Usability Study of ImageScape Integration in the Prolonged Exposure Collective Sensing System (PECSS)

1. Introduction

Post-traumatic stress disorder (PTSD) is a mental health disorder developed after experiencing or witnessing a trauma. According to the U.S. Department of Health and Human Services, typical symptoms of PTSD include an unhealthy level of anxiety, constant depression, frequent nightmares, haunting memories of traumatic events, or avoidance of situations that remind them of the trauma. According to the Department of Veteran Affairs, about 6% of the total population in the US experience PTSD at some time in their lives. This ratio is significantly higher in retired veterans, of whom 11% to 30% have had PTSD, depending on their service era.

Several therapies have been proposed and found effective in treating patients with PTSD. Among them, Prolonged Exposure Therapy (PE) shows a “42% reduction in PTSD symptoms” (Goodson et al., 2013). During the therapy, a patient confronts the trauma. By gradually approaching the past memories rather than avoiding them, the patient can gradually understand that they should not be fearful of trauma-related memories. The therapy consists of two parts, imaginal exposure, and in-vivo exposure. In the former, the patients record their traumatic events while talking with the clinicians, and listen to their recordings later. In in-vivo exposure, the patients go to real-world localities that remind them of the traumatic events.

This study explores the affordances of a set of integrated computer programs that supports patients undergoing Prolonged Exposure therapy. The Prolonged Exposure Collective Sensing System (PECSS) is a novel, user-tailored, and context-aware sensor system that enables the transmission and extraction of patient data outside of the clinical setting. When patients perform the required assignments, they use their mobile phones and FitBit to collect data, including their physical location, heart rate data, background noise, and physical activity. The data will be sent to a centralized API and be evaluated by the clinicians on the clinician dashboard to track the patient’s engagement in the treatment assignments.

Currently, the PECSS system integrates data from two information sources (the DigiScape, where the patient’s mobile phone uploads GPS data, physical activity, app usage data, image data, and so on; the BodyScape, where wearable devices such as Fitbit upload body data). In this study, we propose a new source of information called ImageScape, allowing patients to upload photographs when performing in-vivo activities. Given the utility of photographs in psychological counseling, natural questions have been raised regarding the possible integration of photography into the Prolonged Exposure Collective Sensing System (PECSS) we have proposed. The integration of such, however, has not been investigated. If photographs, serving as a new information source for evaluating patient engagement and treatment progress, can be proved useful to both the clinicians and the patients, then we will have a new opportunity to

enhance our sensing system. Suppose, for example, imagine that a person with PTSD witnessed a traumatic event in a forest and thus developed traumatic memories, causing him to get stressed every time he goes to outdoor environments, a clinician might assign an in-vivo task, asking the person to go to a park, sit on a bench. Without ImageScape, PECSS can only track the patients' engagement indirectly through data collected from mobile and wearable devices. With ImageScape, the person can capture photos of himself in a wooded area. The person can upload the photos, along with his reflection on the task, to the clinician dashboard. The photos and the memos allow the clinician to analyze the veteran's behaviors and prepare relevant questions for future clinical sessions.

This study focuses on ImageScape for clinicians conducting prolonged exposure (PE) therapy. The paper proceeds as follows: First, we include an in-depth description of the ImageScape software design and implementation. This is followed by the design of a usability evaluation protocol for the clinician, which attempts to measure the importance of ImageScape both subjectively and objectively, quantitatively and qualitatively. Next, we provide the results of the usability study with one of the clinicians from our partner university. We will discuss the implications of our study, compare how our system with other existing systems for PTSD treatment, address the limits of our study and discuss the next steps and future studies in the design and implementation of PECSS. Finally, We conclude our study with a summarization of our contributions.

2. Related Work

2.1 Photograph-based Therapy and its Implementation

Psychologists and mental health researchers have studied the usage of photographs in the treatment of mental health disorders. For example, Photovoice is both a research and a treatment method in which the patients take and reflect on photos in their daily lives, allowing the clinicians to address the need and desires these patients possess through images (Wang et al., 1997). A team at the University of Texas, San Antonio tested the method on victims of sexual assaults and found hopeful results that "photovoice participants had significantly greater reductions in anxiety scores than those in the control group" (Werremeyer et. al., 2020). Christensen et al. agglomerated 17 studies of gender-based violence based on qualitative systematic review methodologies. The author concluded that the therapy "may encourage psychological and social processes that facilitate an engagement with trauma that is healing." Seeing the huge potential of photograph-based therapy, Ginicola et al. laid out a guideline for the use of phototherapy in psychological counseling. The authors divided counseling into 4 stages: Rapport Stage, Assessment & Diagnosis Stage, Intervention Stage, and Termination Stage and identified the use case of photos in each stage with usage examples.

Several attempts to implement photograph-based therapy have been investigated. The paper *A positive psychology intervention using smartphone photography* examined how smartphone technology and photography can serve alongside traditional positive psychology intervention techniques to improve a person's mental health and satisfaction with life. To achieve the

research goal, Lee et al. built an app called SnapAppy and tested the app on 74 participants for a period of 35 days, allowing them to take photos, write annotations, and review photos of past events. Participants were also required to take photos, report their moods, and complete a Positive and Negative Affect Schedule (PANAS) survey and a Satisfaction with Life Scale (SWLS) survey. They found that the use of photography positively correlates to satisfaction with life. Isaacs et al. built a mobile app called Echo to study the effect of TMR, or technology-mediated reflection, where people utilize cell phone technology to reflect on past experiences captured with cameras and recorded with notes. The researchers identified two general categories of users: recorders and reflectors. They found that both reflectors and recorders achieved mental health improvements.

2.2 Prolonged Exposure Therapy and its Implementation

There have been several barriers associated with the effective utilization of PE Therapy, including the lack of patient engagement outside of clinical settings and the lack of measurements (Kimerling et al., 2017). The complex nature of PE therapy, which requires audio recording devices and manualized procedures of recording the date, time, duration, and subjective units of distress (SUDs), has prevented the therapy from widespread usage (Reger et al, 2013). A mobile-based solution called PE Coach, developed by the United States Department of Veterans Affairs, attempts to address the issue of the lack of access to therapy. The application offers capabilities such as scheduling PE sessions with clinicians, audio recording, and built-in imaginal and in-vivo exposure procedures. The authors later evaluated the application in a counterbalanced crossover study of 2 soldiers with PTSD, where soldier 1 used the application for the first four sessions, and soldier 2 used the application for the last four sessions. The soldiers were surveyed before, in the middle of, and after the therapy with questionnaires regarding anxiety, depression, PTSD, and application satisfaction. The study found that the soldiers rated the application positively, and reported a higher level of improvement in the PTSD symptom during their usage of PE Coach.

The existing solution, however, has some limitations. PE Coach still does not solve the problem of measuring patient engagement because the application offers no feedback on whether the patient has indeed followed the instructions of the clinicians. For example, a patient's avoidance behavior could cause him or her not to fulfill an in-vivo exposure. He or she could forge an in-vivo session by providing fake data minutes before seeing the clinician. In addition, the application is completely offline, so the clinicians are not able to assign or review assignments to the patient. PECSS will address the existing issues by incorporating sensor data from multiple sources to monitor the patients' commitments to ensure the optimal utility of PE therapy.

2.3 Clinician Dashboards

Clinician dashboards are useful tools that empower healthcare workers to acquire, process, and analyze information from multiple sources for informed decision-making. Several clinician dashboards have been proposed, including one that helps hospital workers allocate resources to treat COVID (Ibrahim, 2020) and one that facilitates co-decision-making in the management

of non-specific low back pain (Bach, 2019).Perhaps more related to our study, some researchers explore the possibility of the integration of clinician dashboards and patient-facing mobile applications to facilitate data collection and information communication. Tsangaris et al. identified the significance of patient-reported outcome and experience measures (PROMs and PREMs) in the treatment of breast cancer, and the team came up with a mobile application and a clinician dashboard called imPROVE after a series of extensive interviews with a total of 73 people ranging from patients and advocacy group members to caretakers and doctors. The resulting patient-facing application includes functionalities such as self-assessment assignments, inspirational quotes, information about breast cancer care team members, visualizations of self-assessment scores, a library of educational resources, links to communities, and private notes to caretakers. The clinician dashboard complements the mobile application and includes overview tables containing patient information such as surgery date, surgery type, body image, physical and mental health status, information of other caretakers, and, most importantly, visualizations of patient self-assessment scores. The authors concluded that imProve “has the potential to transform the way they deliver care to patients.” (Tsangaris, 2022)

Currently, there are limited studies on clinician-facing dashboards for PTSD treatment. In our prior work, Schertz et al. attempted to gather requirements for the clinician dashboard. They identified three needs: improved workflow in clinical sessions, monitoring of patient engagement, and better assessment of patient symptoms outside of therapy. Based on the interview results, Schertz et al. came up with two clinician dashboard prototypes: a social sensing dashboard, allowing a patient’s trusted others to communicate with the clinician and report a patient’s in-vivo assessments, and an information dashboard. The information dashboard is designed to include three functionalities: patient overview, clinical session overview, and imaginal exposure visualization (Schertz et al, 2019). Schertz et al. conducted a round of feedback sessions to elicit think-aloud tasks to identify potential usages of the clinician dashboard. They later interviewed the clinicians on each task and surveyed the System Usability Scale (SUS) of each function. Both dashboards received positive feedback, and the clinicians believed that the dashboards significantly improved their ability to track their patients’ mental health status and review patient information prior to the session. The study identified several issues with the dashboard, including privacy and patients’ lack of control of their data. The clinicians also hoped that the dashboard can “encourage patients to maintain ownership of their treatment” (Schertz et al, 2019) by giving them the ability to mark specific homework or data for discussion in clinical sessions.

