time consuming. P8 reflected that they "would have loved" to build different levels of abstraction into their tool, or to make their tools "less of separate islands" from existing ecosystems, but was simply limited in time. While they enact normative grounds with their tools, researchers also operate under the constraints of institutional academic or corporate forces themselves. It is not easy to build tools that move beyond research prototypes, as less than a quarter of CSTs become publicly available [42]—P4, who built tools in an existing academic ecosystem, acknowledged they had "benefitted a lot" from the substantial work their academic seniors had done to build a user base.

P2 acknowledged the power researchers had over undergraduate students when they deployed a tool in a classroom setting, saying students were incentivized to use it to get good grades within the context of the course, but learning how to use it would not help them get jobs. They firmly believed academic tools should "not over promise and just try to study one thing." Though intellectually privileged, researchers can also experience harms. P7 said that if they received negative feedback from artists about features in their AI tools, they would avoid releasing them. As P7 saw a growing number of lawsuits around fraught subjects like provenance of training data, they did not wish to jeopardize their visa status as an international student. Lastly, both P6 and P8 reflected that "solving technical problems," as opposed to problems around design, creativity, and social structures, was more familiar, provable, and matched their computer science skill sets.

Given these tensions, what can we do as researchers? Section 5 offers our attempt at practical suggestions to address these problems and make them more manageable, building off of the vocabulary we have developed here of normative ground, vertical and horizontal movement, and creativity as on opportunity to refuse, rather than further solidify, researcher-practitioner power dynamics.

4 RE-EXAMINING CST LITERATURE THROUGH A LENS OF POWER

We demonstrate the value of a lens of power by reviewing clusters of HCI literature on creativity support tools in the context of the themes of normative ground, vertical movement, and horizontal movement we uncovered in our interviews. We chose clusters that reflected threads in CST development, as the papers in each topic follow a distinct conceptual framing of what constitutes a CST's contribution. From each cluster, we highlight underlying assumptions using our lens of power, the tensions the assumptions reveal, and what could be done (or is currently being done) to better support creative practitioners. Lastly, we expand on the case of digital fabrication as a distinct research topic that is historically entrenched in unequal power dynamics yet still shapes the design of CSTs for fabrication. Beyond research specifically about CSTs, creating new devices, software, and interactions to empower users has been a core motivation for UIST research. Understanding power dynamics in these interactions may therefore aid researchers, even if their systems are not explicitly defined as "creative" or "artistic."

4.1 Scaffolding novices

One main way CSTs make research contributions is by scaffolding novices' abilities through applying "expert" computational constraints. These projects help novices produce higher quality artifacts and direct their learning through enacting constraints which guide novices towards a computational "ground truth" (such as an uploaded 3D model for freehand carving [122], a reference portrait photograph for sketching [115], or composition guidelines for photography [37]). Applying a lens of power reveals the question of, "higher quality for whom?" In addition to building up skills, we see that these tools also establish a normative ground that upholds traditional notions of what "good" artifacts look like. Even when novices become experts and no longer need the "training wheels" of the tool, the tool's values still implicitly structure and influence their creative processes. Scaffolds are a great starting point for novices to learn the rules, but tools should also allow for intentionally breaking the rules.

4.2 Exposing high-level representations

Another way CSTs empower users is by letting them edit higher level representations that the system interprets to edit the artifact in a different representation, such as editing text for video [105] or HTML-like code for composing 3D models [119]. While many of these tools at a higher level of abstraction allow vertical movement in that the program can export to a lower-level specification, it is more challenging to, after making edits in the lower level of abstraction, move back up the abstraction ladder. Given that artists have non-linear workflows [71], how to accommodate flexible vertical movement up (rather than down) the abstraction ladder is an exciting and open technical problem—applying a lens of power can be generative, as well as analytical.

4.3 Generating design alternatives

Many CSTs aim to computationally generate alternatives for users to explore a design space, be it interface designs [102], visual blends [23], or flyers [103]. While these systems result in users producing artifacts faster and with less mental load, their explorations are still within the normative ground—the aesthetic, technical, and conceptual constraints of the tool. Instead, by exploring how tools could accommodate different *processes* [99]—how the workflow around a tool can be appropriated and recomposed—rather than fixating on alternatives within a single artifact, we can better understand the power dynamics enacted by these constrained spaces.

