DeepThInk: Designing and Probing Human-AI Co-Creation in Digital Art Therapy

by

Xuejun Du

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Author's Declaration

The thesis consists of materials all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contribution

The thesis is based on the research project I led under the supervision of Dr. Jian Zhao. As the main investigator, I contributed to designing and executing user studies, analyzing data and writing the draft manuscript. The draft was further edited by Dr. Jian Zhao and Dr. Pengcheng An. Dr. Pengcheng An contributed to designing and conducting the user studies and analyzing data. Justin Leung and April Li were the primary system builders.

Abstract

Art therapy has been an essential form of psychotherapy to facilitate psychological well-being, which has been promoted and transformed by recent technological advances into digital art therapy. However, the potential of digital technologies has not been fully leveraged; especially, applying AI technologies in digital art therapy is still under-explored. In this paper, we propose DeepThInk, an AI-infused art-making system collaborated with five experienced registered art therapists over ten months, to investigate the potential of introducing a human-AI co-creative process into art therapy. DeepThInk offers a range of tools which can lower the expertise threshold for art-making while improving users' creativity and expressivity. We validated DeepThInk through expert reviews and a two-part user evaluation with both synchronous and asynchronous therapy setups. This longitudinal iterative design process helped us derive and contextualize design principles of human-AI co-creation for art therapy, shedding light on future design in relevant domains.

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Dedication

I dedicate this work to my mother, who has provided me with unconditional love and support throughout my journey.

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Chapter 1

Introduction

Art therapy, as an important form of psychotherapy, has been considered to be effective in helping people cope with various mental challenges, such as anxiety disorder [2], depression disorder [90], post-traumatic stress disorder [15], and autism spectrum disorder [53]. Prior research has shown the significant value of art therapy-based interventions to different user groups, including children [100], adolescents [85, 99], people with dementia [32], and individuals who feel isolated [12]. Recently, emerging digital technologies (e.g., online communication tools, digital art) have been increasingly adopted in art therapy practices [94]. Digital technologies could benefit art therapy practice in different ways, for example, increasing accessibility [20], enhancing a sense of privacy [23], and providing a mess-free and texture-free environment for people who have tactile or olfactory dysfunctions [26].

However, digital technologies for art therapy are still at a preliminary stage, facing several unaddressed challenges that may cause barriers to fully leveraging the benefits of digital art therapy [96, 95]. For example, basic generic drawing tools (e.g., sketch.io [103]) may constrain users' creativity and expressivity. More professional tools (e.g., ProCreate [70]) intimidate users when they have no or little experience in digital art-making, again limiting users' abilities and hindering the effect of such a therapeutic process. So far, only limited exploration has been done in designing art-making interfaces designated for art therapy [81]. The HCI community still lacks sufficient design cases on art-making tools specifically intended for digital art therapy and closely co-designed with art therapists, which has motivated this work.

Another under-explored opportunity for digital art therapy is how to leverage cutting-edge AI technologies to further enhance the engagement and creative process of users. Recent works in the AI community have demonstrated the potential of AI in art-making

(a) (b)

Figure 1.1: DeepThInk is an AI-infused art-making tool that supports human-AI co-creation in digital art therapy for both synchronous and asynchronous settings. (a) The client uses DeepThInk in a live therapy session with his art therapist. (b) The client finishes the art therapy exercises with DeepThInk on his own and shares them with his art therapist afterward.

[97, 42, 13, 61]. Some HCI explorations have been made in supporting users to create artworks collaboratively with AI (for leisure) [91, 60, 28, 105]. These promising results suggest that AI could ease the drawing process and potentially reduce the frustrations due to the learning curve of regular art-making tools. Moreover, such human-AI collaboration could potentially make the art-making process more interactive and engaging [91]. However, prior studies have only focused on art-making for leisure; empirical insights are still lacking on whether and how such a human-AI co-creative approach is meaningful for art therapy. Compared to leisure art-making, art therapy values the process much more than its outcome, and emphasizes the technology's role as *art-making materials* such as painting brushes rather than the creator of artworks [66].

In this work, cooperating with five professional art therapists, we designed and developed an AI-infused art-making tool to explore how to leverage the benefits of human-AI co-creation for art therapy and gather insights into the design of human-AI interaction for this under-explored domain. This iterative design process lasted for over ten months, and yielded a web-based digital art-making tool, called DeepThInk, that supports both synchronous and asynchronous therapy setups (see Figure 1.1). The tool integrates four painting/authoring tools, namely AI Brush, Styling, Filtering, and User Brush, into a coherent simplistic interface to support a flexible multi-dimensional art-making process. The AI Brush allows users to paint color blobs of natural objects (e.g., sky, dirt, sea, tree, etc.), and a generative adversarial network (GAN) [39] leverages these blobs (as a semantic segmentation map) to create photo-realistic images. The Styling tool enables users to apply different artistic styles to the generated image with deep learning style-transferring models. Users could further shift the tint or tone of the image using the Filtering tool.

These tools lower the expertise threshold of digital art-making and enrich the expressive repertoire for non-expert users, thus broadening the audience for digital art therapy. Additionally, the User Brush allows for freely blending user strokes into AI's generation with various textures and patterns. This way, the AI technologies could ease and augment the creative expression of users without taking over the whole art-making process away, which is essential for art therapy practice.

The development of DeepThInk has gone through an iterative and longitudinal design process, which started by gathering in-depth needs from the context of art therapy, and continued with a series of prototyping and refining cycles closely involving professional art therapists. We first validated DeepThInk via expert reviews with three art therapists to gain an understanding of its potential usages. Then, we conducted a two-part user evaluation. The first part aimed to mimic asynchronous art therapy sessions where participants performed art therapy exercises [43] and recorded their outcomes for later discussions with therapists. The second part included two one-on-one, synchronous art therapy sessions led by therapists. Based on the qualitative and quantitative results, we investigated whether and how the design of DeepThInk could be meaningful in the practice of digital art therapy, and derived a set of implications for designing human-AI co-creative tools for digital art therapy.

In summary, our main contributions are as follows: (1) a longitudinal iterative design process with five professional art therapists for consolidating the principles of applying human-AI co-creation in digital art therapy, as well as probing such co-creation in practice; (2) a novel AI-infused digital art-making system, DeepThInk, that offers multi-dimensional painting brushes in a coherent interface to lower the expertise threshold while enhancing users' creativity and expressivity; and (3) results of evaluating DeepThInk in various setups such as asynchronous and synchronous digital art therapy, which lead to more understanding of AI as a material in art therapy.

Chapter 2

Related Work

In this chapter, we first review art therapy with its related theory, technologies for digital art therapy, and then human-AI co-creative systems for drawing activities. Finally, we discuss some general guidelines in human-AI interaction that inspired this work.

2.1 Art Therapy and Related Theory

Art therapy leverages art-making as a *process* of enhancing one's well-being by facilitating self-awareness, self-expression, and self-growth [1, 12]. In an art therapy session, an art therapist would facilitate clients to express their feelings and communicate through the art-making process with structured (e.g., therapists give specific instructions) or unstructured (e.g., clients decide what to draw) directives, followed by a discussion of the artwork, problems and needs [6, 79]. During the process, the clients are motivated to deliberate on or talk about the drawings [58]. By transforming the issues into images, clients and therapists can view the problem from new perspectives to achieve the therapeutic goals [79]. Art therapy benefits people of all ages by promoting self-awareness and self-growth, overcoming intense emotions, settling disputes, and enhancing well-being [1]. It is also a system for self-care and self-expression which could benefit individuals in coping with stress and anxiety, and decrease feelings of isolation and alienation [12].

Viewing art-making as a healing process is differentiated from the concept of using art as merely a *product* (i.e., the result of a process) for item analysis to depict mental states, which was raised in the 1940s [112]. When using art as a product in projective drawing tests (e.g., Draw-A-Person and House–Tree–Person), the contents are analyzed based on

the standardized scoring system, which is found in low validity and has little empirical support [56, 108]. Mapping particular drawing signs with a diagnosis without considering other aspects, such as people's background, culture, and class, is an oversimplification [44]. Instead of focusing on the sign interpretation of the image contents, a better approach relied on understanding the drawing holistically with clients' behavioral information and self-interpretation of the artwork [58].

Differing from using art in psychological tests, art therapists' key objective is to construct a conversational, interactive treatment instead of making a differential diagnosis; thus, art therapists would instruct and observe the process of art pieces creation to collect information, such as the therapeutic goals, clients' engagement and interaction with art media and tasks, and their suitability for art therapy, for the treatment plan development [58]. The clients' assessments and evaluations in art therapy have shifted from the traditional psychoanalytic method to approaches that stress the expressiveness of the tasks and art media [112]. Art therapists can examine the global variables (e.g., prominence of color, quality of line, developmental level) of the artworks and identify the theme and patterns [31, 36].

To evaluate the effectiveness of art therapy, researchers have conducted both qualitative and quantitative studies and the results revealed the potential of art therapy as a treatment for certain disorders and population groups [104, 98]. Metrics such as symptoms and physical measures, health or mental health assessments, and quality of life assessments, have been used in quantitative studies to evaluate the effectiveness of art therapy via questionnaires and selective usage of projective drawings or physiological indices [98].

The growing literature suggests diverse theoretical orientations in the field of art therapy, such as psychodynamic, humanistic, and cognitive-behavioral approaches [112]. In particular, art therapy could be viewed as a form of expressive arts therapy (i.e., a discipline that believes in the therapeutic potential of different art forms, such as art, music, dance, and drama) where intermodal or multimodal approach could be used [78]. In expressive arts therapy, some theoretical models are proposed to help practitioners evaluate clients' interactions with art media to formulate the treatment plan [78]. One of them is the Expressive Therapies Continuum (ETC) [55].