The PECSS dashboard will provide clinicians with a holistic view of the patients’ visualized sensor data, survey results, and patient-reported outcomes (PRO), facilitating clinician-patient communication and the treatment decision-making process.

3. Methods

Our study aims to understand the usability and usefulness of the image capture function for clinicians conducting prolonged exposure (PE) therapy. To fulfill the research goals, we

implemented a minimum viable product for PECSS ImageScape consisting of both the relevant functionalities in the PECSS mobile application and the PECSS clinician dashboard. We conducted the study with a clinician at our partner university to determine the functional and non-functional requirements of ImageScape and evaluate our PECSS ImageScape prototype. We collected three types of data: subjective, qualitative data from the interview with the clinician, subjective, quantitative data from a post-interview questionnaire, and objective, quantitative system usage data from the mock clinical session.

3.1 Software Architecture and System Design

The actual implementation of ImageScape involves an “image capture” function for our PECSS mobile app and an “image review” function for the clinician dashboard, enabling clinicians to visually track their patients’ progress. A “note-taking” function allows patients to record or reflect on their activities and clinicians to engage with the patients in the clinical setting when the patients are reporting their progress and difficulties. The mobile application is written in Java and developed using the Android software development kit (SDK). The clinician dashboard is written in TypeScript and uses the Angular framework. We employed a user-centered design and an empathic design approach, where we paid attention to patients' feelings and clinicians' concerns to maximize the system’s capability to enhance patient-clinician engagement, continuity of care, and point-of-care interaction. In addition, we utilized the principle of Agile Development to adapt to the ever-changing requirements of PECSS.

A high-level diagram of the mobile application architecture is shown in figure 1.

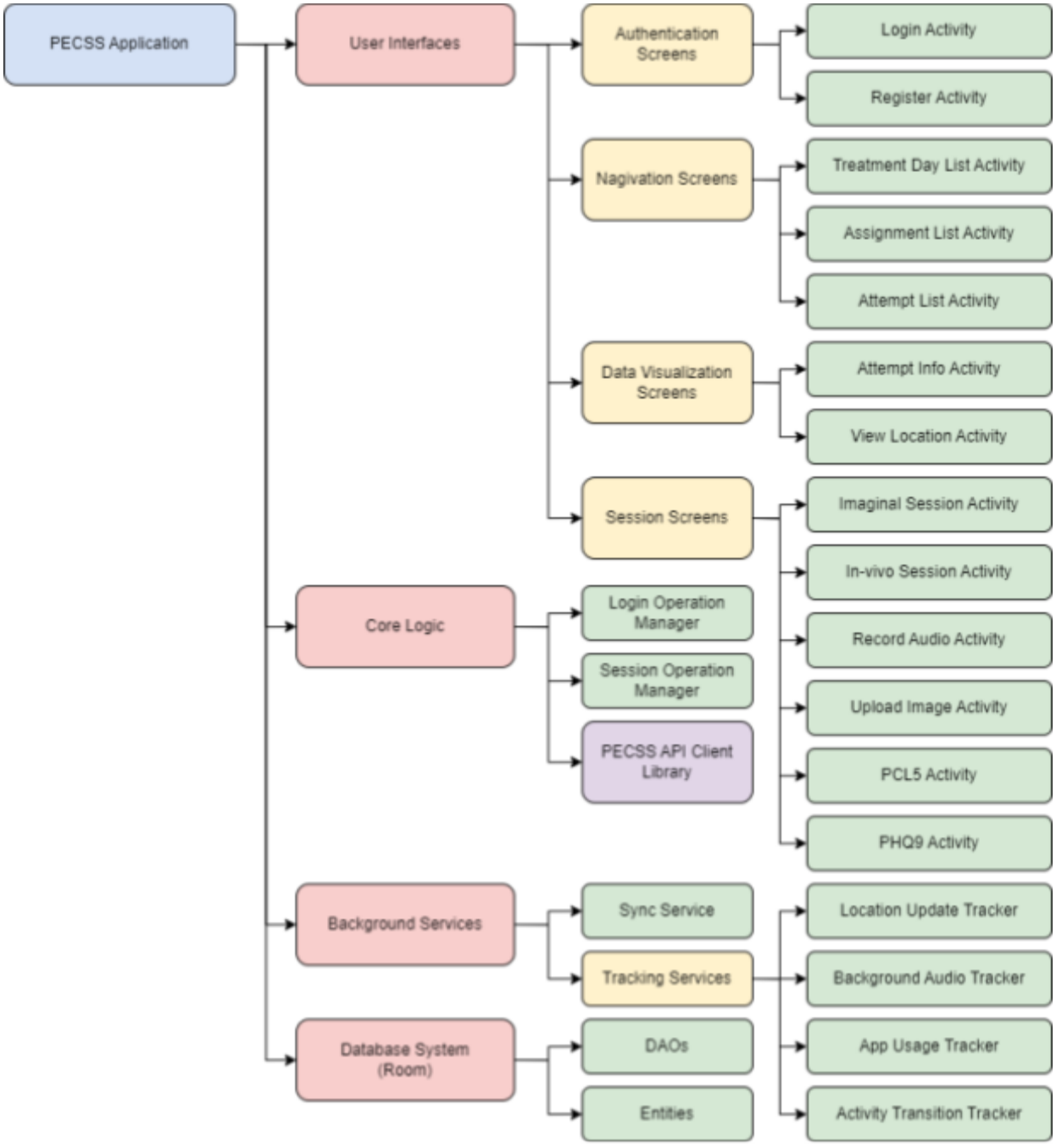

Figure 1: high-level diagram of the mobile application architecture

Our PECSS mobile application contains several interfaces for navigation (the treatment day list screen, the assignment list screen, the attempt list screen), for data visualization (the attempt info screen, the view location screen), and for PTSD treatment tasks (in-vivo sessions, imaginal sessions, PCL-5 surveys, and PHQ-9 surveys), enabling patients to smoothly complete treatment assignments and upload their data to the PECSS API server. We realized 4 background services during an in-vivo session to collect patients' geolocation, background

audio, app usage statistics, and body movement data. A patient may pause a task halfway through the process and resume the activity later.

For ImageScape, the relevant functionalities are implemented in the Upload Image Activity (user interface), the In-vivo Session Activity, the Attempt Info Activity, the SessionOperationManager class, the SyncService class, and the PECSS API Client Library. Once a patient completes an in-vivo session, he/she can upload a photo showing the progress he/she has made during the task, a note describing his/her experience, and the subjective unit of distress values (SUDs). The ImageScape upload process involves the Sync Service invoking the Session Operation Manager, which further invokes low-level HTTP requests with the images attached in the PECSS API Client Library. Once the data is on the server, a patient can review any of his/her past assignment attempts to reflect on his/her experience for better treatment progress.