4.4 Controlling breakdowns

CST research has recognized that breakdowns may also reveal productive and interesting art practices, with several papers developing systems to inspect [79] or support [97] the notion of "happy accidents." Particularly, mixed-initiative creative interfaces [31] aim to get users to reflect on unanticipated and uncontrollable computer generated results in domains from drawing [30] to music [81]. When tool designers pre-define uncontrollable or random features, however, they are the ones exerting power through specifying the bounds of the breakdown, as opposed to the breakdown emerging through friction with the tool. As shown in our interviews, friction in the contexts creative practitioners care about—friction often purposefully enacted through inspection and misuse—results in more unique, human, and personally meaningful art.

4.5 End-to-end digital fabrication

Digital fabrication [75] is another domain of HCI research centering around object creation that has raised unique challenges of machine operation without factory contexts, industrial scale tooling, or domain expertise. Alongside fabrication research, the maker movement has seen widespread adoption of fabrication tools that celebrate a "hacker" and DIY ethos [66], though researchers have critiqued the maker movement for framing empowerment as Westernized, individualized technological innovation [4].

As fabrication machines find increasingly novel applications in art, science, and craft, so does the need for increased creative control over machine capabilities. *Personal fabrication* has been one response towards these newfound end-users, which builds "systems [that] eliminate the need for expertise by embodying all necessary domain knowledge" in software pipelines [7]. Through this framing, many digital fabrication-related papers in HCI espouse end-to-end GUI pipelines which obscure the complexity of moving between the digital and the physical. Across multiple domains, from hydraulics [80, 118], to metamaterials [61], to on-skin electronics [24, 110], we observe a strong tendency for UIST to value systems that present a pre-packaged parameterized design space where exploration requires constrained input from an end-user. However, this framing implies that it is the *responsibility of the designer*, and not the end-user, to address challenges that arise when mapping the analog world to digital tools. As mentioned in the introduction, most solutions are forms of abstraction alignment lacking horizontal and vertical mobility. As a result, designers of end-to-end fabrication pipelines exert power over end-users through preventing them from working with lower level primitives or interoperate with other digital and analog tools.

Prior work [71] observed that artists working with fabrication machines also prioritize creative exploration and low-level control. Additionally, researchers who observed #PlotterTwitter [106]—end-users who built custom software and hardware for pen plotters—found that community members preferred not to use established tools like Illustrator beyond "cleaning up" files generated by others. Instead, they wrote their own lightweight scripts, GUIs, and browser-based tools that they readily shared with the community; other members were able to both integrate these tools into their own workflows as well access the community for help. In terms of horizontal movement, this pattern shows a desire for creative practitioners to build, share, and string together their own tools to produce novel work, rather than rely on all-in-one solutions. By composing smaller tools together, creative practitioners can have the power to construct their own normative ground.

The rise of end-to-end tools mirrors how CNC tools were developed in the mid 20th century. Historian Noble highlights how early developments in digital fabrication allowed factory management to shift power in the manufacturing process away from the machinists and into the separate offices of CNC operators [82]. Existing CSTs, and even conventional software such as slicers, can still reflect historical separations of labor in the design of separate, self-contained systems [20]. In this view, we urge the UIST community to shift towards building CSTs for digital fabrication that first center *domain-specific, composable control of machines* rather than building all-in-one, one-off solutions that only expose a narrow space of parameters for end users to experiment with.

Assumption: Research contributions are complete systems that work a single way, hide implementation details, and remain separate from existing tools.
Problem: Creative practitioners have difficulty re-purposing novel techniques presented in systems; all-in-one CSTs make it difficult to impossible to accomplish non-normative goals.