By integrating the psychological and neuroscience approach, ETC enhances the understanding of visual information processing based on interactions and expressions [73, 74]. There are four levels of experiences with increasing complexity in the ETC where each of the first three levels is a continuum with two ends and the fourth level intersects and connects the first three levels [55]. The first three levels are the Kinesthetic/Sensory level, Perceptual/Affective level, and Cognitive/Symbolic level, and the fourth level is the Cre-

ative level [73].

The Kinesthetic/Sensory level emphasizes bodily expression and movements while the contents are not significant [72]. The Perceptual/Affective level reflects the ability to use forms and colors to convey and express ideas or emotions [74]. The Cognitive/Symbolic level involves rational thinking and metaphorizing personal experiences in the art-making process [75]. The Creative level indicates that creativity can emerge in all of the previous three levels [78]. To the best of our knowledge, there is no prior study explored how human-AI co-creative techniques could support the different dimensions in ETC, which motivates our work to investigate the associations of AI as an art material with ETC.

Therapists can use ETC to analyze clients' artistic expression to see their functioning at each level and if any obstructions appear on certain levels [77]. The selections and interactions of art media can emphasize different information processing levels. Art therapists need to understand the languages of the art materials and select the appropriate ones to suit the different therapeutic goals [63]. For example, resistive media (e.g., pencil, crayons, and markers) can improve "left-hand" components (i.e., Kinesthetic, Perceptual, and Cognitive components), and fluid media (e.g., poster paint, watercolor, finger paint) can promote the "right-hand" components (i.e., Sensory, Affective, and Symbolic components) [76, 46]. As the levels in ETC illustrate a progression of the experiences in creative activities, we designed features in DeepThInk that could help clients to achieve art expressions in different ETC levels. We aimed to understand how AI could be introduced as a *material* in art therapy and investigate its meaning based on ETC.

2.2 Technology and Support for Digital Art Therapy

With the development of digital technologies, distance art therapy has become popular since it increases accessibility and supports the therapist-client relationship after relocation [25]. In 1998, Cubranic et al. proposed a computer system for distance group art therapy for people with limited mobility using a participatory design process [25, 22]. The findings concluded that art therapy is ideal for telehealth [20]. This work is a pioneer in developing an art-making system to support remote art therapy. However, the program provided only basic drawing brushes, such as marker, pastel and spray paint, and the focus of the participatory design was not the expressive properties of the art-making system. Later, some works have been done to investigate the required properties of drawing applications for art therapy for general groups [17] and adults with developmental disabilities [26]. An art therapy-specific app, Art Therapy Draw! was designed to contain two of the proposed features in [17] which are portfolio and security control [81].

The prior works only extracted the desired qualities from existing art-making applications which were not designed for art therapy [17, 26]; or the needs were derived from literature instead of involving art therapists' opinions in early design stage [81]. Therefore, we present an iterative design process that involved art therapists from the ideation stage, and focused on how digital systems—as a new type of art-making materials—could be pertinently designed for art therapy.

2.3 Human-AI Co-creative Drawing

One promising direction to extend the expressive quality of digital art-making systems is to incorporate AI techniques. For leisure contexts, multiple tools have been developed to support and study the human-AI collaboration for drawing. There are mainly two forms of the co-creative drawing process with AI. One of them is that users and the agent take turns (e.g., adding strokes) to finish the drawing. Coco Sketch, an improvisational human-AI collaboration system with music accompaniment, is an early attempt to investigate human and AI co-creativity [29]. Following this, Drawing Apprentice [28, 30] is developed as a real-time improvisational co-creative sketching agent. Oh et al. designed a system, called DuetDraw, that incorporates Sketch-RNN [42] and PaintsChainer [125] to assist human-AI co-creation with various functionalities such as completing unfinished objects [91].

The other set of human-AI art-making systems process users' drawings as input, and output a generated image accordingly. GauGAN, for example, is a demo application for SPADE [97] which can synthesize photo-realistic images based on the input semantic segmentation map. SmartPaint, as another example, utilized GAN to output cartoon landscape paintings based on human sketches as a semantic segmentation map [105].

The prior works have demonstrated the potential of creating artworks collaboratively with AI, but none of the studies has been situated in the context of art therapy. The HCI community still lacks empirical understanding about whether and how human-AI co-creative art-making could be meaningful to art therapy. Therefore, we closely collaborate with art therapies to ground our design rationales for DeepThInk based on the needs of digital art therapy practice and contextualize the benefits, challenges, and design implications of human-AI co-creative art-making via the implementation and evaluation of DeepThInk.

2.4 Human-AI Interaction Guidelines and Challenges

The burgeoning development of AI technologies encourages the studies and investigations in design recommendations for AI-related products. Amershi et al. extracted 18 design guidelines from academic literature and industry sources for human-AI interaction, where the applicability was demonstrated through various AI-infused products [5]. A series of works [117, 119, 116] have been done by Yang et al. to investigate the challenges in designing AI and concluded two major ones, which are capability uncertainty and output complexity [120]. Considering these challenges, DeepThInk offers the User Brush where users can freely refine, adjust, and even completely override AI-generated results, and provides an interface to demonstrate the input and output of generative AI.

Another important conclusion from this body of research is that domain-specific human-AI interaction guidelines are needed besides the general ones [5]. Given that the context of art therapy has been rarely explored by prior research in human-AI interaction design, we argue that the specific design implications and insights yielded from this domain could meaningfully contextualize or complement the existing guidelines for human-AI interaction design in general.

While the scenario of digital art therapy is yet to be explored, a variety of application domains have been studied in prior design research on human-AI co-creation, such as creative writing [18, 38, 115], music composition [69], game level design [41], design ideation [62] and drawing [28, 60, 91, 105, 34]. A common theme that arose in these works is the discussion of the role and contribution of the agent. One of the guidelines for human-AI co-creative systems proposed in [105] is to allow users to feel more ownership. Improving transparency and interactivity have been argued as two ways to increase ownership [38]. Building further upon these studies, DeepThInk incorporates four tools, namely AI Brush, Styling, Filtering, and User Brush, to enable users' control over the outcome image at various levels. Moreover, DeepThInk allows flexible, nonlinear exploration and modification by switching among these tools back and forth during the art-making process, which further increases the interactions and playability of the system. With this study, we intend to provide new and specific insights into human-AI interactions in the art-making process for art therapy where the goal is to enhance self-expression and creativity rather than improve the quality of the outcomes.

Chapter 3

DeepThInk Design

We designed and developed DeepThInk by closely working with five experienced registered art therapists. In the following, we first describe the process and then summarize our design goals obtained during the process.

3.1 Iterative Design Process

The five registered art therapists with 6-38 years of experience involved in the iterative design process were all females (referred to as E1 to E5). They provide services for a wide range of clients, including children, teenagers, and adults, people who have suffered trauma, cancer patients, as well as people with psychiatric diagnoses including schizophrenia, depression, and obsessive-compulsive disorders. E1 and E2 were only involved in the first two months (i.e., requirement gathering), while others (E3-5) were actively engaged throughout the whole design process. The entire process lasted for ten months, during which we conducted a series of interviews, exploratory sessions, and evaluations with the art therapists to gather design requirements, assess prototypes, and identify the next steps. We closely communicated and collaborated with the therapists via various forms including emails, online surveys, and live remote sessions. The activities are summarized in Table 3.1 and the main stages of this iterative process are as follows.

Requirement gathering *(2 months).* In this initial stage, we aimed to understand the general practice of (digital) art therapy and identify the challenges and opportunities for developing DeepThInk. We conducted four exploratory, semi-structured interviews with E1-4. Based on our in-depth conversations, we derived authentic design principles

Stages	Formal Activities	Sessions	Duration	Participants
Requirement gathering (2 months)	Semi-structured interviews to understand needs	4	60 min	E1-4
Early prototype iteration (2 months)	Short discussions to refine mockups and prototypes	3	30 min	E3
High-fidelity prototype development (4 months)	Exploratory sessions to assess the working prototypes	3	30 min	E3-5
Final validation (2 months)	Expert reviews	3	60 min	E3-5
	Self-exploratory sessions	10	60 min	P1-10
	Art therapy sessions	2	60 min	E3 & P5; E5 & P3

Table 3.1: Summary of the activities in the iterative design process.

(Section 3.2) and core functionalities for the system (Chapter 5). As commonly recognized by therapists, online digital therapy had become an urgent need due to the pandemic; however, the art-making systems for remote sessions were far from satisfactory. We demonstrated some AI art-making techniques to the therapists and they appreciated the generative model (e.g., GauGAN [97]) that turns user-drawn color blobs into a landscape painting. This generative approach was then implemented in the AI Brush (Figure 4.1-A_1). The therapists also stressed the importance of the process instead of the end product in art-making. They thus pointed out that users should feel ownership and freely modify or redraw the AI-generated image, which inspired us to incorporate the User Brush (Figure 4.1-A_4).

Early prototype iteration *(2 months).* After identifying the core functionalities (i.e., various types of tools), we started to create some low-fidelity prototypes. We prepared multiple mockups and discussed them with E3 for feedback in multiple ad hoc sessions. We have conducted three formal interviews with E3 throughout the two months and each one lasted for 30 minutes. One critical design decision lay in how users could author the AI generation and the classic drawing process seamlessly. In general, users need to operate on two aspects (which can be flexibly switched back and forth): (1) painting a semantic segmentation map (i.e., the input) to guide the AI to generate an image as the background (i.e., the output), and (2) enhancing and/or drawing over the AI-generated background like in traditional art-making systems. We thus presented a one-canvas layout (Figure 3.1-a) and a two-canvas layout (Figure 3.1-b) of the design. In the one-canvas layout, the AI-generated background superimposes the semantic segmentation map, and they are revealed

(a) (b)

Figure 3.1: Mockups for exploring the design of layout in the main drawing area: (a) one canvas based and (b) two canvas based.