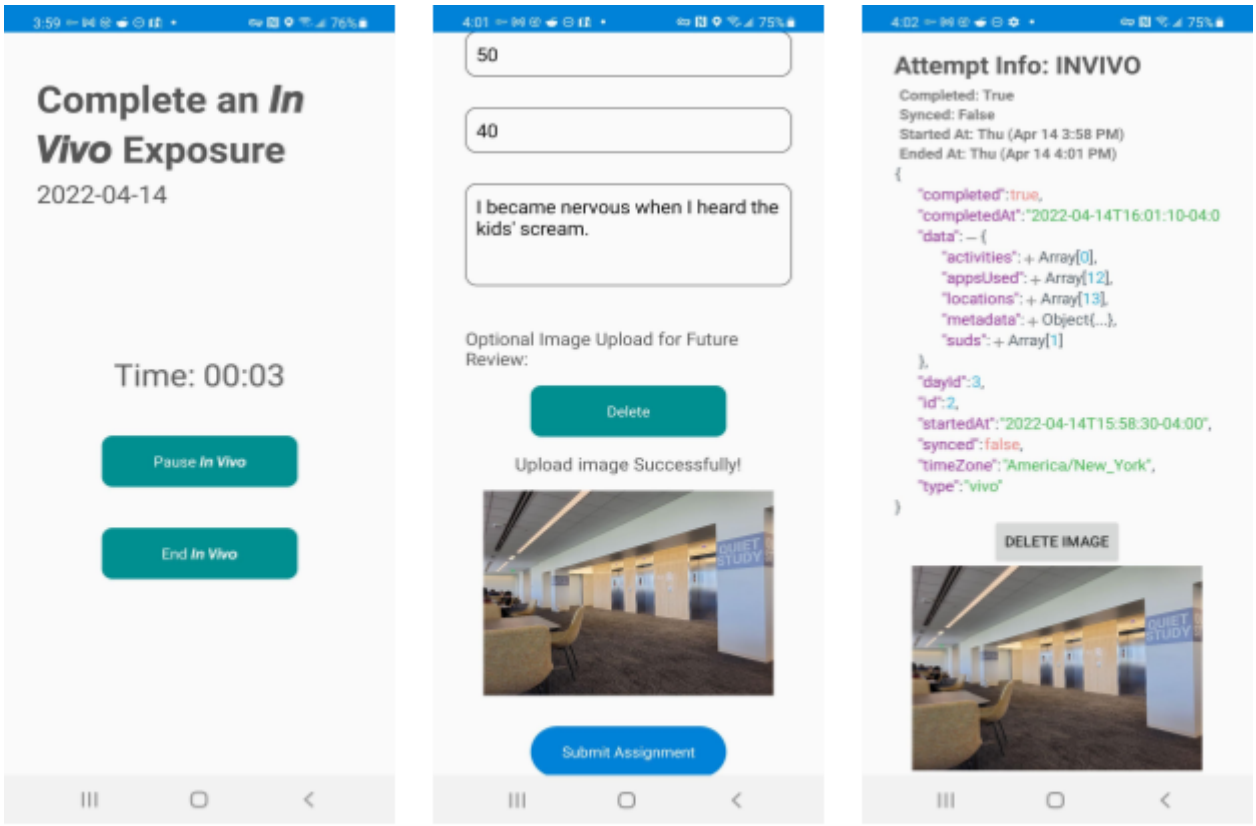

Figure 2: The mobile app user interfaces for an in-vivo exposure (a), for image-uploading and patient self-reporting (b), and for reviewing a past in-vivo exposure attempt (c).

The clinician dashboard contains a login page, a patient list page, a patient subjective unit of distress (SUD) visualization page, and an assignment review page. On the assignment review page, a clinician can select an imaginal exposure, in-vivo exposure, depression symptom survey (PHQ-9), or PTSD symptom survey (PCL-5) assignment he/she wants to take a look at, and then a specific attempt from the dropdown menu. For an in-vivo task, a patient's geolocation data, uploaded images, physical activities, and detailed survey answers will be shown.

Figure 3: The login page for the PECSS Clinician Dashboard.

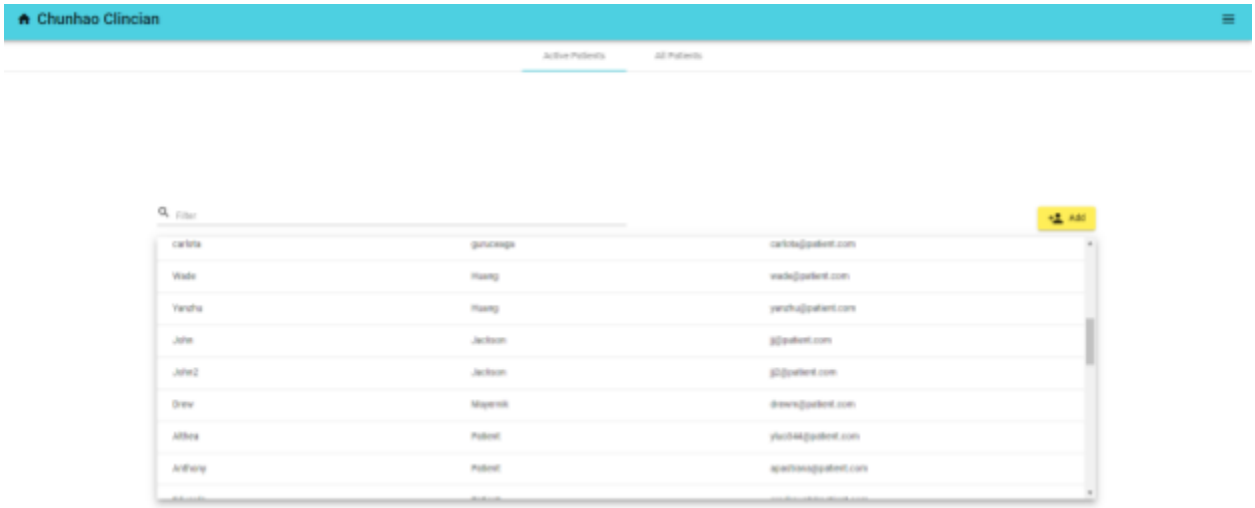

Figure 4: The patient list page of the PECSS Clinician Dashboard.

Figure 5: The patient depression symptom (PHQ-9) and PTSD symptom (PCL-5) summary page of the PECSS Clinician Dashboard.

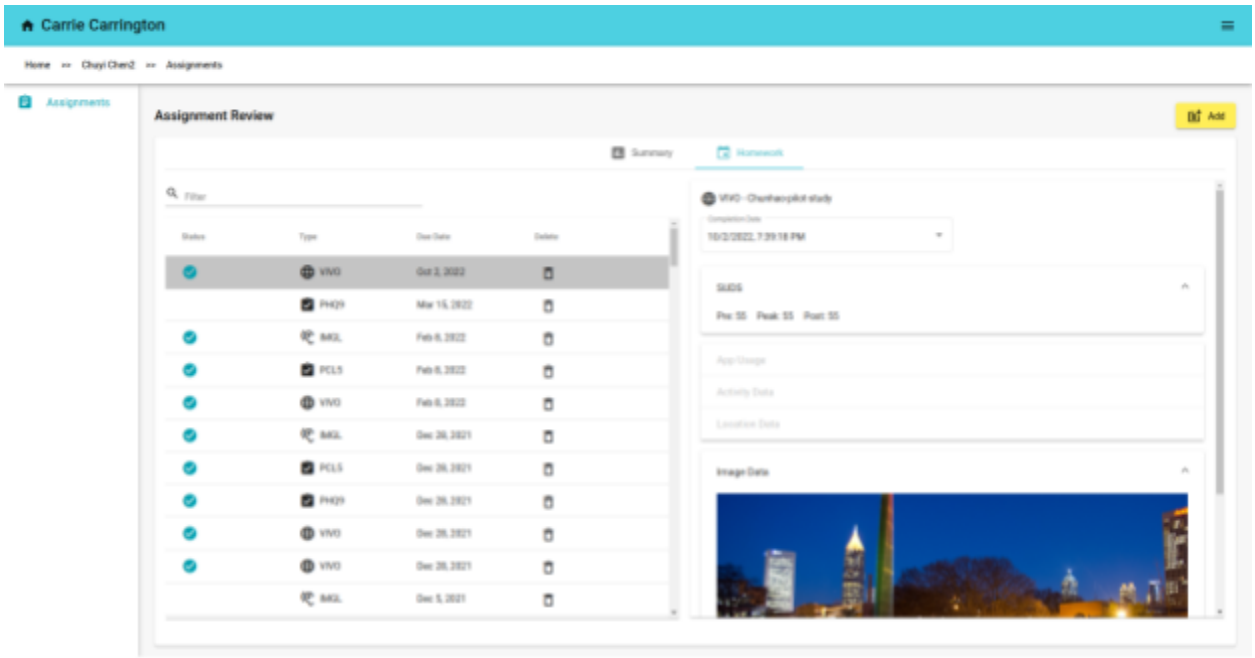

Figure 6: The patient assignment review page showing Subjective Unit of Distress (SUD) values and uploaded photographs.