5 TOWARDS ARTISTIC SUPPORT TOOLS

> "So at some point along the way, rules-as-constraining pass over into rules-as-enabling, even if it's impossible to say exactly where. Freedom, then, really is the tension of the free play of human creativity against the rules it is constantly generating."
> – *David Graeber [47, p.199]*

In this paper, we have tried to understand how making useful and more efficient computational tools sets up relationships of power by establishing normative grounds for how users act and think—rules-as-constraining versus rules-as-enabling, as Graeber says above. Drawing on our interviews with practitioners and researchers, we argued that making tools for artists carries unique considerations in these relationships because creativity and artistic practice often value flexibility, inspection, appropriation, and refusal over efficiency or alignment.

To clarify our position on the relationship between "creative" and "artistic," we view creativity as being about the process of *how* a practitioner achieves their goals, while art making as about *what* kinds of goals practitioners aim for—often non-functional goals that go beyond external constraints, such as those imposed by clients or tools themselves. All artists are creative practitioners, and creative practitioners are artists when they look at their work for more than its immediate, pragmatic end—becoming artists not because of any specific practice or occupation, but through how they *value* and set out goals for their work. This section presents a vision of how CST research might change to accommodate these different values and goals, including the practical design of software systems, the study of users, and how we evaluate and build knowledge around our tools: a vision towards "the free play of human creativity" supported by "artistic support tools."

5.1 Technical recommendations

While researchers cannot control all the subtle and often invisible ways their tools shift and generate power dynamics, we do have control over the design of abstractions, data representations, and how users are first introduced to a tool's normative ground. This section offers practical suggestions towards enabling vertical and horizontal movement, and anticipating, to a limit, what kind of normative ground would arise. In the spirit of offering a generative theory [9] of power dynamics in CSTs, Table 2 shows questions that may be useful in thinking about one's own CSTs with a lens of power.

Our design recommendations are inspired by and built upon other orientations in HCI. Perhaps most related, *seamful design* seeks to make visible the "invisible" and through recommending designing for adaptation, reuse, and appropriation [60]. Similarly, the generative principles for human-computer partnerships—discoverability, appropriability, and expressivity—address how designers can create more *co-adaptable* systems [72]. Victor advocates for movement up and down the abstraction ladder in the domain of interactive visualization [108]. In programming languages research, the technical dimensions of programming systems [62] discuss composability and customizability as core system principles. Some researchers have also understood programming languages normatively—as ways to *think about programs* [54] and express them effectively [57]. This is especially poignant in the creation of Domain-Specific Languages (DSLs), which aim to capture a specific domain of expertise or practice [77] and use certain "domain concepts" to conceptualize it [6].

While we acknowledge our technical recommendations are not novel calls, we hope to provide a new lens for understanding how these concepts might mitigate imbalances in power dynamics and illuminate to researchers the importance of these choices.

5.1.1 Enable vertical movement. Our interviews revealed that the power an artist has over their work comes from their human decision making and interpretation. Rigid abstractions, when misaligned with the idiosyncratic goals of artists, create a power imbalance. How can tools be appropriated—and thus still useful—when faced with a task different than intended? One way is to provide multiple entry points of abstraction for the same task. For instance, to get a specific color of paint, oil painters can choose to gather natural materials to synthesize, buy a limited set of factory-made pigments to combine, or use paint straight from a tube. While buying factory-made tubes is empowering to artists in that they are convenient and remove the obstacle of knowing how to synthesize paints, they also restrict the kinds of colors available. We encourage CST researchers to reflect on possible abstraction entry points in their tool, beyond prescribing the one that is most efficient. Writ-Large [117] is one research project where users can interact at multiple abstraction levels—they can choose to let the system interpret their stylus inputs as typed text, continuous strokes, or discrete stroke parts—as is Object Oriented Drawing [116], where users can define their own abstractions through direct manipulation.

Furthermore, as we saw in Section 3.4, unchangeable representational abstractions such as inflexible UI elements—which seem like minor technical details—caused CST practitioners in the visual arts major pain points in their creative processes. Small changes in display may have big consequences for visually based practices. We encourage flexibility not just for abstractions in function and behavior, but in display.