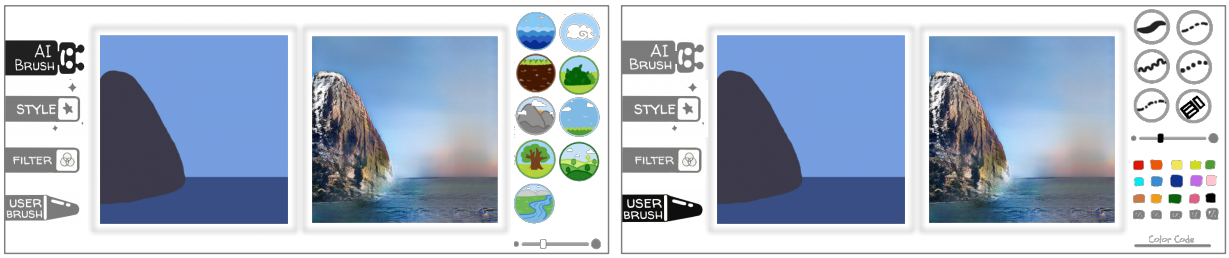

Figure 3.2: Mockups for exploring design alternatives using the two-canvas layout.

individually according to the drawing brush. In the two-canvas design, the segmentation map and the AI-generated background are displayed side by side. E3 commented that the one-canvas layout could be too abstract because users cannot observe the concrete inputs and outputs and make comparisons between them. However, the two-canvas version could easily display them. She also suggested other functionalities such as providing a color palette and offering Styling and Filtering tools (Figure 4.1-A_3) to change the styles and/or tint of the AI-generated photo-realistic images. Based on her feedback, we further explored the design alternatives with mockups using the two-canvas layout (Figure 3.2).

High-fidelity prototype development *(4 months).* In this stage, we mainly focused on developing the working prototype of DeepThInk (Chapter 5). We conducted three exploratory sessions with E3-5 so that they can play with the working prototypes and give feedback on the design and functionalities, thus we can iteratively improve the prototype. Each session was about 30 minutes which art therapists can freely explore the functionalities and give suggestions on the design. To achieve the AI Brush and the Styling tool, we leveraged two types of pre-trained models respectively: SPADE [97] and style-transferring models [54, 109]. The Filtering tool was developed to alter the hue, tint, or tone of the image on the canvas. Additionally, we implemented the User Brush by overlaying the shapes

or texture images repeatedly on a user's strokes. With the feedback from art therapists, we iterated the working prototypes and changed different aspects of the design including the layouts, the choice of icons, and color palettes. One example is that by testing the working prototype with devices with different screen sizes (e.g., tablets, laptops, and desktops), we found that making the two canvases equal-sized side-by-side would limit the drawing space for devices with a small screen. To address this issue, we changed to one small preview canvas and one primary canvas, which would be automatically switched back and forth based on the active drawing tool (Figure 4.1).

Final validation *(2 months).* In this stage, we refined the high-fidelity prototype based on previous exploration and feedback, and conducted a two-part formal validation of DeepThInk, consisting of expert reviews (Chapter 6) and a user evaluation (Chapter 7). In the expert reviews, we observed how the art therapists (E3-5) used DeepThInk and conducted an in-depth discussion with each of them. The user evaluation contained self-exploratory sessions with 10 participants and two art therapy sessions with the collaborating therapists (E3 and E5) and two participants. In the self-exploratory sessions, we asked the participants to complete six art therapy exercises and conducted semi-structured interviews to learn about their experiences. In the art therapy session, the first part was led by the art therapists and the second part was one-on-one interviews with the art therapists and the "client" participants, respectively.

3.2 Design Principles

In close collaboration with the art therapists, the following design principles were derived through thematic analysis of the interview data and consolidated for facilitating digital art therapy. We followed the procedure in Braun and Clarke's work [11], including familiarization with the contexts, generation of the initial codes, themes searching through connecting codes, theme review and finalization, and findings establishment. These principles were initially unveiled during the requirement gathering phase and further refined along with our continued conversations with the therapists.

D1: Lower the art-making expertise threshold to benefit broader client groups. This principle has its unique meaning in the context of art therapy, due to the very common misunderstanding—artistic talent is a requirement for art therapy [113], which scares people off from participation. Some people do not believe others could understand their drawings, and easily get frustrated while attempting to convey certain messages in art-making. As mentioned by E3, there is *"built-in frustration in any medium in art"* and *"also a learning curve."* It is reported that artistic ability might affect art therapy

assessments and non-artists found it difficult and challenging to express their ideas due to the unfamiliarity of the medium [8]. Making the drawing process more effortless could potentially reduce the initial frustration and hesitation about the art creation, and encourage more participation, self-expression and self-exploration in art therapy. We integrate the generative ability of AI as a special set of brushes in DeepThInk to allow users to depict their ideas without putting much effort, thus reducing the time spent on the drawings and promoting enjoyment.

D2: Promote AI as an art-making material and strike its balance with clients' creative efforts. The nature of art therapy predominantly determines that AI techniques should be seen as art materials, rather than automators of the art-creating process. Based on the ETC model in art therapy, the Kinesthetic/Sensory level, which is the first level of information processing, emphasizes motor expressions [77, 74]. To support kinesthetic expression such as frantic scribbling, full automation in the art-making process should be avoided [74]. Although many AI-infused drawing systems support high-quality image generation, they often automate the tasks completely, lacking a balance between automation and users' manual effort [45]. To make clients feel the ownership, we design two separate drawing layers in DeepThInk: a background layer for automatic generation (i.e., AI Brush, Styling, and Filtering) and a foreground layer for customization (i.e., User Brush), which are seamlessly integrated together. Such design does not only leverage AI's power to improve users' creativity and expressivity but also preserves the capability for agitated actions. Thus, users can have the options to guide the AI generation, refine the generated image, and combine the creative outcome between themselves and AI to fully express themselves.

D3: Enable multi-dimensional art-making in a nonlinear process to enhance clients' expressivity and creativity. The essential benefits of art therapy are largely granted by the multi-dimensional, exploratory interactions between the client and the art-making medium. Providing various simple but powerful features is identified as one of the desired qualities of digital art materials for art therapy [17]. The second level in ETC, namely the Perceptual/Affective level, mentions that the affective pole involves expressive and emotional usages of colors and forms [74]. Thus, we consider integrating various tools for users to inspire expressiveness through different shapes, colors, and forms. Moreover, to increase playfulness which E5 expressed as an important property in art therapy, users should have the freedom to choose which tool they want to work with, instead of following a predefined order. To guarantee the richness of expression and flexibility of exploration in art-making, two concepts evoke during the design of DeepThInk: multi-dimensionality (i.e., combining various art-making systems), and non-linearity (i.e., enabling flexible switching among different toolsets). Therefore, besides the AI Brush and the User Brush, the features

to transfer styles and apply filters are integrated into DeepThInk, and these tools can be flexibly used and combined to enrich users' creative repertoire in the context of art therapy.

D4: Facilitate both synchronous and asynchronous interactions with therapists with ubiquitous access. Traditional art therapy sessions usually require users and therapists to be co-located in the same place, which creates obstacles for people who cannot travel [126]. Some researchers have explored means of conducting online synchronous (digital) art therapy sessions [21, 67]. A digital art-making system that allows users to create artworks with a therapist as well as alone could provide more opportunities for participating in art therapy. Also, users should be able to access the system on different devices. E3 mentioned that she would recommend clients keep an art journal: *"It means that the person has an ongoing sense of being connected to the therapy through the work that they're doing and to the therapist. They haven't had to let this issue go just because the session is over. "* -E3 E4 also stated that *"I do get art from my clients. They would send me poems or music or a visual art piece sometimes between sessions."* To assist the synchronous and asynchronous communication through arts, DeepThInk is designed to be accessible ubiquitously, so users could perform the art creation in their daily life, before or after the art therapy sessions.

Chapter 4

Interface and Usage Scenario

In this chapter, we present a scenario to show the usage of DeepThInk in art therapy. For simplicity, we only demonstrate how the client interacts with the system, omitting the conversation between the client and the therapist.

Suppose that Tom feels very depressed because he has been stuck at home for a long time due to the pandemic. He decides to see his art therapist and the therapist suggests he draw a dream holiday as part of the exercises to relieve the anxiety and stress. He thinks somewhere that has a vast landscape could be a good place for vacation. He opens DeepThInk (Figure 4.1) in his browser on his tablet and its interface contains three panels: (1) a toolbox for selecting different tools and adjusting basic brush properties such as size and color as shown in Figure 4.1-A, (2) a main drawing area with two canvases side by side as shown in Figure 4.1-B, and (3) an options panel based on the selected tool as shown in Figure 4.1-C. The two canvases always have one larger primary canvas (Figure 4.1-B_2) and one smaller preview canvas (Figure 4.1-B_1), based on the tool selected.

He first selects AI Brush (Figure 4.1-A_1) and notices that the primary canvas has a default segmentation map that includes the *Sky* on top of the *Sea*. Then he selects the *Mountain* on the options panel for this AI Brush to paint a color blob of *Mountain* on the segmentation map (Figure 4.2-a). He feels satisfied with this layout and clicks the "GENERATE" button. A generated image by DeepThInk is shown on the preview canvas in the main drawing area, displaying a rocky mountain beside the sea.