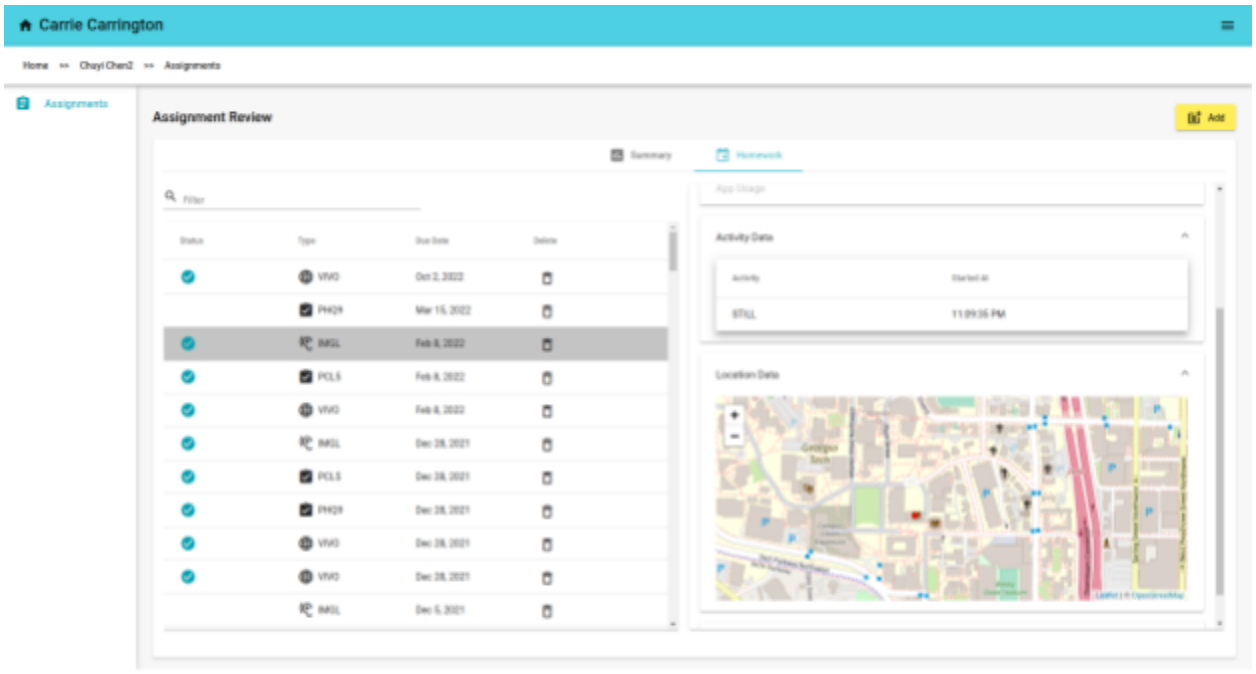

Figure 7: The patient assignment review page showing physical activities and geolocation.

3.2 Clinician Interview

3.2.1 Interview Setting

We interviewed a clinician with a Ph.D. degree and 4 years of experience. The clinician is affiliated with a PTSD treatment program offering two-week intensive outpatient programs to veterans who have undergone traumatic events. The clinician has already been in our cross-disciplinary research group. The interview took place right after the deployment of our PECSS mobile application and clinician dashboard. The interview was conducted via Zoom with a laptop and a mobile phone where our researcher would go through each functional component of PECSS.

3.2.2 Interview Process

The interview consisted of three parts: an open-ended requirement probing, an introduction to PECSS with the think-aloud protocol, and a mock clinical session.

The first part of the interview was conducted before we showed the actual PECSS implementation to the clinician. It contained both general questions about the usage of photos in prolonged exposure therapy, such as how he would use photographs to guide discussions when he meets his patients during a clinical session, and specific questions about the clinician's expectations and concerns about the software implementation, such as desired components, privacy issues, and problems with successful integration into the therapy. The list of questions is described below.

Table 1: List of Questions to be Asked before the Usability Testing
Do you commonly use photographs to assess your patients' progress throughout their PE sessions? If so, could you give us an example?
How do you think a phone camera can aid you in the PE treatment process (in terms of patient engagement, continuity of care, and point-of-care interaction)?
Can you give us an example of a potential in-vivo task you may assign to your patients involving the use of photos?
How do you think your patients would use the phone camera when they are conducting in-vivo exposure tasks?
What functionalities would best complement the phone camera?
Would you prefer the patients also write about their experiences as a photo caption?
Would a photo reflection function, where patients look back on the photos they have taken before, be useful?
What information should be available, and what functions should be present in the clinician dashboard to utilize the photos the patients capture?
When you are with your patients in a clinical session, how would you use the ImageScape function of the clinician dashboard and evaluate patient engagement?
Who should be able to access the photos? Would they be shared with trusted others?
What concerns do you have about ImageScape (in terms of privacy, etc.)?

In the second part of the interview, we showcased our real PECSS prototype. This part of the interview tried to qualitatively analyze the effectiveness of the ImageScape functionality in particular and the PECSS system as a whole. Due to our clinician's limited availability, we held the meeting online via a video call. We presented the user interfaces of the mobile app (see figure 1-2) via the computer camera and the clinician dashboard (see figure 3-7) using the screen-sharing feature of Zoom to the clinician, and our researcher manipulated the devices to demonstrate the effects of every function, with the main emphasis on ImageScape. During the

demonstration, our researcher created a mock in-vivo task called “sitting in your room” and demonstrated the steps to complete the task on the phone, which included navigating to the task, entering the pre-task subjective unit of distress (SUD) value, clicking the “start button” to enable all the trackers, sitting in a room for two minutes, taking pictures of the room, entering the peak SUD value and the post-task SUD value, writing about the experience, uploading the picture, and syncing the task data with the remote server. To simulate different kinds of distractions a patient might encounter and to collect a rich amount of data, our researcher briefly stood up and walked around the room for 30 seconds before returning to the seat. The researcher also exited the app to watch a YouTube video before returning to the app to stop the tracking. The application running in the background recorded a diverse range of physical activities such as standing still (STILL) and walking (ON_FOOT) as well as the duration of YouTube app usage. Most importantly, our interviewer took two images (see figure 8) showing his commitment to the activity and wrote notes describing the photos. We directly asked the clinician whether the system was usable and intuitive, whether the inclusion of several visual components was desirable, and what future improvements we should make to make ImageScape or PECSS as a whole more useful. A detailed list of questions that would be asked is shown in Table 2. The usability test utilized the think-aloud protocol and was semi-structured, where the clinician was free to elaborate on any thought that came into his mind.

Table 2: List of Questions to be Asked After Exposure to ImageScape
How do you like the photograph viewing function of the clinician dashboard?
How do you like the ImageScape function in the PECSS mobile application?
What additional functionalities do you wish could be implemented in the PECSS mobile application or the clinician dashboard?
What functions do you think need improvements?

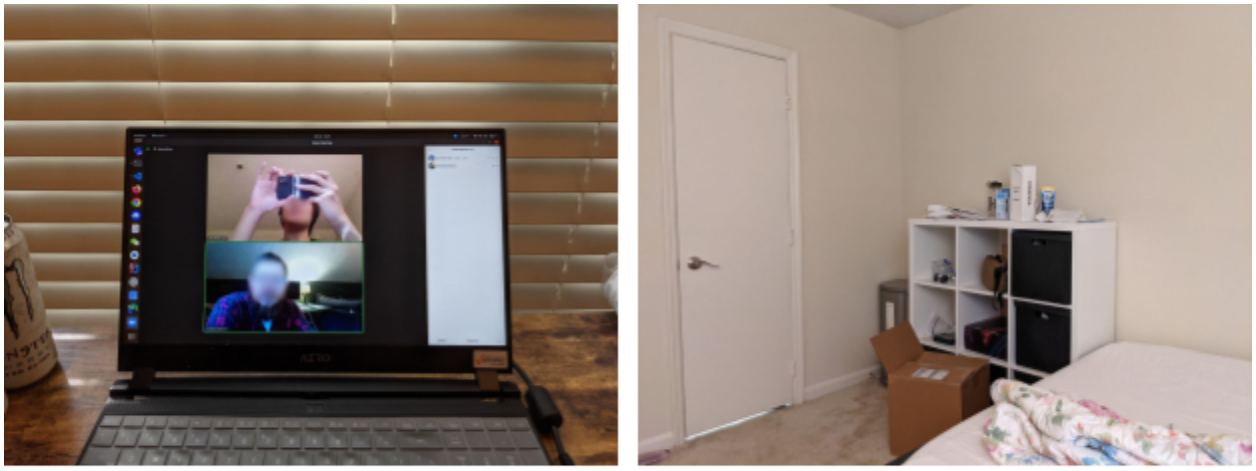

Figure 8: Uploaded Photos for the In-vivo Task. Left: A picture of Researcher Conducting Interview. Right: A Photo Taken in a Quiet Room.