5.1.2 Enable horizontal movement. From our discussion in Section 4.5, we see that "real world" digital fabrication practitioners prefer small tools that can be flexibly composed, rather than end-to-end black box systems. We also see the strength programming provides, and advocate for greater domain-specific programmatic handles [77] to open up the black box that afford interoperability and remixing. Maslow's law of the instrument ("If the only tool you have is a hammer, it is tempting to treat everything as if it were a nail" [73]) means that tools shape not just what users can do, but also how they think—without horizontal movement, creative practitioners may be trapped in prescriptive ways of thinking.

Researchers in CSCW advocate for piggyback prototyping [39]—building and evaluating new social computing contributions on top of existing ones—in that it promotes ecological validity and leverages well-tested features, though sometimes in tension with ethical and privacy concerns. Expanding this finding with the idea of normative ground, and echoing the praise of plug-ins in section 3.5, we also argue that one way to mitigate power dynamics is through building new tool contributions on top of CSTs users already use, as opposed to creating entirely new tools, to build within an existing normative ground.

Concept	Analytical	Critical	Constructive
Vertical Movement	What are the abstractions of this tool? How do users interact with them?	Are the abstractions of this tool transparent and malleable?	How can users inspect, modify, and appropriate the given abstractions, or design their own abstractions within the tool?
Horizontal Movement	What are the data representations and primitives of this tool? How do users interact with them?	Are the primitives composable within the tool and data types interoperable with other functionally equivalent tools?	What is the smallest/lowest unit of useful operation for the tool, and how can it be composed together within the tool or extended to interface with other tools?
Normative Ground	What is this tool intended to do? In what ways do users first learn this tool?	What are the ways you can anticipate the tool constraining users? Are there stakeholder groups that are more constrained than others?	How do you intend to culturally situate this tool? How does it fit with the normative ground of other tools, and how will its own normative ground differ and evolve?

Table 2: Questions that can be asked to apply concepts born from a lens of power analytically, critically, and constructively [9].

5.1.3 Tool design creates normative ground. In section 3.3, we saw how documentation matters: as the starting point for how many users learn the tool (in addition to video tutorials), beyond simply telling users how tools work, documentation also helps establish a tool's normative ground. The functionality exposed by a documentation structures what users immediately know is possible with a tool—and, consequently, the aesthetics associated with a tool. In the lens of mitigating power relationships, then, we postulate what documentation would look like that not only explains the functionality of a tool, but also describes how the tool constrains, and how to appropriate and extend the tool in the face of such constraints. Olsen writes about the "fatal flaw fallacy" in evaluating UIST research [85]: systems will always have missing pieces due to limitations of researcher time. We agree that no research tool can do everything. But instead of ignoring the things tools cannot do, researchers should be conscious of, and reflect on, how users may become disempowered in the spaces their tool forgets.

The trouble with normative ground is that there are limits to how much researchers can anticipate, due to subtle, always changing institutional factors and situations. As a result, turning our attention towards studying the normative ground—and power dynamics—our tools enact requires methodological shifts.

5.2 Methodological shifts

In addition to the technical design recommendations we discuss above, we also call for a change in how we *value* and *conduct* creativity support tools research: if creativity support is less about supporting "saying common things" and instead about how artists use tools to "say uncommon things," [21] especially when the things are not predicted by the designer, what represents a CST contribution? What kind of knowledge do we gain in building CSTs, and how do we obtain that knowledge? Overall, we argue for (1) viewing CSTs as *probes to study creativity and artmaking*, rather than as prototypes for "effective" design principles and interactions, and (2) seeing CSTs themselves as creative artifacts aimed at exploring how computers ground creative practice in collaboration with users.

A view of creativity support which goes "beyond the artifact" is a view that recognizes how tools influence and structure larger creative situations in addition to the functionality and usability of the tool itself. To empower users in the domain of CSTs, we argue, requires moving beyond a question of aligning an abstraction to a user task or need. Instead, empowerment might focus on how creative practitioners appropriate software abstractions to their own ends, how they can remediate, restructure, or replace abstractions easily, and to what extent they can make visible or change the normative grounding of a given abstraction.

