University of Twente

Master Thesis Health Sciences Faculty of Science and Technology

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Identifying Opportunities for Improvement of the Virtual Reality Biofeedback Game DEEP in Forensic Inpatient Care – A Qualitative Multi-Method Study

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By

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October 2023

Abstract

Background: In forensic psychiatry, the primary treatment approach is focused on cognitive in-person therapy aimed at reducing the risk of criminal recidivism. However, this approach might not always fully address the diverse needs of forensic patients. As a result, there is a growing interest in innovative approaches that prioritize experiential learning and practical skills, particularly those related to emotion regulation, which are better suited to this patient population. One such approach is DEEP, a virtual reality (VR) serious game that employs breath-based biofeedback to enhance relaxation and emotional regulation skills through diaphragmatic breathing training. Despite its potential, limited research has been explored on how DEEP can effectively integrate into forensic care practice.

Objectives: The aim of this thesis was to investigate how DEEP can better align with the needs of forensic inpatient care, by analyzing the experiences of caregivers and forensic inpatients following a three-month pilot study with DEEP in practice and by identifying similar VR technologies, in order to explore its effective integration into forensic care practice.

Methods: A qualitative multi-method approach was employed in this study. First, a pilot with DEEP was conducted, involving the analysis of logbook data, collection of DEEP session evaluation forms, and the conduct of semi-structured interviews with stakeholders. This pilot took place in two forensic inpatient clinics, the FPA and De Verbinding, and was guided by the Consolidated Framework for Implementation Research (CFIR). Additionally, desk research was conducted in parallel with the pilot study.

Results: During the three-month pilot period, DEEP was utilized five times at the FPA and fifteen times at De Verbinding. In total, seventeen patient session evaluation forms were completed by thirteen different patients and twenty caregiver session evaluation forms were completed by four different caregivers. During the interviews, participants acknowledged DEEP's effectiveness in redirecting attention, inducing relaxation, and improving breath control. However, challenges were also identified, such as integrating DEEP into caregivers' workflows, the need for technical skills, and issues related to understanding DEEP's purpose, technical problems with the abdominal band sensor, and maintaining focus on breathing during gameplay. During the desk research, thirteen similar VR technologies were identified, sharing design and biofeedback elements with DEEP. However, differences were found in data management, gamification, and implementation tools.

Discussion: To enhance DEEP's alignment with forensic care, it is crucial to clarify its purpose, streamline deployment, and maintain ongoing engagement and evaluation. Although initial experiences with DEEP were positive, actual usage was lower than expected. Therefore, to improve utilization and adoption of DEEP, conducting a workflow analysis for integration into existing care processes could be valuable. Additionally, a User-Centered Design (UCD) approach can be considered for adding new elements to DEEP that align with forensic inpatient care needs. Lastly, continuous evaluation with end users to assess relevance and improvement opportunities is important to consider, a longitudinal study with DEEP can provide insights into this.

Keywords: Forensic Psychiatry, Virtual Reality, Treatment, Pilot Study, Implementation, CFIR

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1 Introduction

In forensic psychiatry, patients with complex psychiatric disorders, psychosocial challenges, and criminal behavior are treated to prevent recidivism and address psychosocial issues (1). In the Netherlands, forensic hospitals offer a range of security levels to accommodate the diverse needs of these patients (2). These patients vary in terms of the types of offenses they have committed, their psychological characteristics, and their risk of reoffending. Many of them also struggle with issues as impulsivity, addiction, and antisocial behavior, and a significant portion have limited education and literacy skills (3). The diverse characteristics of forensic patients illustrate the importance of suitable treatment, that fits the complexity of these patients.