Next, we used the collected photographs and phone sensor data to conduct a mock clinical session with the clinician where our interviewer acted as a patient. The data was visualized on the dashboard to guide the discussions. We asked the clinician to conduct a mock clinical session naturally (we phrased our question as “how would you use the dashboard and mobile application to interact with your patient” to deemphasize ImageScape) with our interviewer (acting as a patient). The clinician was also asked to carefully examine the data on the clinician dashboard, such as the photos and the recorded geolocation data, and to ask questions relevant to the in-vivo task. We analyzed the characteristics of the conversation between our researcher and the clinician to determine the importance of ImageScape in the whole PECSS (the analysis method is described in the next subsection).

3.3 Usability Evaluation

We wanted to understand the usability and usefulness of ImageScape. To achieve the goal, we evaluate the usability and usefulness of ImageScape both qualitatively and quantitatively, incorporating perspectives from the clinician’s subjective opinions and the objective ImageScape usage data during the mock interview.

3.3.1 Subjective, Qualitative Measure: Thematic Analysis

We utilized the method of thematic analysis (Braun et al.) similar to the work by Schertz et al to gain key insights from our interview. We recorded and transcribed the conversation throughout the interview process. We then extracted, summarized, and categorized the keywords and main themes from the conversation. The result would be a holistic summary of the pros and cons of the PECSS system, including ImageScape, with original quotes from the clinician as supporting evidence. The summary will guide our design choices iteratively and make PECSS more usable and useful in the future.

In addition, thematic analysis could also be employed to evaluate how well ImageScape is integrated into the whole PECSS during the mock clinical session. We hoped to find out whether ImageScape was compatible with other existing functions so that a clinician would be able to utilize not just photographs themselves, but a combination of photographs and other data together to draw inferences about a patient during a clinical session. We analyzed whether the topics the clinician raised that involved the images also involved other forms of data that PECSS collected. The results would help us understand how the images fit into the overall clinical session workflow and inform our design decisions.

3.3.2 Objective, Quantitative Measure: Percentage of Time Spent on ImageScape During Mock Clinical Session

To gauge the relative importance of ImageScape on the whole PECSS, we would like to understand how much attention our clinician paid to ImageScape compared to other functions in the PECSS such as DigiScape and BodyScape. We assume that the number of interesting topics the clinician could raise, or the time the clinical session is spent discussing the images, is strongly correlated to the usefulness of ImageScape. We measure the percentage of time our discussion revolved around the photographs, which was the time spent discussing the photos our mock patient took divided by the total time spent on the mock clinical session.

3.3.3 Subjective, Quantitative Measure: USE Questionnaire

Immediately after the interview, we asked the clinician to complete a Usefulness, Satisfaction, and Ease of use (USE) Questionnaire (Lund, 2001). The USE Questionnaire is a psychologically validated (Gao et al., 201) (Dantas, 2017) measure that is used to assess a user's self-perceived experience with a given system. The first 8 questions measure the usefulness of a system. Questions 9-19 measure how easy it is to use the system. Questions 20-23 measure the ease of learning to use the system. Questions 24-30 measure the subjective level of user satisfaction. The questions are rated on a 7-point Likert scale, with higher scores indicating greater levels of the construct being measured. For the quantitative analysis, we would collect and analyze the scores of the USE Questionnaire. We would calculate the mean and standard deviation of each dimension of usability identified by the USE questionnaire and discuss their implications.

4. Results

We present our results in the same order as the methods section. First, we discuss the findings from the clinician interview, which includes an outline of a clinician's perspective on the use of photographs in Prolonged Exposure Therapy and the key system requirements elicited from the interview before the clinician's exposure to PECSS. Next, we present our findings from the second and third phases of the interview about the usability of the system. We (1) outline the clinician's opinions about our current implementation of PECSS, specifically the ImageScape-related functionalities, with thematic analysis, (2) discuss the objective measurement of the use of ImageScape during the mock clinical session, and (3) present a quantitative analysis of the final USE questionnaire results.

4.1 Clinician Interview

4.1.1 Clinician's Insight into the Use of Photos in Prolonged Exposure Therapy

We interviewed our clinician to seek his insight into the use of photographs. The goals were (1) to acquire a list of common themes for in-vivo tasks where the use of photographs is encouraged, (2) to evaluate the benefits photographs possess as a means of communication, and (3) to understand a patient's typical behaviors, both physical and psychological, when the use of phone cameras is expected from a clinician's observation, and what should be kept in mind when assigning in-vivo tasks involving photo capturing. We present our findings in this subsection. The findings serve as a justification and a theoretical foundation for the potential utility of PECSS ImageScape and guide our design choices in future amendments.

During the interview, we learned that the use of photographs before or during Prolonged Exposure therapy is not very common, and it is only at a patient's discretion. (*When I do, its when the patients initiate it. I won't request it, but some of our patients have the idea of doing that.*) Nonetheless, the clinician provided two examples of his patients bringing photographs to personal meetings as in-vivo deliverables:

"One… exposure was taking the family to the beach, and they took a picture of themselves, like a selfie of themselves, the whole family at the beach, like the beach behind them… The trauma… was child sexual abuse. The reason why that was important - outing - was (because) the person was avoiding any outdoor activities at all. They would stay inside and not be in public spaces. She said she always wanted to go to the beach, and she had never really been to the beach, never taken her kids to the beach. So that was important being outdoors in public."

"(Another) One was the patient wearing, like, really really fancy makeup, and really fancy outfit that was form fitting. She took a picture of herself before she went out. That was an exposure to... being in a public setting looking as attractive as she wanted to… Her… experience… occurred shortly following a party, and she blamed herself for being raped because she was just, you know, wearing very revealing clothing."

Our interviewer proposed an application that allows a patient to share photos with a clinician and asked whether such an application would be helpful. Despite the rarity of the use of photographs in PE therapy, the clinician expressed positive views of the involvement of photos and described three benefits he could think of.

The first major benefit is that a photograph taken during an in-vivo session served as evidence of achievement that reinforces the continuity of care. The clinician stated:

"Primarily it's to help the patient, you know, get reinforced for doing their exposure so it'll be reinforcing to kinda share their achievement, so that's one thing."

"When they don't complete the homework, we know, it predicts the dropout. So any kind of mechanism that makes it easier and more reinforcing to complete homework should increase attendance."

The clinician also held that having photos available during clinical sessions would allow him to better assess a patient's treatment progress.

"For us, it'll help us assess what actually happened, like, working through the picture: where they were, how they approached it, and I think especially if it's a picture of themselves, it would give us a sense of their kind of mental status during it, so my two examples… That woman wearing the clothes and makeup, she was just excited to be out. And the same thing with the family at the beach. They're just very very joyful. So you know, it's some good data you are able to get instantly with an image."

Furthermore, the clinician believed that discussing the contents of photos makes a clinical session more efficient.

"I think it will help just make the discussion much more efficient. You know, it's just a second to look at a picture to know what happened."

Our interviewer asked the clinician when taking photos during an in-vivo task would be suitable, and the clinician discussed three potential scenarios where a photo helps document a patient's commitment to therapy: when they are completing long-lasting tasks, when they are creating things, and when they are going to certain places.

"Wearing certain kinds of clothes, going to certain places, and going to work… For those exposures that take a long time, that might be hard to track otherwise because there's so much happening during it. A photo can… be good evidence that they did something, so I think wearing clothes would be a good one for that, taking, like, a picture of the outfit. Anything they kind of do to their body, whether it's makeup, hair, clothes, would be good."

"Also things that they create, so it could be that… they cook, or could be like a painting or drawing… It's part of their exposure, like maybe (they) draw their perpetrator do something kind of creative (when they're doing such things), taking a photo would be good. Any kind of tangible thing that they can't bring into the office…"

"Other ones could be, like, any kind of place that they went. You know, they'll be taking a picture of the place. It could be like a stadium, could be a carnival or fair, could be a marketplace. I would definitely ask for that. That way, we can get all the information really really quickly."