He likes the big picture created by the AI Brush, but he realizes that the sea is too calm and thinks there should be some winds blowing over the sea. He clicks the Styling tool (Figure 4.1-A_2) from the toolbox and the two canvases in the drawing area switch positions, making the generated image the primary. He then chooses *Kanagawa* from the

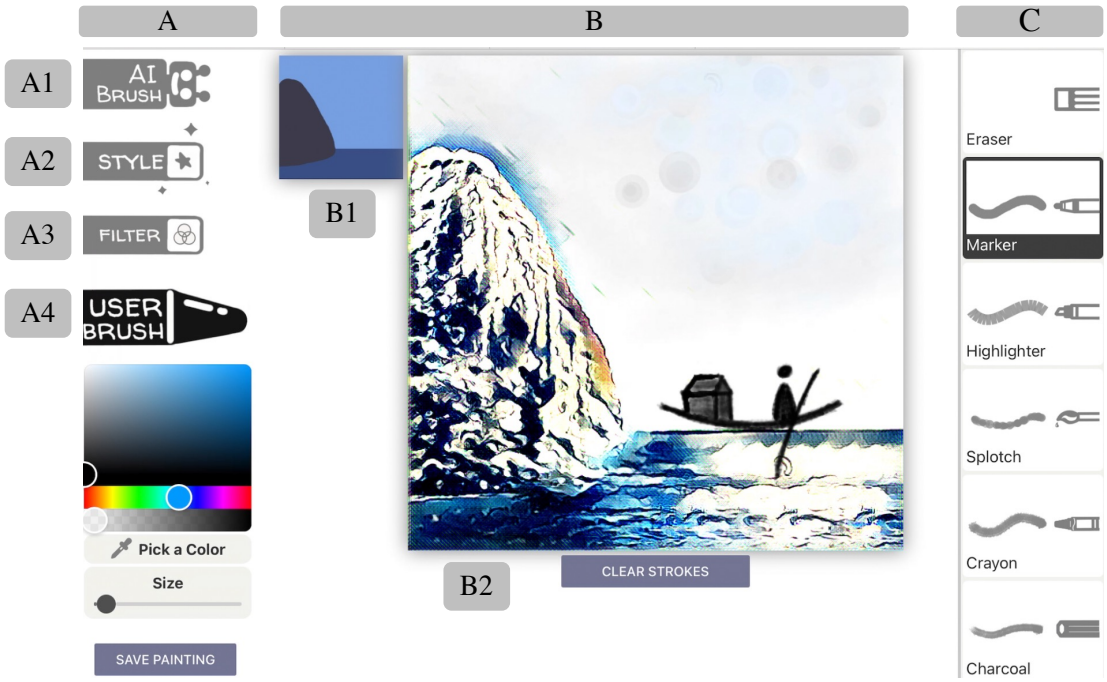

Figure 4.1: DeepThInk is an AI-infused art-making tool to support digital art therapy by offering a human-AI co-creative process. The user interface of DeepThInk consists of three interactive panels: (A) a toolbox for selecting different tools and adjusting basic brush properties such as size and color, (B) a main drawing area with two canvases side by side to facilitate human-AI art co-creation, and (C) an options panel based on the selected brush in the toolbox.

(a) (b) (c)

Figure 4.2: Key steps of the art-making process in the usage scenario: (a) drawing on a segmentation map using the AI Brush, (b) applying the *Kanagawa* using the Styling tool, and (c) setting the *Contrast* filter using the Filtering tool.

options panel to create some waves on the sea. However, the *Kanagawa* style introduces some warmer colors to the image and he thinks *"I want it to be a little bit cooler in tone"* (Figure 4.2-b). Thus, he switches to the Filtering tool (Figure 4.1-A_3) to see if any filters can achieve these effects. By going through each filter on the options panel, he realizes that the *Contrast* filter can make the bright and dark regions more distinguishable which results in cooler colors (Figure 4.2-c).

"The image looks good, and I would like to stay here on a boat," Tom thinks. He thereby selects the User Brush (Figure 4.1-A_4) and chooses *Marker* from the options panel to add a boat and himself on the sea (Figure 4.1). When he is done, he feels relaxed and peaceful in creating a vivid drawing of his dream holiday. Meanwhile, Tom's therapist can observe these behaviors, investigate the reasoning behind them, and offer consultation during the process.

Chapter 5

System Implementation

In this chapter, we introduce the details of DeepThInk by providing a system overview and describing the implementation of the four tools. The development of DeepThInk was guided by the aforementioned design principles (**D1-4**).

5.1 System Overview

We designed and developed DeepThInk as a web application that is composed of a front-end interface and a back-end server (Figure 5.1). The front-end interface is designed as simple and intuitive as possible by mimicking a basic drawing system, consisting of three panels as introduced earlier (Figure 4.1). As demonstrated in the scenario (Chapter 4), in the main drawing area, one canvas allows the user to paint a segmentation map using the AI Brush to control the AI generation for a background image. The background is displayed dynamically on the other canvas, and then the user can select the User Brush to draw customized foreground strokes on top of the background. Meanwhile, the Styling and Filtering tools can be optionally used to modify the AI-generated background. The user interactions on the front end are supported by the back end.

To increase the ubiquity (**D4**), DeepThInk is deployed on the cloud for easy access with various kinds of devices, as long as there is a browser application. It also adapts the interface layout to different screen sizes such as tablets, laptops, and desktops. Drawing interactions can be performed using a mouse, touchpad, finger touch, or stylus. Thus, both synchronous and asynchronous art-making sessions could be conducted.

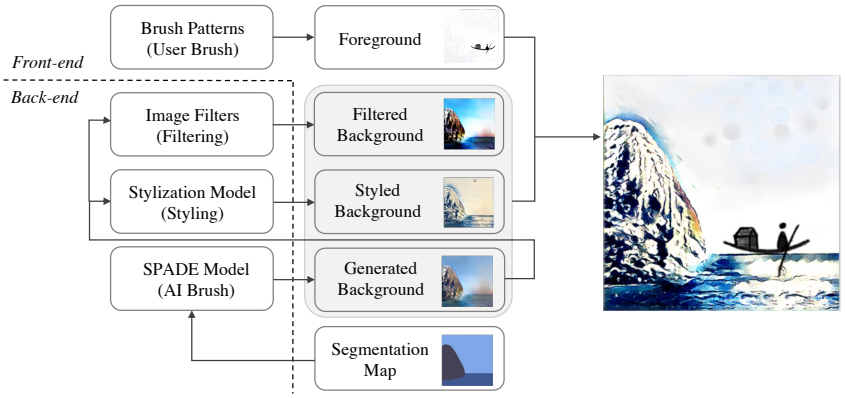

Figure 5.1: DeepThInk system architecture. The front end allows users to select different tools and make art with an AI-tuned background and a customized foreground. The back end handles user interaction requests from the front end and communicates with various pre-trained AI models to support human-AI co-creation.

5.2 Drawing Tools

Here, we introduce the implementation of the tools equipped by DeepThInk to support human-AI art co-creation in digital art therapy. All the tools can be accessed freely in the art-making process back and forth, allowing a flexible and non-linear experience (**D3**). Overall, users can employ the AI Brush, Styling, and Filtering tools to compose a background image and leverage the User Brush to draw the foreground. While designing each tool, we added small features that could allow users to express in terms of different ETC components (Table 5.1). The background and foreground can be adjusted anytime and iteratively to form a tight human-AI co-creative process.

AI Brush. With the AI Brush, users can compose natural scenery with simple sketches, which significantly lowers the bar for a general audience to make art (**D1**). Users need to define a semantic segmentation map that represents natural objects by first selecting the desired object (e.g., sea, cloud, dirt, etc. as mapped in different colors) and then directly painting color blobs on the canvas. This segmentation map is then sent to the back-end server for generating a photo-realistic image accordingly. To achieve this, we employed the SPADE model[1] [97]. This approach requires the user to paint on a segmentation map that emphasizes the bodily movements at the Kinesthetic level in ETC. Since one major usage of art therapy is to support clients who face limited verbal communication skills and are unwilling to use words for expressions [50], we chose this approach to reduce the

[1] https://github.com/NVlabs/SPADE

ETC Component	Visual Expression	System Implementation
Kinesthetic	Scribbling	**AI, User Brushes:** enable users to freely draw on the canvas
Perceptual	Lines, forms and shapes	**AI, User Brushes:** provide different brushes with size adjustment, so they can discriminate forms in the drawing
Affective	Colors for emotion	**Styling Tool:** provide artistic styles with different colors theme (e.g., Stary Night and Rain Forest). **Filtering Tool:** provide filters to change, remove or enhance the color tones (e.g., Grey, Contrast, and Invert). **User Brush:** provide a color palette.

Table 5.1: The development of DeepThInk's drawing tools based on Expressive Therapies Continuum (ETC).

text involvement in the art-making process, compared with other text-based generative art approaches [33, 92, 68]. In this AI Brush, the segmentation map is set to be in the primary canvas (Figure 4.1-B_2), whereas the AI-generated image is shown on the preview canvas (Figure 4.1-B_1). The AI Brush supports the generation of common natural objects since they are often used as themes in art therapy exercises. For instance, in Haeyen's book [43], "Emotion Island—Map" requires clients to use landscape elements to represent emotions, "The Leaf" requires clients to imagine themselves as leaves, and "Imagination—The Seed" requires clients to perceive themselves as seeds and draw the surrounding landscape. Details about the AI models are in Section 5.3.1.

Styling. The Styling tool allows users to transform the AI-generated image into different painting styles, which enriches a multi-dimensional art-making process with various options (**D3**). There are six supported painting styles in DeepThInk such as *Kanagawa*, *Starry Night*, and *Rain Princess*, where each style corresponds to one specific pre-trained stylization model[2] [54, 109]. Each provided artistic style introduces different shapes and colors, aiming to support the Affective component in ETC. The option to keep the originally generated image effect is also available. As the user's main operation target is the generated image, the image canvas in the main drawing area is set to the primary canvas, while keeping the segmentation map canvas on the left as a reference (Figure 4.2-b). This

[2] https://github.com/pytorch/examples/tree/main/fast_neural_style

layout remains the same for the Filtering and User Brushes described below. As different materials have different expressive properties [66], the Styling tool could enhance the creativity of users and allow them to express their minds with various artistic styles which could be a valuable dimension in art therapy. Details of the style transfer models can be found in Section 5.3.2.