In this frame, **relying too heavily on formative qualitative research to understand user needs might be counter-productive for CST research**. Methods like contextual inquiry [13] or semi-structured interviews [69] often end with researchers defining generalized problems which their users face, or opportunities to automate and abstract work. These are helpful methods for making tools *when the goal is making the work easier, more efficient, or less visible to the user.* If, instead, our goals for CST research are about "saying uncommon things," we ought to build tools which users appropriate for ends unforeseen by designers.

Rather than first defining common problems and then addressing them with tools, CST research might instead be oriented towards democratization and knowledge-sharing priorities of co-design methodologies [120] and community-centric design [14] methods, to build tools alongside artists not as a way to better understand "the problem," but to **build systems which those artists can genuinely appropriate to their own ends**. We echo a recent call [71] to involve artists as technical collaborators, as this is not only crucial to building tools which address real user needs, but also so that users have the technical insight and capability to remix these tools for their own ends, maintain the software themselves after the research is complete, and seed a community of knowledge sharing and appropriation. While the technical recommendations outlined above are a place to start, we envision CST contributions interested in how to build inspectable, flexible, and re-workable software, how to support practitioners in developing practical understandings of the tools they work with, and how to express "uncommon things" with computers.

Subsequently, if CST research contributions are not always about making well-defined tasks easier to execute or well-defined problems easier to solve, how we evaluate our tools might also change. While initial usability testing [68] is an important step for making useful software, supporting making artifacts faster and with less mental load, technical demonstrations of program "expressivity" [40, 85], and collections showing a diversity of possible outputs [70] only scratch the surface of the rich, exciting, and unpredictable ways artists use creativity support tools. Therefore, **we propose shifting the object of evaluation in CST research away from the artifact and its technical capabilities and instead towards the *interactions* our tools support**. How do real world users re-work and repurpose CSTs over a long period of time? In this frame, our research questions would not only be about whether or not tools "successfully" solve problems, but also engage with the kinds of aesthetic, social, and political relations tools open up, or even how tools fail to do this in surprising or interesting ways.

Possible methods to get started include treating CSTs as a form of research through design [45], and reporting not only results from the Creativity Support Index [22] and NASA-TLX [53] but also embracing qualitative and ethnographic methods such as offering thick descriptions [46] and interpretive criticism [5] of situated contexts of use, reporting on the aesthetic cultures which emerge from new tools [33], and building participatory coalitions and accountable community involvement [112]. If we see CSTs not as prototypes to test the validity of design principles but as *probes* [109] for understanding and intervening in a creative culture, **cases where our tools fail to work may actually be more generative and insightful than when they do**.

Many questions remain: how do we formally evaluate how our tools shift power relationships? How should we study CSTs which are meant for retooling or, in some cases, even complete refusal? How should we evaluate the kinds of artistic communities, aesthetics, economic, or social circumstances which arise around our tools? How do we design good *materials*, which allow for flexible, unexpected, and unpredictable composition, rather than good interfaces, which allow for efficient performance on select tasks? These questions, we argue, are critical towards user empowerment and, equally as important, mitigating the power differential between user and researcher. We envision a program of CST research in which we tackle these questions as a community—a program for "artistic support tools."

6 DISCUSSION

Having presented a vision for "artistic support tools," we begin this section by acknowledging limitations of our interviews and discussion thus far. We then consider the case of AI art tools in which "empowering" users with our suggestions may create harm, and end on a future speculation of what treating creating CSTs as an artistic practice could look like and lead to.

6.1 Limitations

Our interview participants were primarily Americans under the age of 40 with strong technical skills; their experiences are not reflective of all perspectives on CST design and use and this highly Western sample (along with the authors' backgrounds) impacts our discussion of power. Future work should surface how a lens of power in CSTs can explicitly intersect with other axes of marginalization, such as race, gender, and class. Finally, as CST researchers ourselves, we acknowledge writing this paper, critiquing current research threads, and setting out a new agenda is an act of power over the UIST community.