Currently, the primary approach to treatment involves in-person therapy as well as activities of daily living, education, occupation and creativity aimed at reducing the risk of criminal recidivism. Cognitive engagement plays a central role in these treatment interventions (4). Studies have consistently shown that such treatment significantly reduces the risk of patients reoffending, resulting in lower rates of recidivism. For example, among patients, those with inpatient readmission had a significantly higher criminal recidivism rate (39.3% vs. 2.1%) than those without readmission (5). However, it is important to note that overall recidivism rates within inpatient clinics remain high in the Netherlands, ranging from 26% to 37% according to Kwaliteitskader Forensische Zorg (6). Moreover, there is notable variability in treatment outcomes for forensic patients (1). This variability is partly attributed to patients often lacking the motivation to adhere to mandatory treatment programs. Additionally, they are facing difficulties in applying what they have learned outside of therapy sessions, mainly due to limited self-awareness (7). Many patients also struggle with reflecting on their behavior and emotions, which are central components of existing psychological treatment programs, for example in cognitive-behavioral therapy (CBT) (8). However, gaining control over emotions, thoughts, and behaviors is essential for offenders to successfully reintegrate into society after treatment or rehabilitation (9). These observations underscore that current treatment, including CBT, may not always align with the specific needs of this population. A solution can be found in interventions that prioritize experiential learning and practical skills, particularly strategies for regulating emotions (10). These interventions may offer a better fit for this population. Hence, there is a clear demand for interventions that teach these emotion regulation skills in an easily accessible manner and emphasize their practical application, going beyond cognitive engagement alone.

Innovative technologies can help bridge the gap in addressing the specific needs of forensic patients when it comes to emotion regulation treatment. A particular intervention that might meet those requirements is DEEP, a meditative virtual reality (VR) serious game that promotes relaxation through deep breathing and breath-based biofeedback (11, 12). DEEP utilizes biofeedback to measure and provide feedback on respiration-related physiological variables, fostering breath awareness and promoting desired breathing patterns (13). It uses an abdominal band to measure diaphragmatic deep breathing (see Figure 2) in an immersive underwater environment. Throughout the experience in the game, players receive feedback on their breathing stage, visual cues, and even witness elements in the environment mirroring their own breathing patterns (14). This innovative approach shows promise for enhancing relaxation skills and emotion regulation strategies in forensic patients (14). Compared to for example cognitive-behavioral therapy, VR interventions such as DEEP offer distinct advantages in the realm of psychological treatment. First, it facilitates the actual practice of specific behaviors and emotions instead of solely discussing them (15). Second, DEEP's gamified approach to teaching breathing techniques can be advantageous for forensic psychiatric patients, given their lower education levels, as it provides a more practical learning

experience (16). This approach also has the potential to enhance treatment motivation in this patient group, which often struggles with active engagement and commitment to interventions, as they derive enjoyment from using the technology (17). Third, DEEP provides patients with direct feedback on their breathing technique, potentially increasing their self-awareness and confidence in deep breathing. This may extend to their breathing in various situations, allowing them to apply this skill beyond the treatment context (13). A previous focus group study involving DEEP in forensic care highlighted that DEEP is in line with the needs and abilities of forensic populations. It provides a distinct and captivating experience without requiring participants to complete explicit tasks or achieve specific goals. Also, this study within forensic care uncovered factors related to the implementation of DEEP. It emphasized DEEP's capacity to engage forensic patients in relaxation and emotional regulation. The findings also underscored DEEP's versatility in serving a diverse patient group and its adaptability for integration into forensic care processes. This integration can take various forms, including a structural, ad hoc, or complementary approach. However, as DEEP was initially not developed for forensic psychiatric care but mainly focused on adolescents in special education, further research is needed to explore the effective integration of DEEP into forensic care. This research is essential to determine how well DEEP aligns with the needs of the forensic care population, given the importance of digital interventions matching the end user's requirements (18), as well as the inherent complexity in implementing such interventions (19).

Additional research has identified several areas for potential improvement in DEEP. This research was conducted in adolescents with special education needs and forensic inpatient care, by means of a focus group study and SCED study. First, Bossenbroek et al. conducted research in special education and suggested to explore possibilities for enhancements in DEEP's system to bolster intrinsic motivation and sustained engagement during repeated training sessions (20). This was also a result from the focus group study in forensic care, where it was mentioned that a potential drawback of DEEP could be its simplicity and straightforward design, which could hinder long-term adoption. Therefore, considerations regarding prolonged usage and continuity of use were recommend being taken into account before implementing DEEP in practice. Second, during the SCED study, patient engagement with DEEP occasionally waned due to technical issues or initial scepticism about its daily life benefits. These factors, which pertain to the complexity of hardware and its adaptability to individual user needs, might impact the incorporation of eHealth technology in healthcare settings (21). Especially in the context of its ongoing implementation process, a deeper understanding on how DEEP can be integrated and optimized within the context of forensic inpatient care is essential.