In Prolonged Exposure therapy, people with PTSD learn to confront their memories of traumatic events. There exists literature where photographs are utilized in prolonged exposure therapy, serving both as a tool for PTSD diagnosis and an in-vivo therapy measure. Several examples include going through old pictures/videos from the time of the trauma (Cuccurullo et al., 2020) or looking at photos of loved ones who have passed away (Wells et al. 2020).

Given the nature of PTSD, we anticipate that a patient may become mentally distressed and exhibit avoidance behaviors during an in-vivo task. We asked our clinician how the use of photographs might impact a patient's behavior, and whether such impact may negatively affect the patient's commitment to a treatment task.

The clinician remarked that a photo should be best taken before or after an event to let the patient naturally interact with his or her surroundings.

"I would ask them to take photos after the exposure is complete, so they can actually interact with whatever we want them to interact with. Like going to the baseball game. It's a very common one or a kind of sporting event with this large noisy crowd. Have them first sit down and experience the game, and after they've done… have them take a picture… I would probably phrase it to them as... the picture is a chance to mark your accomplishments, so I'd love it to be the very end. But some of these could be the very beginning, so the example of a person going out to a club wearing a form-fitting dress with makeup. She did that before she went out… Anybody was a natural part taking a picture… But in general, I think I'd want to do it afterward so it doesn't interfere with the engagement of the task itself."

We questioned if the requirement that a patient take photos to mark the completion of his or her task would encourage avoidance behavior, like evading the completion of assignments or creating counterfeit photos. Our clinician, however, believed that it is rare and expressed optimistic views that the photographs could have on helping clinicians diagnose avoidance behaviors.

"That'd be very interesting to talk about with a patient because the disorder is all about avoidance… People do that though. They'll lie about their homework activities, but if they go to the extent of faking some kind of a photo, umm, that'd be great content to talk about in therapy. So I welcome it for them to try that."

Lastly, our interviewer and clinician discussed the significance of the Hawthorne effect that PECSS can impose on the patients: the tendency for a patient to behave better to meet a clinician's expectations when the patient is aware that our system is actively monitoring their actions.

"We want them to be conscientious in a way when they are doing these exposures, so, that's a part of the whole process… The end goal… is to not have to have a therapist monitoring them for them to make these decisions. We are definitely leveraging that phenomenon."

To conclude this subsection, we discussed the complexities and implications of photo-capturing activities during PTSD treatment. Our clinician was hopeful that the inclusion of photographs in an in-vivo task could improve the effectiveness of prolonged exposure therapy. This serves as our theoretical validation for our implementation of PECSS ImageScape.

4.1.2 ImageScape Requirement Analysis

After asking the clinicians general questions about the usage of photographs in prolonged exposure therapy, our interviewer also introduced PECSS to the clinician. The clinician was told that the whole system consists of a patient mobile app, a clinician dashboard, and a centralized API server, allowing the clinician to assign prolonged exposure tasks to his patients. We informed the clinician that our mobile application allows tracking of the patient's location data, physical activity, phone usage, and background audio as well as the aforementioned ImageScape functions that allow the patients to share photos with their clinicians. Furthermore,

we let the clinician know that Fitbit is also integrated into the system, allowing continuous monitoring of a patient's heart rate data. We expressed our future plans to improve the system, including incorporating feedback from trusted others, using machine learning to predict patient stress levels, and deploying more advanced methods to analyze a patient's background audio without sacrificing privacy.

Despite all the details we disclosed to the clinician, the clinician was not exposed to the actual implementation of the system. In other words, the clinician did not see the actual user interface and function implementations of the mobile application and the dashboard. We asked the clinician what he expected from the system and ImageScape in particular, what his concerns were, and what he wished should be implemented. We also proposed several functions that we felt could be developed, and we asked the clinician whether he desired to include such functions in the final product. During our survey with the clinician, several insights arose.

The first thing was that ImageScape should not be completely separate from other components such as BodyScape and that all components of PECSS must be incorporated in a seamless manner to maximize the system's overall utility.

"Being able to pair a photo with the rest of the data from the in-vivo exposure. So you are looking at, like, their SUDs, their locations, all that, and the photo at the same time to get, like, the whole heuristic of what happened."

"I think the dashboard should have all the PECSS data, so that I will have access to, like, location, time, duration, SUDs level, usage of other apps… You know, for example, (from viewing) the usage of other apps I can see the usage of the camera. Better than it, if we were able to integrate the heart rate into it, you know, and accelerometer data… Everything built into the PECSS is what we want the therapist to see."

The second takeaway was that ImageScape should serve the purpose of "guiding the discussions." The clinician described how he might use ImageScape in a clinical session and what he expected to acquire from the conversations with his patients.

"Looking at the picture, I might just praise, and I just say 'great job', or I might say 'tell me about this', so it could be, for example, they took a picture of where they sat at a baseball stadium. I might say... It guides me with questions that are like 'Oh, so it looks like there are people around you. Tell me about the people around you. Tell me about how many were behind you. Tell me about the mood behind you' based on the photo. I'd use it as a conversation starter... so that me and the patient can better process what the experience was like."

The conversation with the clinician provided us with valuable insights into many PECSS ImageScape design choices. We learned that a patient has to complete multiple in-vivo activities of increasing difficulty levels during the two-week intensive outpatient program. The clinician proposed a thumbnail feature for the PECSS mobile application that would visualize a patient's in-vivo task hierarchies and display all the pictures the patient has taken that demonstrate his or her accomplishments.

“When looking at the hierarchy of all the things you're doing… If there could be a thumbnail within the hierarchy, that could be helpful.”

“It’s just like a small little picture, so it is, instead of just seeing a list of words, being able to see words and pictures that go along with it (each other)... There's not that much detail, but I feel like it would be even more reinforcing to have objective evidence alongside everything a person did. Cuz that's a powerful moment in therapy when they can see a whole list of things that they accomplished. Something (like) adding the photo would just sweeten the deal for them even more.”

We proposed several components in the PECSS mobile application and asked the clinician whether he deemed them to be necessary. Our clinician expressed positive views of the photo captioning and annotation function that we proposed, stating its value in enhancing photo explainability, but cautioned against putting the function in the highest priority. (*Optionally it could be good. All the time… they say a photo speaks a thousand words or something like that. There might not be the need to do it, but having the option of being able to explain what it is, you know, would be good.*) On the other hand, he believed that a photo reviewing function similar to SnapAppy by Lee et al., where a patient is asked to write a reflection on the photo several days after they complete a task, should not be enforced on the patients. (*Part of the therapy… is reflecting on the process. I think it’s something that's already built into it, so I wouldn't add anything additional to it where they reflect upon it outside of the clinical session… It would be good to allow them to review the progress. Definitely, I think for all of their in-vivos, being able to review what they've done is really important. But I wouldn't make it a mandatory thing.*) For the clinician dashboard, we asked the clinician whether an image searching function based on timestamp, hashtag, or caption would be useful. The clinician doubted if it is necessary. (*I think that could be helpful, but I don't think there are gonna be enough photos. I think at maximum, we might have like 10 photos. I don't think being able to search would be necessary.*)

Finally, we discussed the privacy concerns around PECSS ImageScape. The clinician believed that only a patient and the team of clinicians in charge of the patient should have access to the data, and the photos must be encrypted in the back end to prevent the server maintainers from viewing the data.

“I see having the photos as a part of the secure app as the main benefit… So rather than texting them or sending them through email, knowing that they’re going to get to the clinician in a protective, secure way is how I see, like, this is being a value added.”

“We definitely wouldn't want that incredibly sensitive person formation in the wrong hands I wouldn't want people in the back end, you know, managing the dataset to be able to look at that. I wouldn't want anybody besides the clinical team to be able to look at it.”

“I want to make sure that they have the option to delete the photo… Across the whole board of the app, they should be able to delete whatever they want. ”

4.2 Usability Evaluation

4.2.1 Qualitative Results

An analysis of the mock session conversation revealed that the clinician was able to leverage multiple sources of information, as was demonstrated in the following dialogs:

“I would say aloud everything I'm looking at, so… I'd say "Oh, you started at 5. You ended at a 12, but you said your peak was at a 10. So, you know, in the future, we want to, like... Your peak would be a 12, right? So sometimes people do end up with a peak, and that's okay… Um, it looks like you did kind of go onto YouTube for a little bit, so let's talk about that in a second… Looking at the location data. You did this exactly where we wanted, and the picture you took about the Zoom session is exactly what we wanted, so it looks like an overall success…”

“Yeah, awesome! That's so great that you actually caught yourself in the act of the middle of doing it, and you refocused your attention. that's really really good. We want, you know... It's a big skill that we have here, so I'm not going to criticize you at all for turning on YouTube, but it's part of the habits you develop, and you did notice it, and you turned it off and you went back to the task. Great job!”