6.2 Counterexample: AI art and potential harm

Though our analysis of CSTs leads us to advocate for transparent, malleable abstractions and a reduction in the power tool designers exert over tool users, recent developments in AI art tools offer an interesting counterpoint, showing that transparency and malleability of abstractions can also result in negative outcomes. Text-to-image models such as DALL·E-2 [88] and Stable Diffusion [92], trained on large corpora of co-occuring text and image data, allow users to produce a wide range of coherent imagery by expressing their intent in written form. The ecosystem that has emerged around these models allows users opportunities for both horizontal movement (for example, by integrating text-to-image models as Photoshop plug-ins, used in tandem with traditional tools) and vertical movement (by using techniques like DreamBooth [93], models can be fine-tuned to fit a specific individual's appearance with a small amount of user-provided data).

However, because these concepts emerge from training data rather than are explicitly programmed, it is hard to restrict users from creating harmful outputs, such as "deepfake" sexual content corresponding to recognizable individuals [65]. DALL·E-2 initially banned generating nudity and identifiable likenesses without consent, using a simple keyword flagging approach to remove corresponding prompts [78]. However, once Stable Diffusion emerged, any user could deploy a copy of a text-to-image model at low cost, and circumvent restrictions on nudity simply by changing a few lines of code to disable its CLIP-based safety filter [89]. Even if concepts like nudity are erased from the model [44], with access to the underlying weights they can be re-added by anyone with sufficient data and computing resources. Designers who wish to set normative ground for their tools face an uphill battle against both users and competitors. This matches findings from recent empirical work interviewing designers of open source deepfake technology [113], who feel like their individual decisions carry limited weight in the face of technological inevitability and the ease of 'forking' existing tools to remove restrictions.

This case highlights reasons why tool designers might want to enforce a restrictive normative ground to prevent harm and also explains the challenges they may face in doing so. While this troubles the unnuanced reading of malleability and user empowerment as unambiguously good, it points to a further need for in-depth qualitative work to understand the power relations that are embedded in emerging CST ecosystems.

6.3 Creating CSTs as an artistic practice

In this paper, we argued that viewing CSTs as invisible automations results in a power asymmetry between the designers and users of a system. To ameliorate this power dynamic, we argue CSTs instead should be *continually negotiated* by practitioners throughout their use, opening themselves to be flexibly adapted and re-purposed. We see a future where creativity support tools might not be defined and imagined prior to a creative practice—after all, it is through this pre-definition that CST designers actively set normative ground.

But instead, what if CSTs were also participants in a creative practice? What if we saw building CSTs as an *artistic practice in* itself? Alongside the art which CSTs enable making, CSTs are able to make normative claims and investigations, as tools can structure culture through their normative ground. Thus, just like how artists make work for social change or to access higher meaning, building creativity support tools can also open up that path.

Adopting a lens that sees making CSTs as an artistic practice allows CST researchers to be responsive to, and participate in, the ongoing cultural conversation. For instance, in viewing *Being the Machine* [32] as itself a conceptual and artistic exercise, Devendorf and Royal were *responsive* to artistic practice in a way which would be closed off if *Being the Machine* was viewed just as a tool. As an artifact which intentionally proposed and investigated the normativity of computational art making, the project opened itself for investigation, troubling, and adaptation from its users, demonstrating how creativity-support can become artist-support.

Rather than trying to eliminate or obscure its normative bounds, we speculate a future where CSTs can, like the example above, intentionally propose and probe new normative understandings (and sites of counter-hegemony [48]) of tools and creativity. When making a CST is an artistic practice rather than an activity of what dictating what art should be, researchers can be on a more level playing field of power with the creative practitioners they wish to support. Through close collaborations, artists can be researchers, and researchers, now, are artists as well.

7 CONCLUSION

By applying a lens of power to creativity support tools, we reveal that tools have traditionally empowered users when pre-defined abstractions align with users' goals, mental models, and methods. However, creative practice extends beyond accomplishing tasks with more efficiency or lower mental load: it is unpredictable, emergent, and messy. All these things make creativity wonderful, yet are difficult to computationally support. We propose three concepts of power to help make sense of these tensions: normative ground, vertical movement, and horizontal movement. When we treat CSTs as probes to study artmaking, rather than prototypes for effective abstraction alignment, we argue that we get closer towards understanding—and mitigating—the power dynamics our tools enact. We advocate for a research agenda of "artistic support tools" that moves beyond artifact creation to take creative practices and practitioners seriously.

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