Implementing DEEP and align it closely to the needs of forensic inpatients and caregivers can be a challenging process. A scoping review by Kouijzer et al. emphasizes the importance of a systematic and structured process when implementing VR technology in healthcare (22). One model that fits with this structured approach for VR implementation is the Consolidated Framework for Implementing Research (CFIR) (23). The CFIR is organized into five key domains: intervention characteristics, outer setting, inner setting, characteristics of individuals involved, and the implementation process. Each domain is then linked to a range of constructs informed by established implementation theories and conceptual models (24). Due to its comprehensive taxonomy a notable aspect of CFIR is its capability to elucidate the reasons behind the success or failure of a particular implementation initiative (25). For this reason, CFIR was employed in this thesis (as well as in the overarching pilot study with DEEP in forensic inpatient care) to identify implementation strategies for DEEP. These strategies were derived from the experiences of both caregivers and patients with the technology in real-world practice during a three-month pilot study. It is

especially important to focus on the experiences with the technology and design of the intervention itself because it may also impact its adoption and perceived usefulness for end users (26). Therefore, this thesis only considers the innovation domain of the framework. More specifically, it focuses on the CFIR constructs adaptability, trialability, complexity and relative advantages.

This thesis aims to investigate how DEEP's current integrated system[1] can better align with the needs of forensic inpatient care, by analyzing the experiences of caregivers and forensic inpatients following a three-month pilot study with DEEP in practice and by identifying similar VR technologies. In order to explore its effective integration into forensic care practice.

Hence, the three research questions are structured as follows:

1) What are the experiences of caregivers and forensic inpatients with DEEP after using it in practice for three months?
2) How can DEEP be improved to align more closely to the needs of the forensic inpatient care according to caregivers and forensic inpatients?
3) What are key points of VR technologies that are comparable to DEEP and what are the differences and similarities between DEEP and these comparable VR-interventions?

[1] In this thesis, the reference to the term 'DEEP' pertains to the innovation behind DEEP, which includes the integrated system of DEEP. This integrated system encompasses the combination of hardware components, software functionalities, and the design of the serious VR game DEEP. It also encompasses its purpose, service, and how it works in practice.

2 Methods

2.1 Study Design

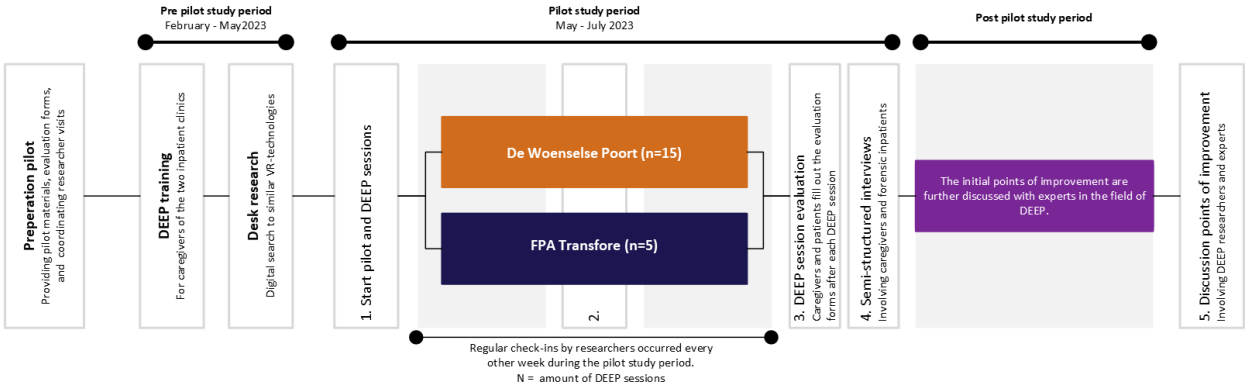
In this thesis a qualitative multi-method study design was employed. First, a pilot with DEEP was conducted, involving the analysis of logbook data, collection of DEEP session evaluation forms, and the conduct of semi-structured interviews with stakeholders. Additionally, desk research was conducted in parallel with the pilot study. This research timeline is visually represented in Figure 1.

The pilot study in this thesis was guided by the CFIR Framework from 2022 (24). The interview questions and other pilot documents were designed based on its five domains. This thesis particularly emphasized the innovation domain, integrating adaptability, trialability, and complexity into the interview questions. Desk research also included considerations of relative advantage.

Ethics approval for this research has been granted by the university of Twente faculty of BMS' ethics committee under research number 230042. Funding for this study was provided by a grant from Kwaliteit Forensiche Zorg (KFZ 2020-146).

Figure 1

Timeline of Research Methods Utilized in this Study.