Filtering. DeepThInk also provides several simple image filters in which the hue, tint, tone, and/or shade of the AI-generated background can be altered, with the content of the image remaining. There are six filters supported by the tool, including *Blur*, *Sepia*, and *Contrast* (Figure 4.2-c). This Filtering tool again adds an extra dimension to the art-making process and brings different color tones to the art piece (**D3**). This aims to inspire the emotional relations and descriptive usages of colors based on the Affective component in ETC. Further, Filtering can be used together with Styling, on top of the AI Brush, increasing the vocabulary of human-AI art co-creation as well as users' creativity and expressivity.

User Brush. Finally, the User Brush in DeepThInk provides users with the opportunity to change the generated, stylized, and/or filtered image background by painting on top of it, like a traditional drawing system. Thus, users' expressions are not restricted by the images generated by the AI (**D2**), via painting a customized and fine-controlled foreground. This way helps support the Kinesthetic, Perceptual and Affective components in ETC. We implemented a set of basic user brush patterns, including *Crayon*, *Charcoal*, and *Chalk* (Figure 4.1-C). To do so, the brush pattern image (set in the selected color) is repetitively rendered on the canvas with some randomness in opacity, rotation, and scale. Such richness of textures or materials in the User Brush is essential to digital art therapy, mimicking real-world art-making systems as well as offering benefits of digital presence such as increasing accessibility.

5.3 Implementation Details

In this section, we explain the architectures of the two off-the-shelf models we used in the AI Brush and the Styling tool.

5.3.1 AI Brush

To achieve the semantic image synthesis task in AI Brush, we leveraged the framework proposed in [97]. The SPADE generator (Figure 5.2) takes a random vector as an input

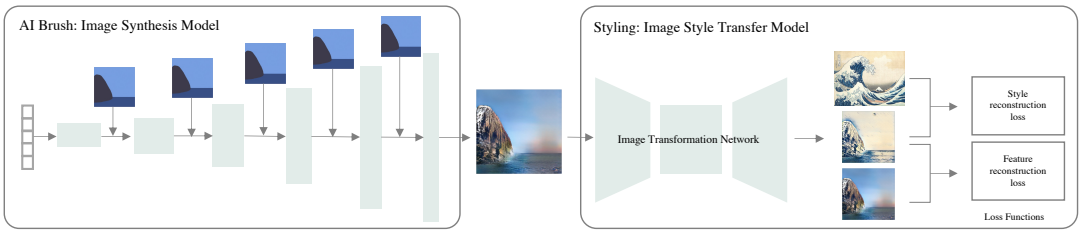

Figure 5.2: The model architectures of the SPADE model used in AI Brush (left) and the stylization model used in the styling tool (right).

Perceptual Losses	**Loss Network (VGG-16) Layers**
Feature Reconstruction Loss	relu3_3
Style Reconstruction Loss	relu1_1, relu2_2, relu3_3, relu4_3

Table 5.2: The Perceptual Losses and the associated Loss Network layers.

and outputs a photo-realistic image based on the users drawn semantic map. It utilizes the decoder of the generator of the image-to-image translation network (i.e., pix2pixHD model [114]), and used the spatially adaptive (de)normalization method between the up-sampling layers. The spatially adaptive (de)normalization method takes the semantic segmentation map as the input, which ensures the semantic information does not get lost in the normalization process. Hence, in the AI Brush, users can draw a semantic segmentation map and generate a photo-realistic image.

5.3.2 Styling

For the style transferring task, we adopted the method proposed in [54]. We get an output image by feeding the input content image to the image transformation network. The feature reconstruction loss is computed to preserve and maintain the content and structure of the content target (i.e., the original input image). The style reconstruction loss is computed to enforce the artistic style of the style target (i.e., the Kanagawa image). As shown in [54], the shallow layer of VGG-16 [102] could be used for feature reconstruction, and the stylistic features could be maintained through even deeper layers (see Table 5.2). Instead of using the image transformation network in [54] directly, we replaced the batch normalization in the image transformation network with the instance normalization, since it can discard the contrast information of the content images and improve the generation [109]. In the inference stage, given user generated photo-realistic image from AI Brush and a selected style, a styled image can be produced by the Styling tool.

Chapter 6

Expert Review

To gain an in-depth understanding of the potential usages of DeepThInk in art therapy, we conducted an expert review with each of the three registered art therapists (E3-5) who have been involved in the previous stages of our iterative design process (see Section 3.1). This also allows the art therapists to interact and familiarize themselves with DeepThInk, thus setting the stage for our further evaluation (see Chapter 7).

6.1 Study Setup

Each expert review session lasted around 60 minutes and consisted of hands-on activity and an in-depth discussion. First, we explained all the features of the working high-fidelity prototype of DeepThInk and demonstrated the drawing process. Then, the therapists were asked to explore the system on their own under our observation. During the activity, we requested them to think aloud and articulate the thought process in their minds. To help us understand the properties of the AI Brush as an art-making material, we encouraged the therapists to not only draw realistically but also abstractly. They were allowed to ignore the semantic meaning of the elements in AI Brush and treat them purely as textures to create the image. An in-depth discussion was then followed where therapists were asked to envision the potential usages of the system in their practice and speculate on the capabilities, benefits, risks, and limitations of AI Brush in terms of art therapy. Each art therapist received $20 in compensation. The sessions were video-recorded and transcribed verbatim for thematic analysis.

6.2 Results

A thematic analysis was conducted on the interview data, after transcribing the audio recordings, by using the same method stated in Section 3.2. The results can be grouped into the following themes.

6.2.1 General experience.

The art therapists confirmed two benefits of DeepThInk as a digital art-making system for art therapy: simplicity and accessibility.

Simplicity. The simplicity of DeepThInk was highly valued by the art therapists. As mentioned by E5, *"that's one of the real benefits of creating this very simplified system for our therapy rather than asking clients to use one of the products that's already on the market."* Such *"simplification"* also makes them feel like they can *"play with the system."* -E5 Playfulness is important in art therapy since learning to play means the possibility to *"let down the guard."* -E5

Accessibility. Based on E4, due to the pandemic, the art therapy sessions have been forced online and they have been *"struggling with clients who don't have access to a lot of art materials (e.g., pastels)."* She appreciated that DeepThInk supports easy access to various materials (i.e., AI Brush, Styling, Filtering, and User Brush) which encourages participation in the art therapy sessions. This confirms our intention to increase the accessibility of DeepThInk (**D4**).

6.2.2 Support the drawing process without fully automating art creation.

When asked about the potential value of introducing AI as an art-making material, E3 mentioned that the AI background can be useful when people *"cannot represent what they see in their minds in the art."* Moreover, helping people to realize drawings in their minds might produce *"a certain kind of satisfaction."* -E3 This verifies that AI could ease the process of art creation (**D1**). Meanwhile, with User Brush, E5 showed appreciation of reducing the automation level in DeepThInk because it makes *"the whole process more manual"* and *"much more akin to traditional art-making."* As explained by E4, it is important for clients to immerse themselves in the art-making process, otherwise, it would *"lose the meaning of the healing process."* Hence, avoiding completely automating the process and replacing users' works is essential in art therapy which confirms **D2**.

6.2.3 Association of styles and emotions.

The art therapists recognized that styles evoke feelings and thoughts during the session. Reflecting back on the ETC models, E4 pointed out that *"styles are associated with affective channels, which imply different feelings and help clients to express their emotions."* She also explained that *"colors can bring joy"* in the art-making process. The richness and colorfulness of some styles (e.g., *Rain Princess*) could make her attempt to use User Brush more compared with less colorful styles (e.g., *Starry Night*). E3 shared a similar feeling that she would like to respond to the style changes. This verifies that providing different styles in art-making, which adds another dimension to the art-making process, inspires emotional expressions in art therapy (**D3**).

6.2.4 Potential therapeutic benefits for specific groups.

While envisioning the usages of DeepThInk, the art therapists recognized the following therapeutic benefits for specific groups.

Dance with Unpredictability. Playing with the unpredictability of DeepThInk in the art-making process could help people who have controlling issues. As E4 mentioned, there is *"a sense of control"* and *"a sense of surrender."* She mentioned that the materials can either bring a lot of surprises or can be highly controllable. The uncertainty of DeepThInk introduced by the AI Brush and Styling tools makes it less controllable (**D2**) and could help the therapeutic process to regulate the sense of being out of control. Based on E3, challenging the uncertainties could be a treatment for some people who have *"a strong belief in they have certainty in everything"* such as those with obsessive-compulsive disorder.

Cultural Significance. *Kanagawa*, one of the painting styles in Styling, caught the art therapists' attention as it is related to cultural significance. E4 reported that one problem with art therapy is that *"Western art is the dominant frame."* She also mentioned that *"the idea of white supremacy is so problematic"* since they all use *"western models of psychotherapy"* and *"western models of art."* Hence, the value of bringing different painting styles from different countries in Styling was highly appreciated, because it can help people to create a more familiar painting style that might have specific meaning to them (**D3**).

Chapter 7

User Evaluation

We further conducted a user evaluation to gather insights into the usage of DeepThInk and the role and properties of AI in the art-making process in art therapy. The user evaluation is composed of two parts to test both the asynchronous and synchronous setups: (1) self-exploratory sessions where users completed art therapy exercises using DeepThInk at their own pace and based on their availability in a week, and (2) art therapy sessions where users worked with therapists to make arts.

7.1 Self-Exploratory Session

The self-exploratory sessions were designed to mimic the asynchronous usages of DeepThInk, where art therapy exercises were given to clients to complete on their own and shared with therapists later.