“So looking at this data, it looks like you did move around a little bit you went back to remaining still. Is that the kind of the same thing with YouTube, like you have to remind yourself what the task was?”

“Yeah, so in a future exposure that you do. I wanna see what happens when you don't move around at all. Remember, we want to make sure that you're facing the emotion directly and not being to reduce the emotion. (I) just want to see what happens when you face it, and you kind of learn through experience, that it really is safe. So I don't mean to be too nitpicky, but next time, let's remember, stay still and just keep in mind that you'll be able to kind of monitor yourself with this app to help you keep accountable for that. But overall, it's great!”

When the clinician was asked directly about his thoughts on ImageScape in particular, he described his experience as overwhelmingly positive and pointed out its potential to bridge the gap between other PECSS functionalities.

“Seeing it (ImageScape data) on the dashboard really helps… tie all of the information together. Having the visual data will let the clinician know what their exposures actually look like and that would help the clinician better understand the location, the movement, and other app use. It really seems to be a missing piece to how we currently do things, and I think about it as it really helps contextualize the overall experience.”

The clinician also had high praise for the mobile application.

“It (mobile app) looks very smooth. I really like it.”

Our clinician suggested several things to improve, including allowing a patient to take photos within the mobile application rather than using the camera app to take photos. (*It would be preferable if you can take it within the app, not leaving the app every time to take it. I could just see how that can create some bugs or other user issues. They might forget how to turn on the app. Besides that, it looks very very intuitive*), providing better visualizations on the mobile app instead of displaying raw JSON (*Okay, but the SUD values are not digitalized yet.*)(*It looks like it's going to be hard for the patient to navigate the same the metadata*), allowing a patient to completely delete their data even when the data is uploaded to the server (*The patient might be in therapy until they decide they don't want to do therapy anymore, and they don't want to have their data out there anymore. They should be able to remove it, you know, especially since this is not the medical record, which is permanent. I feel like... I'd say, at the front end, if you, say, at any point, you can delete your information, they (patients) could be more willing to do it.*), and improve the calendar on the mobile app (*I think the dashboard is looking good, nothing looking too suboptimal for the dashboard. But the patient app. I think the way the calendar is kind of set up and navigating the attempts… You know, it's a really hard kind of interface to kind of create. Right now, I feel like, knowing which tasks are completed and uncompleted and knowing, like, being able to add tasks for a certain day or delete tasks, my memory would bet, could be more intuitive*).

4.2.2 Objective ImageScape Usage Results

Even though thematic analysis showed that the clinician viewed ImageScape positively, a quantitative analysis of the ImageScape Usage Results did not yield a conclusive result. During the mock clinical session, the clinician rarely mentioned the photograph our interviewer took in the room except once when he mentioned that the photographs met his expectation. Among the mock clinical session that lasted 6 minutes and 25 seconds, the discussion on the photograph only lasted about 6 seconds, which was less than 2 percent of the total time. It suggested that the photographs did not significantly contribute to the discussion given the mock clinical session setting.

4.2.3 USE Results

The results of the Usefulness, Satisfaction, and Ease of use (USE) questionnaire are shown in table 3. The questions are rated on a 7-point Likert scale. A score of 7 indicates that the subject completely agrees with a statement. A score of 1 indicates that the subject strongly disagrees with a statement. The minimum, maximum, median, average, and standard deviation values for each evaluation axis are calculated independently and shown in the highlighted bar of each section. The overall scores are shown at the bottom of the table.

Table 3: Usefulness, Satisfaction, and Ease of use Questionnaire Result

USEFULNESS	Min: 5, Max: 6, Median: 6, Average: 5.75, Standard Deviation: 0.463	
1	It helps me be more effective.	6
2	It helps me be more productive.	6

3	It is useful.	6
4	It gives me more control over the activities in my life.	5
5	It makes the things I want to accomplish easier to get done.	6
6	It saves me time when I use it.	6
7	It meets my needs.	6
8	It does everything I would expect it to do.	5
EASE OF USE	Min: 3, Max: 6, Median: 5, Average: 5, Standard Deviation: 1.183	
9	It is easy to use.	6
10	It is simple to use.	6
11	It is user-friendly.	6
12	It requires the fewest steps possible to accomplish what I want to do with it.	6
13	It is flexible.	5
14	Using it is effortless.	3
15	I can use it without written instructions.	5
16	I don't notice any inconsistencies as I use it.	6
17	Both occasional and regular users would like it.	5
18	I can recover from mistakes quickly and easily.	4
19	I can use it successfully every time.	3
EASE OF LEARNING	Min: 5, Max: 6, Median: 6, Average: 5.75, Standard Deviation: 0.5	
20	I learned to use it quickly.	6
21	I easily remember how to use it.	6
22	It is easy to learn to use it.	6
23	I quickly became skillful with it.	5
SATISFACTION	Min: 3, Max: 7, Median: 5, Average: 5, Standard Deviation: 1.291	
24	I am satisfied with it.	6
25	I would recommend it to a friend.	7
26	It is fun to use.	5
27	It works the way I want it to work.	5
28	It is wonderful.	5
29	I feel I need to have it.	3
30	It is pleasant to use.	4
Min: 3, Max: 7, Median: 6, Average: 5.3, Standard Deviation: 1.022		

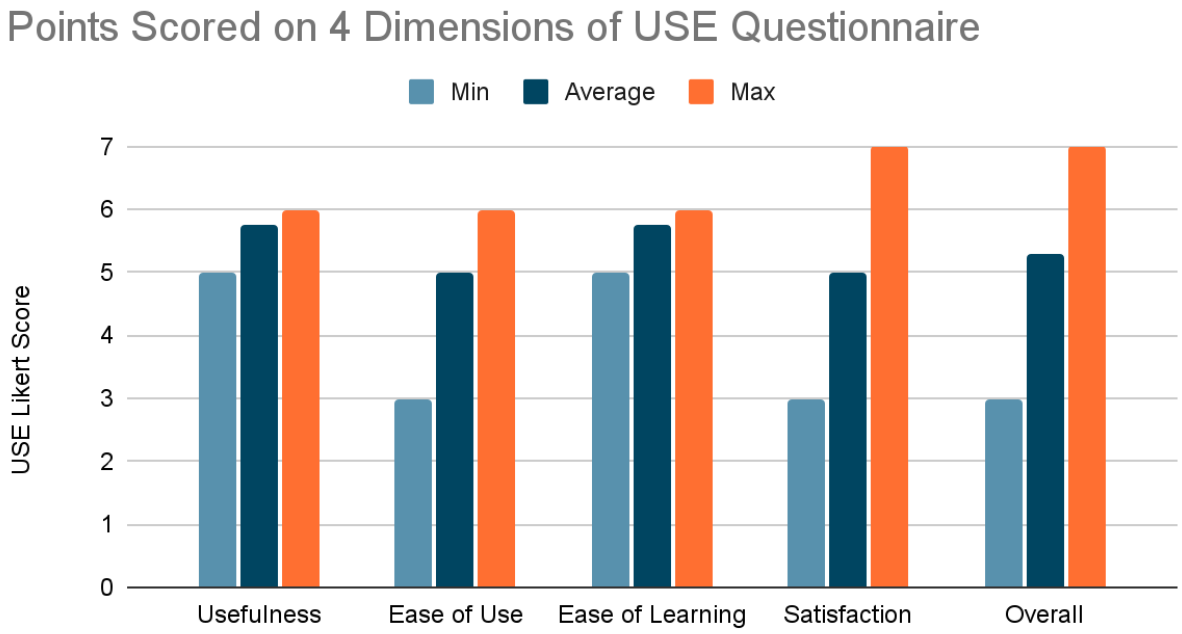

Figure 9: Minimum, average, and the maximum Likert Score of the four dimensions of USE

In general, the clinician believed that the PECSS is useful (average USE score = 5.75), generally easy to use (USE score = of 5), easy to learn (USE score = 5.75), and moderately satisfactory (USE score = 5). Specifically, the clinician cited the system's potential to increase productivity (Q1, Q2), save time in clinical sessions (Q6), and fulfill the goals of targeted, curated treatment of patients with PTSD (Q5, Q7). The clinician described the system as mostly easy and simple to use (Q9, Q10), having a friendly and consistent user experience (Q11, Q16), and allowing the user to complete an action in the fewest steps possible (Q12). Furthermore, the clinician held that the system requires little to no memorization (Q22). Overall, the clinician reported a high level of satisfaction (Q24) and would recommend the system to his friends or co-workers (Q25).