2.2 Setting

2.2.1 Pilot

The three-month pilot took place in two Dutch forensic mental health care organizations from April to July 2023. It drew upon prior DEEP research: the focus groups and SCED studies in order to evaluate DEEP's alignment with everyday care practices and potential for implementation.

In preparation for the pilot, caregivers underwent a two-hour training on DEEP (April 2023) to familiarize themselves with the technology, previous DEEP research, and the objectives of the pilot. This training also provided them with hands-on experience. Allowing them to play the roles of both patients and caregivers and become familiar with the evaluation forms. In the FPA Almelo, three healthcare providers participated due to staffing constraints. At De Verbinding in Eindhoven, approximately 25 caregivers across two clinics participated in the training.

During the pilot, DEEP was made available on-site for patients and caregivers to use it at their convenience. This accessibility allowed patients to request DEEP sessions spontaneously, for example in response to stress, or through scheduled appointments facilitated by their caregivers. After a DEEP session, both the patient and caregiver filled out an evaluation form. This information was also covered during the training session. A binder folder was available in each clinic, containing additional information about DEEP, a step-by-step guide on how to start DEEP, and the (on-paper) evaluation forms.

Two researchers supervised the pilot, each serving as the primary contact for one clinic. Regular check-ins and evaluations occurred during the pilot, with researchers maintaining a logbook. The pilot concluded with the semi-structured interviews at the end.

2.2.2 Organizations

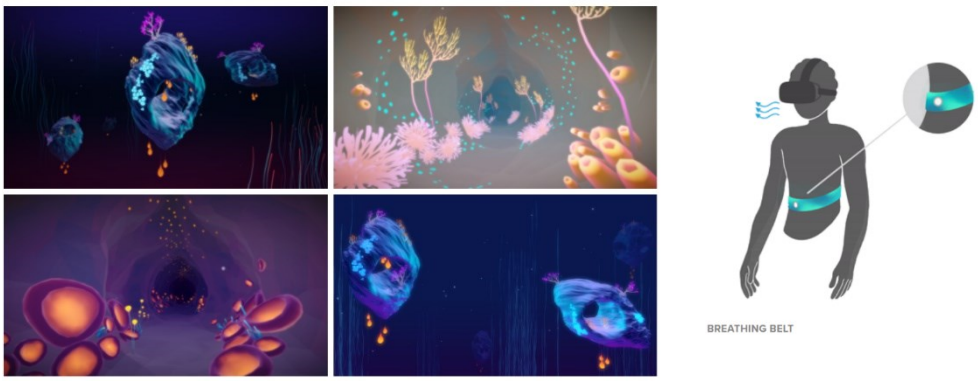
Two Forensic Inpatient Clinics participated in the pilot. The FPA of Transfore and De Verbinding of De Woenselse Poort. These secure clinics, both classified with level 2 security are specialized in treating individuals transitioning from incarceration to forensic psychiatric care for severe mental illnesses. They are characterized by locked ward doors and enclosed perimeters (2). Treatment is primarily administered within clinical settings and focuses on addressing psychiatric symptoms, mitigating the risk of future criminal behavior, and resolving related issues such as financial difficulties or unemployment (4). Both clinics included in this study are of medium security classification and possess similar bed capacities, each accommodating up to 20 patients. The clinics have been engaged in prior DEEP research, participating in focus group studies and the SCED.

2.2.3 DEEP

The focus of this study is on DEEP. An eHealth intervention that utilizes a serious game in virtual reality to teach diaphragmatic breathing and relaxation skills innovatively. Users wear a VR headset and are immersed in a virtual underwater world. This world is designed by an interdisciplinary team, including artists. Through deep diaphragmatic breathing, users can navigate through the virtual underwater world. The quality of their breathing directly influences their movement and enhances the visual aesthetics of the world (see Figure 2). The deeper and more effective the breathing, the smoother the user's movement and the more visually stunning the world becomes. Currently, DEEP is only available on request and is primarily integrated within a research context. DEEP is expected to be released on the commercial market by the end of 2023.

Figure 2

DEEP's virtual environment and the different hardware components.



2.3 Pilot: Logbook Data

The logbook served two primary purposes during the pilot study: keeping a record of the study's progress and addressing issues promptly. After each of the 14 visits to the clinic, researchers completed the logbook by filling out the key fields outlined in Table 1. This logbook documented observations and 1discussions with stakeholders during these visits and it was organized chronologically by date for analysis. This chronological organization allowed for an overview of the pilot study's progression over several months, including information on the date, the number of DEEP sessions, and feedback received, which enabled a comparison between the clinics. The logbook template used for data collection can be found in Appendix A.1.