7.1.1 Participants

We recruited 10 participants (aged 18-30, 6 females, 3 males, and 1 transmasculine) from social media and an institutional recruitment website. In the pre-study questionnaire, we provided explanations of art therapy and asked them to specify their needs in an art therapy session, with multi-choice selections and an "Others" text box. As shown in Table 7.1, cultivating emotional resilience, reducing and resolving conflicts and distress were the most frequently selected needs by the participants. Based on a pre-study questionnaire on a 5-point Likert Scale (1 - Not familiar, 5 - Very familiar), participants self-reported

Options	Counts
Cultivate emotional resilience	9
Reduce and resolve conflicts and distress	6
Foster self-esteem and self-awareness	4
Promote insight	4
Enhance social skills	2
Other (text box)	0

Table 7.1: Participants' responses for their needs in art therapy.

their familiarity with drawing was 3 to 5 (MD=3, IQR = 1) and their familiarity with digital drawing was 1 to 5 (MD=3, IQR = 1.5). We also tried to balance the usage of tablets and desktops/laptops (three used tablets, five used desktops/laptops, and two used both). We refer to them as P# in the following sections.

7.1.2 Design and Procedure

Tutorials. First, participants were required to watch a 5-minute tutorial video to get familiar with DeepThInk. The tutorial video demonstrates the basic functionalities of the system and encourages participants to explore the system by giving examples for both realistic landscape drawings and abstract drawings.

Art-making Tasks. Five art therapy exercises were selected from the widely used exercises described in the "Mindfulness," "Emotion Regulation" and "Distress Tolerance Skills" modules in Haeyen et al.'s work [43], which aimed to understand how participants would use DeepThInk for expression and self-reflection (see T1-5 in Table 7.2). We selected these exercises from these modules based on the participants' needs (see Table 7.1). The five tasks were making arts with themes of "Basic Forms," "Six Basic Emotions," "Watercolor Picture," "Landscape Fantasy" and "Dream Holiday." The first two tasks allow participants to draw abstract things with DeepThInk; the third and fourth tasks aim to understand how participants would use DeepThInk to create landscape drawings; and the last one is an open-ended task where we can observe how the system can be used for other themes. Participants were required to submit their artworks to us online.

Questionnaires. Participants were required to fill in an online questionnaire after completing the five tasks. The questionnaire included user experience and usability questions (Q1-8) developed from the USE questionnaire [71] and System Usability Scale (SUS) [14]; and questions (Q9-13) that help us understand the general workflow of DeepThInk, on a 7-point Likert Scale (see Figure 7.1 for the questions). In particular, Q1 and Q7

are from the Usefulness category of USE; Q2 and Q5 are from the Ease of Use category; Q3 is from the Satisfaction category; and Q4 and Q6 are from the Ease of Learning category. Meanwhile, we added Q8 developed from the user's confidence question in SUS. The questionnaire questions also helped us prepare the following in-depth discussions in the semi-structured interviews.

Semi-structured Interviews. A follow-up semi-structured in-depth interview was carried out for each participant to understand how they used DeepThInk for exploration and expression, and their thoughts about using AI as a material in the art co-creative process. The interviews were conducted via an online video conferencing tool and were video/audio recorded for further analysis. Each interview session lasted for around 60 minutes and contained two sections.

- *Section 1 (15 minutes):* Each participant was asked to complete an additional art therapy exercise "Self-Portrait—Four Sentences" in [43] (see T6 in Table 7.2). During the art-making process, we asked them to think aloud and tell us their thought process and the ideas that emerged in their minds. Participants needed to share their screens during the task.
- *Section 2 (40 minutes):* Participants were first asked to talk about the five artworks they created on their own and reflect on their experience with DeepThInk. After, we opened discussions with them in terms of exploring and expressing ideas with DeepThInk. In addition, a series of questions that focus on understanding the properties of AI as an art-making material was asked. Participants were encouraged to share additional thoughts they had with us.

7.2 Art Therapy Session

To help us envision the employment of DeepThInk in real art therapy practice, we conducted user evaluation in an art therapy setup. In the session, the art therapist conducted an art therapy session with one paired participant under the observation of experiment facilitators. No preset format was given to the therapists, and they applied their own professional approach for the two sessions to envision the usage of DeepThInk. The goal of this study is to probe the usage of DeepThInk in practice by obtaining in-depth, contextualized qualitative insights, rather than usability testing with a large number of participants.

7.2.1 Participants

We reached out to the participants in the self-exploratory sessions and recruited two "client" participants (P3 and P5, 1 male and 1 female, aged 24-29). We chose the "client" participants from this user pool because we wanted to compare the experiences in the self-exploratory sessions (i.e., the asynchronous usage of DeepThInk) with that in the art therapy sessions (i.e., the synchronous usage of DeepThInk). Two registered art therapists (E3 and E5) were also contacted to pair each of them with a "client," specifically, P5 with E3 and P3 with E5.

7.2.2 Design and Procedure

The art therapy sessions were conducted online via a video conferencing tool, including the following components.

Art therapy session. During the first 30 minutes, the art therapist would conduct a normal art therapy session with the "client" participant. Experiment facilitators also joined the video call to provide technical support and conduct quiet observations (with the camera turned off and the microphone muted). It was the therapist and the "client" participant's decision on what they would like to talk about. No instructions and interventions were given in this process. It was also reminded that sensitive information should be avoided.

Semi-structured interviews with art therapists. The interview lasted for 40 minutes. The art therapists were asked to discuss the experience and envisage the opportunities of using the system and incorporating human-AI co-creation in their practice. We also showed them the "client" participants' artworks and explained clients' self-interpretations which were recorded from the previous sessions to better envision the asynchronous usages with DeepThInk. Each art therapist was remunerated $20.

Semi-structured interviews with "client" participants. The interview took around 20 minutes where we mainly focused on discussing the "client" participants' thoughts and feelings about using DeepThInk in the art therapy sessions, as well as comparing this with the self-exploratory sessions. Each "client" participant was remunerated $15 after their participation. The interviews with the art therapists and the participants were conducted separately by the experiment facilitators in different breakout rooms of the video conferencing tool.

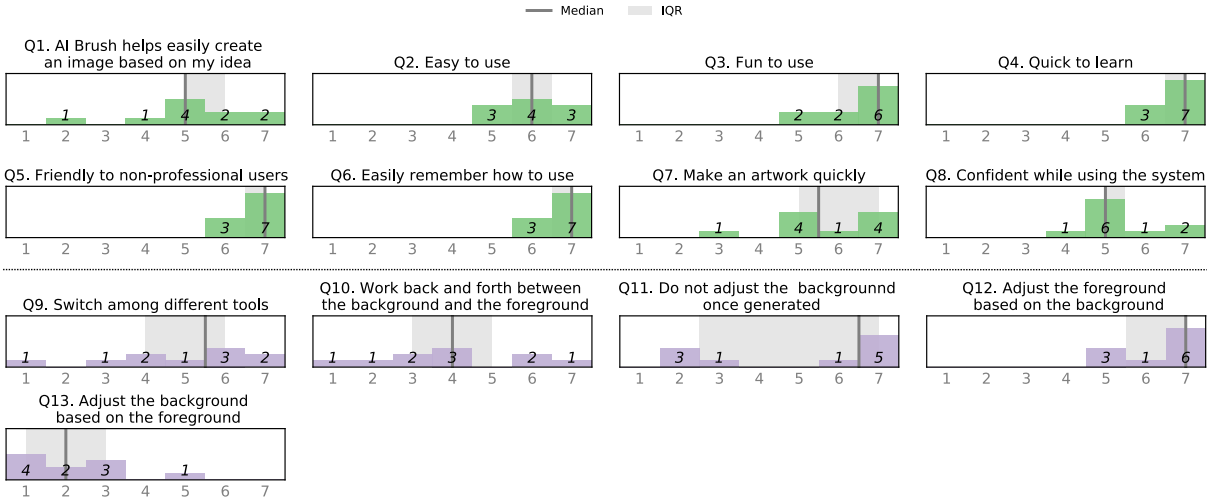

Figure 7.1: Participants' ratings on the questionnaire, where Q1-Q8 (green) regard users' general experience and Q9-Q13 (purple) regard users' workflows (1 - Highly disagree, 7 - Highly agree).

7.3 Outcomes and Quantitative Results

Our quantitative findings are meant to reflect the general attitudes of participants and serve as a supplement to the in-depth user experiences addressed in qualitative findings. All the participants successfully completed all the therapy exercises in the self-exploratory sessions. Figure 7.2 shows some examples of participants' artworks.

The results of the questionnaire are shown in Figure 7.1 on a 7-point Likert scale. Q1 to Q8 refer to the participants' general experience with DeepThInk, where all medians equal to or are greater than 5. Overall, they thought the AI Brush can help them easily create an image based on their ideas (Q1), and considered that DeepThInk is easy to use (Q2), fun to use (Q3), and quick to learn (Q4). They also confirmed that DeepThInk is friendly to non-professional users (Q5), and believed that they can easily remember how to use it (Q6), and make artwork quickly (Q7). Further, they felt confident while using DeepThInk (Q8).