However, the clinician reported several limitations in the current system possesses, especially in its usability and intuitiveness. The clinician expressed his concern that he could not use the system successfully every time (Q19) and that some functional expectations were not being met in the current iteration of the system. For example, the clinician wrote in a personal note that the treatment day page on the mobile application is "not very intuitive" since the calendar only displays the dates with assignments due, but not the titles of the specific assignments themselves. A patient has to choose a specific date to see what the assigned tasks are. In addition, the assignment scheduling functions were somewhat inflexible. Once an assignment is created, there are no ways for the clinician to make any further modifications, and the only option is to delete and recreate an assignment. The patient would not be able to modify any existing attempts associated with an assignment once they are uploaded, either. The clinician also expressed that some metadata and attempt data (e.g. time to complete the assignment or audio data), which were vital for inpatient treatment sessions, were neither visualized on the

mobile application nor on the clinician dashboard. The clinician was also concerned that the dashboard “has not yet been integrated with BodyScape, LanguageScape, and DigiScape” since the dashboard currently only displays the patients’ photos and sensor data, and shows no Fitbit data, transcriptions, or notes from past in-person clinical sessions, or information from trusted others. Furthermore, despite the clinician’s overall satisfaction, his answers to questions in the satisfaction section had a high standard deviation (1.291) with huge differences (low=3, high=7) in individual items. Even though the clinician expressed in a private note that the system “feels like a commercial product” and helps him with his work, he believed that the performance boost is not yet game-changing, and the product is still not a necessity (Q29) and sometimes not pleasant to use (Q30) until more useful functions are added to the system. We attribute the differences to the gap between the huge potential of our system and the limitations in its current implementation. We expect the gap to narrow once more functionalities that the clinician expects are implemented.

5. Discussion and Limitations

Our study focuses on ImageScape for clinicians conducting prolonged exposure (PE) therapy. To fulfill our goal, we implemented the related functionalities in the PECSS mobile application and clinician dashboard, respectively. We described the system architecture of PECSS in a hierarchical diagram and provided screenshots of the user interfaces.

To our knowledge, this is the first attempt in the human-computer interaction and healthcare community to create a real-time computational assessment toolkit to motivate patients with PTSD to promote their engagement in prolonged exposure therapy and facilitate their interactions with their clinicians. This is also the first PTSD treatment toolkit that integrates photograph-based therapy and allows patients to take, share, and reflect on pictures they take. Our system leverages the power of modern cell phone technology and wearable devices to enable efficient tracking of patients with PTSD. Our implementation of PECSS is different from the existing solutions of PE Coach and PTSD Coach, both of which developed by the US Department of Veterans Affairs, in that their solutions are off-line PTSD assessment tools that utilize none of the phone sensors or tracking mechanisms to ensure patient fulfillment of PE assignments.

We conducted a study with a clinician from a research university in three steps: an open-ended requirement probing, an introduction to PECSS with the think-aloud protocol, and a mock clinical session. We employed three usability evaluation protocols: a qualitative analysis of clinician feedback, an objective, quantitative measure of the usage of ImageScape during the mock clinical session, and a subjective, quantitative Ease of use (USE) questionnaire for final usability evaluation.

Throughout the study, we elicited constructive feedback from the clinician and summarized them into a thorough report by means of thematic analysis. For example, the clinician dashboard does not permit the visualization of data such as heart rates, clinician notes, or background audio analysis results. Our clinician noted the lack of such a feature and believed that it may decrease user satisfaction and hinder the effectiveness of our system. The clinician's insights

should guide our decisions about future enhancements to the system. Thematic analysis also showed that ImageScape was well integrated into the whole PECSS during the mock clinical session because the clinician would be able to utilize not just photographs themselves, but a combination of photographs and other data together to draw inferences about a patient.

However, the objective evaluation of the usefulness of ImageScape based on the percentage of time spent on ImageScape during the mock clinical session returned mixed results. We based our study on the simplistic assumption that ImageScape would be useful if it was able to prompt discussions. As a result, we only measured the time we spent going through the photographs as opposed to other data during the mock clinical session. It turned out that less than 2 percent of the total discussion during the mock clinical session actually came from the photographs our researcher took. We believe that the result was due to two factors. On the one hand, our photograph showed little contextual information. As the clinician pointed out, the most suitable occasions for the use of photographs involved going to certain localities, demonstrating creative works, or marking the fulfillment of long-lasting tasks. Our mock clinical session did not fit into any of the categories. On the other hand, there exists a reality gap between our mock session and a real setting. Our demo procedure was mostly curated toward showing the technical aspects of the system rather than toward letting the clinician gain insights from the photographs. On top of that, it was not the clinician that created the task, but our researcher that created the task. It would thus be expected that the clinician would be unable to take the initiative to actively look into anything he desired to see from a patient. We caution against generalizing the result of a single mock clinical session to all clinical settings and believe that more studies on the effect of images in a real clinical environment are needed.

The survey results show that our PECSS application as a whole received positive views, with an average USE score of 5.3. The clinician agreed that PECSS is useful, easy to learn, and enhanced patient-to-clinician communication. The clinician also agreed that the system allows him to better organize his work during the clinical sessions. Especially interesting was the fact that there was a high standard deviation in his answers to questions in the satisfaction section. The clinician applauded the potential of the system and expressed his strong desire to recommend the system to his co-workers, but he believed that the product was still not a necessity. We believe that the gap between our system design and its current implementation is responsible for the differences. We expect the gap to narrow once more functionalities that the clinician expected are implemented.

Our study has some additional limitations. First and foremost, our study was conducted with a single clinician, and therefore the opinion of the clinician cannot be generalized to all healthcare workers and psychotherapists. In addition, the usability study was conducted in a mock clinical session with dummy data engineered by our researcher. As a result, no real patients were involved, and the dummy data might not contain particular features that could draw the attention of the clinician. Furthermore, since different clinical sessions for patients with different traumas and past experiences require different forms of deliverables, the methodology of determining the usefulness of ImageScape by simply judging the amount of time spent discussing the uploaded images is questionable.

In the future, researchers must deploy our system in a healthcare setting to verify its usability in the real world. They must survey both patients of diverse demographics and backgrounds and certified PTSD clinicians with a wide range of specializations to gain a more comprehensive understanding of our system. A usability test should be conducted in a way similar to this study - both quantitatively and qualitatively, and both on PECSS as a whole and on ImageScape individually - but with a large number of participants to improve the generalizability of the results. More rigorous ImageScape evaluation protocols should also be developed and tested. In addition, future researchers might consider a randomized trial measuring patient-reported PCL-5 and PHQ-9 scores to measure the real patient outcomes with and without our system to determine the true effectiveness and potential our system possesses.

6. Conclusion

We studied the usability and usefulness of PECSS for clinicians conducting prolonged exposure (PE) therapy with a special focus on one functional component of PECSS called ImageScape, which allowed patients to share photos of their in-vivo tasks with their clinicians. We conducted a usability study and found that the PECSS as a whole is highly valuable for the clinician we interviewed. However, our conclusions on the usefulness of ImageScape are limited due to the small sample size and unrepresentativeness of the photographs used in our study.

Our main contributions are the following:

1. We developed a system that allows clinicians to assign treatment tasks to patients with PTSD.
2. We developed a system that allows clinicians to collect a patient's data during therapeutic exercises (in-vivo sessions).
3. The system allows patients with PTSD to share and annotate the photos they take to assist them to reflect on their In-vivo session experiences for better treatment progress.
4. We conducted a usability and usefulness study on the whole PECSS system as well as ImageScape specifically in a mock clinical session.
5. The system has been evaluated by a certified clinician as being both useful and usable through our interview and qualitative/quantitative analysis.
6. Our system allows clinicians to better organize their work and communicate with their patients during clinical sessions.

Our study builds upon the prior work of Schertz et al by coming up with a real implementation of a clinician dashboard and a patient-facing mobile application. In spite of the huge progress we have made in the field of building usable and useful tools to empower patient care, our study still has serious limitations. We expect future studies to address these remaining questions. With every study, we will incrementally improve our system with user-centered design strategies. Our

long-term goal is to deliver on the promise of technology that will help individuals live healthier and more positive lives.

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