Table 1

Logbook Key Fields and Definitions.

Key fields	Definition
Visit to Organization	Noted the date of the visit to the participating forensic care organization.
Date	Recorded the specific date of each visit.
Number of DEEP Sessions	Documented the total number of DEEP sessions conducted during the visit.
Status of DEEP Components	Assessed the functionality of all DEEP components to ensure they were working correctly
Availability of Forms	Checked if there were a sufficient number of DEEP session evaluation forms available.
Questions from Caregivers	Recorded any inquiries or questions posed by the healthcare providers.
Comments	Provided a space for general observations and comments related to the visit.

2.4 Pilot: DEEP Session Evaluation Forms Caregivers and Patients

DEEP session evaluation forms were employed to collect feedback on user experiences after each DEEP session. These paper forms were conveniently available within the clinic and patients and caregivers completed separate forms designed for their roles. The caregivers' form (Table 2) included questions regarding session details, such as the session's structure, the patient's emotional state before and after the session, and an overall session grade. Twenty caregiver forms were completed by four different caregivers. The patient's form (Table 3) focused on the patient's experience and was concise, designed for simplicity and ease of use within the target audience (27). Seventeen patient forms were completed by thirteen different patients.

For data analysis, each form category was structured into a single table, with questionnaire outcomes presented sequentially. This structure provided an overview of trends and common responses, facilitating to detect patterns in the data analysis. The evaluation forms templates used for data collection can be found in Appendix A.2 and A.3.

Table 2

The DEEP session evaluation form for caregivers.

Question	Answer(option)
Date	Open-ended
Name patient	Open-ended
Name caregiver	Open-ended
Structured /Ad hoc	Multiple choice
How did the patient feel	Open-ended

before playing DEEP?	
How did the patient feel after playing DEEP?	Open-ended
Any remarks?	Open-ended
Overall grade	Open-ended

Table 3

The DEEP session evaluation form for patients.

Question	Answer(option)
Wat is your name?	Open-ended
How often have you played DEEP?	Open-ended
Did you enjoy this DEEP session?	☐  ☐  ☐ 
Is there anything else you would like to share about DEEP?	Open-ended

2.5 Pilot: Interview Caregivers, Patients and eHealth Advisor

2.5.1 Participants

The pilot study ended with semi-structured interviews. The objective of these interviews was to gain insights into the experiences of caregivers and patients with DEEP, with a focus on optimizing DEEP's alignment with forensic care. Inclusion criteria for caregivers were participation in DEEP training before the pilot and active engagement within the pilot, either by personally using the technology or serving as points of contact during visits. For patients, the criteria were using DEEP at least once and being willing and able to reflect on and provide feedback about their experiences. To assemble the interviewees, a combination of convenience and purposive sampling was employed to maximize representation from the clinics. Initially, the pilot allowed all clinic members to use DEEP at their convenience. However, due to lower-than-expected usage, a selective group was eventually interviewed, and strategies for future implementation were discussed. This approach resulted in interviews with five caregivers, three patients, and one eHealth advisor. The decision to include an interview with an eHealth advisor was influenced by the study's intersections with implementation research.

2.5.2 Materials and Procedure

The interview guides (Appendices B, C, D) were structured based on previous DEEP research, pilot phase feedback, and aligned with the five constructs of CFIR. They included open-ended questions with sub-questions to encourage in-depth discussions based on participants' responses. For caregivers, a selection of questions from the interview guide, along with their sources of origin, is presented in Table 4 below:

Table 4

Example Questions of the Caregivers' interview guide.

Category	Sample question	Source question
Inner Setting	"How was a DEEP session set up in practice?"	CFIR
Individuals	"What have you observed in patients who have used DEEP more than once?"	Previous research –

		SCED
Innovation	"How can DEEP be enhanced for the forensic patient group?"	CFIR
Outer Setting	"Would you continue using the current DEEP technology in the clinic beyond this pilot research?"	CFIR
Process	"What was your overall experience with the DEEP pilot?"	Pilot phase feedback
Category	Sample question	Source question
Inner Setting	“How was a DEEP session set up in practice?”	CFIR

Caregivers reviewed the interview guide for patients during a clinic visit to ensure it was understandable for them. Informed consent was obtained from all participants before the interview process began, see Appendix A.4 and A.5. Interviews were conducted in Dutch at the participants' locations in Almelo and Eindhoven, the Netherlands, to align with the research population. The interviews were audio-recorded, with durations ranging from 11:00 to 43:22 minutes and an average duration of 24.02 minutes.