We also asked how they used DeepThInk to complete the art-making tasks (Q9-Q13). The ratings of the tendency of switching among different tools (Q9) and working back and forth (Q10) had widespread. This indicates that participants worked in various orders when using DeepThInk to draw which verifies our **D3**. Six participants did not adjust the AI-generated background once created while the other four participants preferred modifying

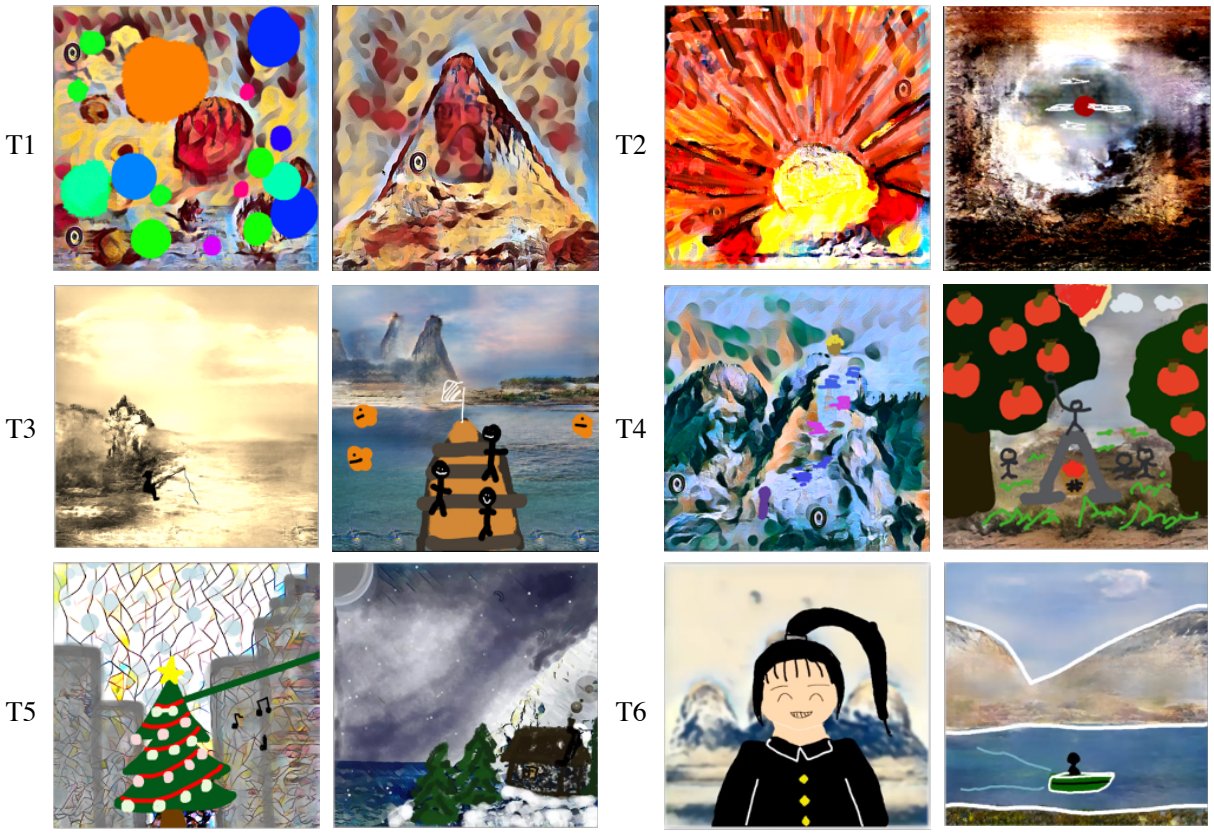

Figure 7.2: Sampled participants' artworks from the six tasks in the self-exploratory sessions. See Table 7.2 for task descriptions.

the background with the AI Brush, the Styling and Filtering tools (Q11). Thus, DeepThInk was able to support flexible ways of art-making depending on individual preferences. Also, according to Q12 and Q13, most people preferred changing their foreground strokes based on the AI-generated, stylized, and/or filtered background (MD=7, IQR = 1.5) than vice versa (MD=2, IQR = 2). This may imply the participants' general workflow (i.e., from background to foreground) when co-creating art with AI; however, we did observe participants switch among different tools back and forth based on their needs.

7.4 Qualitative Results

A thematic analysis was conducted, using the same method above [11], for the interview data gathered from both the self-exploratory and art therapy sessions. These findings incorporate both therapists' and clients' perspectives and contextually demonstrate how the actual usage of DeepThInk embodied our design principles (Section 3.2).

7.4.1 Reducing frustration for art making (D1).

From the therapists' perspective, reducing the frustration of making art can allow a broader range of people to use art expressively in therapy. E3 mentioned that the AI Brush can help people *"who would like to make art but lack confidence that they can do anything nice in art get over that barrier."* Her experience reflected that a lot of people come to art therapy and say that *"I'm not an art person, and I can't do anything in art."* Getting over this barrier can help them *"use art expressively without it having to be something that somebody wants to put up on their wall."* -E3 *"It doesn't have to be for somebody else's pleasure or for somebody else's interest. They can still express something and have a piece of art that is an expression, a concrete manifestation of that expression. "* -E3 Easing the art-making process can help them believe that they can create art for expression and *"value the expression as their own right."* -E3 These results confirm **D1** that using the AI-generative function to simplify the drawing process can encourage engagement in art therapy.

From the clients' perspective, participants appreciated the easiness of creating artworks with DeepThInk. P5 expressed that normally he needs to think about *"the perspective"* and *"color theory"* while drawing, which *"exchange the brain energy for relaxation."* However, with DeepThInk, the AI Brush and Styling tool can provide *"hints"* to complete the drawing which allows him to *"stop thinking hard on how to accomplish something but focus on what to express."* P7 shared a similar feeling that using Photoshop or Illustrator *"is not good for trying to relax"* and feel like *"doing homework,"* but DeepThInk could be beneficial in expressing feelings therapeutically. *"The reference provided by AI Brush can help people draw and express themselves more easily, as it would be difficult for people who do not draw a lot to start from a blank paper."* -P3

7.4.2 The roles of AI in the art-making process (D2).

While the art therapists appreciated that AI could generate sophisticated images in a short time, they also expressed concerns to adapt such power in therapeutic sessions. For people who only use traditional art materials, the fact that AI creates *"eye-popping effects"* very easily could be *"a little bit overpowering."* -E5 Thus, one of the risks of using AI to create *"sophisticated visuals"* is that clients might *"get really involved in the technical aspect to the detriment of pursuing self-expression."* -E5 Hence, it is essential to guarantee the users' participation while adopting AI's power in digital art therapy.

Another observation from the art therapists is that people need to reason and relate the input and output produced by AI since the models are black boxes to them. With the traditional materials, the randomness is *"more related to the gestures"*, but randomness generated by AI is *"more surprising and less intuitive"* -E5. Pouring paint on paper is an example of how traditional material suggests the next step in art-making, but this is very different from the lead of AI. As mentioned by E5, AI is guiding on the conceptual side, not on the physical side. Based on the ETC model, E5 expressed that AI power *"is on the cognitive side,"* because *"it takes a kind of planning and conception,"* which *"is an extra step."* This is different from *"intuitively choosing colors and shapes and laying them on the page."* -E5 This observation helps understand the characteristics of AI in the art-making process and potentially assists the process to choose the right medium for digital art therapy.

Through the interviews, the participants expressed their expectations of the roles of AI in the art-making process. In general, most of the participants considered AI as an assistant, which helps them explore different ideas and realize their imaginations in digital art therapy exercises. P5 used a metaphor to describe the relationship between himself and AI: *"the master"* and *"the apprentices."* In the past, the master would request each apprentice to *"draw the idea in different styles"* which might take them a month to do and now the AI can offer multiple styles of the same ideas quickly and conveniently. P4 also mentioned that the stories were created via User Brush and the AI *"improved the details of the stories."*

7.4.3 Supporting expressivity and creativity (D3).

The art therapists confirmed that the intuitiveness and simplicity of DeepThInk set up a therapeutic environment for clients to easily explore and express themselves. *"People start out making art with a lot of control. It's often hard to move towards unpredictable,*

uncontrolled freedom with the art materials, letting the art materials shape and dictate more of what happens." -E5 With DeepThInk, *"the unpredictability right from the start is very enjoyable."* -E5 Also, DeepThInk *"allows things to progress very quickly."* -E5 which means DeepThInk can support more explorations compared with traditional art materials, leading to the emergence of more creative ideas. Similarly, in the views of clients, by offering tools that manipulate the background and foreground in art-making, DeepThInk can promote their expressivity and creativity.

Expressivity. Participants reported that providing the User Brush with the two-layers design (i.e., background and foreground) can help them express more precisely, and the Filtering tool can help produce certain feelings that are associated with personal experience. P8 reflected that she used the User Brush to *"create the stories"* because the *"simple sketches"* in the foreground could stand out from the photo-realistic or painting-like backgrounds. In addition, the User Brush was used to *"add the elements that weren't reflected by the AI-generated part."* -P6 As regards the Filtering tool, P10 felt that the Sepia filter could bring an *"old-timey feel"* which leads to the same feeling as her hometown, Calgary. Similarly, P5 utilized the Sepia filter to take away the color deliberately so he can mimic a Chinese painting effect. This echoes back to the comments from the art therapists in the expert review sessions: cultural significance plays an important role in self-expression.

Creativity. Participants found that the uncertainty of the backgrounds can inspire new ideas. Specifically, the inspiration could come from two aspects in DeepThInk. The first is the AI Brush. Based on P4, *"the creative ideas emerged from the unpredictability of the AI Brush,"* so he could connect the initial rough ideas with the generated background to create *"unexpected and surprising"* outcomes. P3 shared similar feelings that the generated image could help her determine where to add new elements. The second is the Styling tool. As described by P9, applying different artistic styles to the image can help her explore creative ideas and not *"get drawn to a specific style"* that she is used to and *"stick with that."* Additionally, P5 mentioned that the Candy style would make him draw more circles in the foreground while the Mosaic style suggests using User brush to draw more lines.

7.4.4 Synchronous and asynchronous setups (D4).

Enabling clients to draw alone and share with their art therapists can benefit from handling their issues and maintaining therapeutic relationships. This is *"another way to process, communicate and express what is being grappled with,"* and represents *"an ongoing self-reflection."* -E3 When the art therapists discussed the "client" participants' artworks

created in self-exploratory sessions, they verified the capability of DeepThInk for self-expression in the art therapy exercises. This makes DeepThInk the desired tool for asynchronous communications. E3 mentioned that the finished art pieces demonstrated that P5 can draw *"realistically," "abstractly," "use color to express emotion,"* and *"respond to any art prompt,"* with DeepThInk. Moreover, supporting various devices is appreciated by art therapists. E3 mentioned that *"I think that the embodiment through using the touch screen is an approximate experience to working in person."* Being able to *"make art at a distance"* and *"make art without materials"* is a great benefit so *"people don't have to have the space or the cleanup,"* said E5.