2.5.3. Analysis

The methodology for this analysis was based on Thomas's general inductive approach (28). The coding process involved distinct steps. First, the interviews were transcribed. Second, the text was thoroughly read to grasp the content and uncover underlying themes and nuances related to the innovation domain of CFIR and DEEP’s technology. Important quotes or segments related to that were identified and organized in the first column of the Microsoft Excel sheet (29). Third, main code categories were established in the second column of the sheet, with broader categories based on research goals and specific categories emerging from multiple readings of the raw data (in vivo coding). Fourth, continuous refinement and revision took place as new interviews were analyzed. When main codes became too extensive or multiple sub-results/contradictory perspectives emerged, they were added in the third column of the sheet as subcodes. In total, six code categories were identified, encompassing essential aspects of the themes present in the raw data, aligning with the research objectives. A second researcher independently coded all CFIR domains. A comparison between both coding schemes for the innovation domain was conducted in this study, and consensus was reached on the identified codes.

2.6 Desk Research

Desk research was conducted to investigate the key features of comparable VR technologies, with a particular focus on those emphasizing breathing techniques and relaxation skills within the healthcare sector. To ensure replicability, a specific search string was employed, including terms as virtual reality OR VR OR serious game AND treatment OR intervention OR therapy AND relaxation OR meditation OR mindfulness OR breathing techniques. The research encompassed scientific literature from platforms as Researchgate, SpringerLink, and ACM Library, as well as grey literature from sources such as Google, TechwijzerFZ, and Zorginnovatie.nl. This data collection occurred simultaneously with the pilot study from April 15th to May 15th. The collected information pertained to the VR technology's objectives, biofeedback mechanisms, different environments, gamification elements, hardware and software, and points of comparison with DEEP. Thirteen comparable VR technologies were identified, and their details can be found in Appendix E. For data analysis, the primary step involved analyzing the main table provided in Appendix E. This analysis aimed to extract key points of these technologies in comparison to DEEP. The second step involved grouping these key points into relevant categories. Lastly, within each category, a more in-depth analysis was performed, allowing for the merging or removal of closely resembling key points that were already part of DEEP's system. In total, this analysis revealed seventeen key points, which were organized into four distinct groups: hardware components, software functionalities, design, and system delivery.

3 Results

3.1 Pilot: Logbook Data

During the pilot study, a logbook was maintained by the researchers. For each date, the logbook provided a detailed account of the visits and the notes made by the research team, see Table 5.

Table 5

DEEP's Pilot Study Logbook data overview.

Date	Visit	Usage in total	Feedback
De Verbinding			
May 1, 2023	First visit	DEEP was used twice on one patient.	DEEP's location too far, reduced visibility for caregivers. Decided to alternate DEEP's placement between clinics A and C. DEEP introduced in clinic C during a weekly meeting. Posters added on clinic walls to serve as a reminder for the pilot. Question regarding the caregivers' evaluation form, whether patient behavior should be described in words or quantitatively.
May 25, 2023	Second visit	DEEP sessions unchanged.	Caregivers found it hard to integrate DEEP into daily routines. Patients in the eHealth program also engaged in relaxation exercises. Contacted the eHealth facilitator responsible for that program. Discussed the patients' interview guide.
June 8, 2023	Third visit	DEEP sessions unchanged.	Interviews scheduled during this visit.
June 20, 2023	Fourth visit	DEEP sessions unchanged	Meeting with eHealth facilitator; expressed interest in DEEP and the willingness to conducted DEEP sessions (knows the patients, acquainted with VR) First patient interview; expressed enthusiasm. Coordinated two caregivers (from clinic A and C) to use DEEP for the remaining pilot month. Contacted Innovation Center, because of the focus on implementation.
June 29, 2023	Fifth visit	DEEP was used fifteen times.	Patients found DEEP enjoyable, however abdominal belt issues arose for patients with larger waistlines. Caregivers from the clinic did not conduct DEEP sessions themselves.
July 5, 2023	Sixth visit	DEEP sessions unchanged	Meeting with Innovation Center, DEEP's post-pilot usage insights. Clinic visit same day: DEEP was not used due to new patients.
July 10, 2023	Seventh visit	DEEP sessions unchanged	Interviews with eHealth facilitator and caregiver, structure was deemed crucial when implementing DEEP.
July 20, 2023	Eighth visit	DEEP sessions unchanged	Interviews with Innovation Center and two caregivers.
July 24, 2023	Ninth visit	DEEP sessions unchanged	Second patient interview, coinciding with pilot conclusion.
Date	**Visit**	**Usage in total**	**Feedback**
FPA			
April 25, 2023	First visit	-	Broken abdominal band, switch malfunction. Band retrieval by researcher in first week. Repair delayed due to May vacation period (over two weeks).
May 11, 2023	Second visit	-	Abdominal band returned to FPA.