P3 and P5 appreciated that DeepThInk can improve their capability to explore and express ideas with artworks, and using it with art therapists can help them reflect on themselves more. The inspirations from DeepThInk depend on participants' own interpretations, while the art therapists could provide guidance and suggestions which help them see things from a new perspective. P3 used a visual metaphor to describe the roles of the art therapist and DeepThInk: the guidance from E5 was like a *"dot"* and the inspirations from DeepThInk extended the *"dot"* to *"lines,"* which she used to create a *"plane."* P5 shared that DeepThInk can help him express emotions and E3 can enlighten him to perceive things in a different direction.

	Task	Description
T1	Basic Forms	Make a painting based on one of the following basic forms: cross, circle, square, spiral or triangle. Each of the forms may call to mind entirely different things.
T2	Six Basic Emotions	Start from six of the basic emotions: happiness, sadness, anger, fear, surprise, and disgust. Choose an emotion that is close to you right now. Try to portray it in the act of drawing in a symbolic manner or with recognizable images.
T3	Watercolor Picture	Make a picture showing a background of air, land, and perhaps water or a sea in a way that it looks the most pleasing to you. Follow what is in your mind and look to see what the painting needs in your opinion. Try not to let yourself be led by what you think is "proper" or ought to be done.
T4	Landscape Fantasy	Sit down, relax and try to imagine a landscape. Imagine a dwelling or shelter in this landscape. Now, a person appears in the landscape. And now a problem has arisen in this picture; what do you suppose that is? When you have answered all the questions, draw or paint the image in your mind.
T5	Dream Holiday	Make a picture of your dream holiday. Everything is allowed. You can go where you want; there are no restrictions. Try to put across the atmosphere you have in mind as well as possible with the picture.
T6	Self-Portrait —Four Sentences	Make an abstract image with "self-portrait". Take your inspiration from one or more of the following sentences (Art magazine Dada theme issue "self-portrait" 2004): (1) I am who I am. (2) I am more than what you see. (3) I don't just show everything. (4) Maybe I am only what you see

Table 7.2: Task descriptions in self-exploratory sessions.

Chapter 8

Discussion

In this paper, we present the crafting and probing of DeepThInk to empirically understand the design of an AI-infused digital art-making system specifically for art therapy. Through a 10-month iterative design process with therapists, we formulated a set of design principles for human-AI co-creation interfaces in this domain and then contextualized these principles through expert reviews, asynchronous art therapy exercises, and live therapy sessions.

8.1 Design Implications

Besides the specific insights above, the most important message from this exploratory design research is that human-AI co-creation, while rarely explored for this particular context, has revealed itself as a novel yet meaningful form of digital art therapy. Below we reflect on the implications of designing such an emerging form of HCI systems.

8.1.1 Lowering the art-making threshold means making art therapy more inclusive.

Attempts to facilitate digital art therapy have been made for over two decades [25]. However, recent surveys still showed that therapists more often use technologies in administrative tasks rather than directly for art-making with clients [126]. As confirmed in our need gathering, the real gap is not the availability of digital infrastructure but the inclusiveness of the design and the easiness of use. The therapists appreciated DeepThInk's effectiveness

compared to the digital drawing systems they had been using. Creating sophisticated images to explore and express thoughts easily can make people more confident and willing to participate in art therapy. These results suggested how leveraging AI techniques to lower the art-making threshold might help art therapy include and benefit a broader group of audiences.

8.1.2 Designing for the process instead of the product.

One unique characteristic of art therapy as a specific application domain for human-AI co-creation is the emphasis on the process rather than the quality of the final product. Designing for the process of human-AI co-creation in art therapy includes the consideration of the extent to which AI should automate the process and be controlled.

Conversation, not Automation. Carefully balancing manual efforts with AI's automation means preserving AI's capability to lower the art-making threshold and ensure human endeavor in the art-creation process. In this way, the role of AI is to enrich the art expression repertoire and shift the human's effort from struggling to draw something presentable to deliberating on the feeling and concepts. More importantly, preserving human endeavor ensures the space for back-and-forth conversation between the client and material which affords self-exploration. The design decision includes considering which part of the process AI should automate, so the engagement of humans can be guaranteed.

Leveraging unpredictability as resources. One distinct difference between AI and traditional materials is that its unpredictability by nature is inevitable. In art therapy sessions, there exists *"a tension between control and lack of control"* -E5. The unpredictability creates space for exploration and creativity. Therapists perceived clients' ability to *"play with unstructured, uncontrolled"* art pieces as a *"stretch of the comfort zone"* and a *"way to think and feel the things they are afraid of"* -E5, which is often the need of the therapy. The unpredictability of AI can benefit in navigating the tension between "control" and "surrender," and help clients express and explore themselves and enhance their creativity. Another potential that is valued and appreciated by therapists is that such uncertainty could be beneficial for special groups, such as people with controlling issues or living with OCD, to overcome their mental challenges. In addition, therapists recognized that AI's guidance might involve conceptual planning and relate to the Cognitive level in ETC. Leveraging such unpredictability as resources for the therapy process requires further understanding and investigation.

Hence, designers should carefully consider the situations and scenarios in which AI-empowered art-generation methods could be used for different treatment purposes. As

mentioned above, the unpredictability of AI can be leveraged as resources for treatments that are desired to have some uncertainty. However, unpredictability should not be introduced when treatment wants to gain high control and precision. In addition to creating the conversation space and leveraging unpredictability as resources in art therapy, designers should understand AI's characteristics and identify suitable situations for it.

8.1.3 Providing robust and diverse features to fully exploit AI as art-making materials.

Lazar et al. advocated developing an understanding of materials is a critical lens for studying and supporting art therapy practice [66]. For instance, for some therapists, fluid materials like watercolors are considered suitable for conveying affective and sensory states, and resistive materials like pens provide structure and boundaries to the artwork [66]. As illustrated in our study, the therapists have also been greatly intrigued by probing and discussing AI's characteristics as a new form of material. However, due to the complexity, developing a language to articulate and envision the properties of AI art-making materials is challenging. While our study has presented a preliminary inquiry into this exciting topic, more explorations are needed in the future. This requires future human-AI interaction design to not only focus on pragmatic usages but also on the experiential, subjective qualities of AI tools. Further, the meaning of the materials can be interpreted differently by different groups. Different features in digital art-making systems would have different expressive properties. Thus, providing robust and diverse features allow people to find the appropriate and comfortable way to express themselves. Such richness, in turn, could enable us to understand AI-infused art-making materials more comprehensively.

8.2 Limitations and Future Work

Our work still has limitations, and we discuss them in the following. We also point out potential future directions to address these limitations.

First, while participants could easily make expressive art with the help of the AI Brush, the tool only provides a limited number of natural objects and can only generate landscape images. Users may struggle with drawing other types of objects, such as buildings, everyday things, etc. To better support art therapy with a broader scope of art-making activities, it is necessary to support the generation of more objects with the AI Brush. This can be done by training the same model using datasets of other objects when available.

Second, from the art therapists and users, we notice that different styles and filters are associated with cultural significance and emotional channels. Although users can use User Brush to explore freely styles and colors, the styling tool allows them to experiment with these quickly. A style-specific algorithm was chosen to probe the potential values of style transferring in art therapy. Providing the same set of styles in the current tool gives the same initial conditions to all users in the evaluations. However, after investigating the potential of styles in art therapy, we will facilitate users with more styles in the future. We plan to adopt models that work with arbitrary styles, so users can upload new images based on their preferences as a source style to apply.

Third, as we aim to probe the usages of AI technologies in digital art therapy, our design is shaped by the limitations of current techniques. For example, while we attempted to balance the manual efforts and automation, the image is generated when the "GENERATE" button is clicked rather than the users' strokes end, which might take away the sense of ownership. We chose this approach because the generation cannot be instant due to the limited computational power. The drawing experience would be interrupted if the images are generated every time the stroke ends with the slow generation process. Future exploration of more effective AI technologies is needed to extend DeepThInk. Especially, text-based generative art approaches have shown promising results and provide different forms of interactions, which requires further investigations to understand the meaning of such interplay in art therapy. In addition, DeepThInk currently only supports global adjustments of styling and filtering. As the potential values have been demonstrated through the study, we plan to facilitate local adjustment in future work.

Fourth, while the iterative design process and evaluations of DeepThInk verified the effectiveness and usefulness of our design, our participant pool does not include a wide range of clients who need art therapy more frequently, such as those with mental issues. Their behaviors and perspectives may differ from those of our study participants. Further, we tested DeepThInk with only two art therapy sessions due to the limited number of professional therapists, while it is along with three expert reviews and 10 self-exploratory sessions. To understand whether and how DeepThInk can support people with different mental health challenges, future endeavors are needed for conducting case studies and evaluations with different user groups as well as more art therapy sessions. Meanwhile, as no sensitive information was exposed in the evaluation, longer-term deployment studies in therapy sessions are required to concretely evaluate the effectiveness of the system.

Chapter 9

Conclusion

We have presented DeepThInk, an AI-infused online art-making system that probes human-AI co-creation in digital art therapy. The design and development of DeepThInk was a 10-month, iterative process involving five art therapists by first understanding the opportunities and challenges of leveraging AI as art-making materials, and then refining and validating the system. DeepThInk operationalizes the human-AI co-creative process by offering various tools which lower the expertise threshold for art-making as well as enhance users' abilities. The evaluation of DeepThInk consists of expert reviews and a contextual technology probing which contains both synchronous and asynchronous therapy setups. The results reveal that DeepThInk can ease the art-making process while promoting creativity and expressivity by leveraging AI technologies and allowing flexible and multi-dimensional processes. By co-designing and evaluating DeepThInk, we explicate and validate a set of design principles regarding supporting human-AI co-creative art-making for art therapy, which has been aimed at informing future design and development in related domains.

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