June 8, 2023	Third visit	DEEP sessions unchanged.	Busyness in the clinic and short-staffed. However, clients were found who wanted to try it. Caregivers pressured to use DEEP perfectly, low-threshold approach agreed upon.
June 30, 2023	Fourth visit	DEEP was used two times.	Third caregiver returned one caregiver used DEEP successfully. Inclusion criteria clarified; all three caregivers agreed to use DEEP more frequently in final month. Caregivers wished for a refreshing training with DEEP. Researchers focused on pilot goals that were set on June 30th. Weekly email updates and scheduling helped caregivers stay engaged.
July 15, 2023	Fifth visit	DEEP used five times.	Final visit to FPA. Two caregivers used DEEP with patients. Interviews with caregivers and patients were scheduled for August 2023.

The pilot process initially encountered challenges in both clinics. At FPA, a shortage of team leaders necessitated a selective start with a small, experienced group of three sociotherapists to introduce DEEP. Meanwhile, at De Verbinding, a change in team leadership required swift coordination, facilitated by support from both clinics' leaders and a graduate intern GZ-psychologist. Hereafter, in both organizations, a one-hour DEEP training session preceded the pilot, offering caregivers an overview of the project, DEEP, and hands-on practice. Approximately 25 caregivers from clinics A and C participated at De Verbinding, while FPA saw the initial involvement of two caregivers, later expanding to three.

Following the training sessions, DEEP remained available on-site. The initial adoption of DEEP varied between the two clinics. De Verbinding had one patient try out DEEP early on, while FPA faced delays due to technical issues with the switch on the abdominal band. Caregivers from both clinics recognized the value of DEEP, although integrating it into their daily routines in the clinic remained challenging. In June, the number of DEEP sessions did not increase at the FPA due to the busyness in the clinic, a caregiver from the FPA mentioned "*When is the time to deploy it? The clinic is often quite busy. When you're short-staffed, you almost feel guilty leaving with DEEP*". At De Verbinding, there was concern about potential overlap with the eHealth program, and a caregiver mentioned, "*I'm not sure if a patient has already participated in mindfulness exercises that they would like to engage in them at the clinic again, so combining the two could be a solution*." As a response, contact was established with the eHealth facilitator of de Woenselse Poort. This facilitator expressed willingness to conduct DEEP sessions due to its familiarity with the patients and technological expertise. This resulted in twelve patients additionally using DEEP. Positive outcomes of these sessions were reported. However technical issues were reported as well, including problems with an ill-fitting abdominal belt for patients with larger waist sizes. Meanwhile, at FPA, caregivers expressed a need for a refresher course on DEEP's setup and usage, leading to an increase of five DEEP sessions shortly thereafter. The pilot study ended with semi-structured interviews.

3.2 Pilot: DEEP Session Evaluation Forms Caregivers and Patients

During the pilot, caregivers completed an evaluation form after each DEEP session. Their findings are presented in Table 6. It is evident that, overall, caregivers rate the sessions positively and observe an improvement in a clients' emotional state after the session. However, sessions receive lower ratings if there were issues with the VR hardware, such as the headset or the abdominal band. Additionally, by the FPA, DEEP was implemented structurally, while De Verbinding opted for an ad hoc approach. It is noteworthy that, by C1, eHealth sessions were pre-scheduled as part of the patient's program. However,

patients were approached on an ad hoc basis for DEEP sessions without prior arrangement. This approach was taken as the eHealth facilitator assessed the patient's current state (during the scheduled time) and sought their consent before actually initiating DEEP sessions. Lastly, few clients experienced physical discomfort after playing DEEP, such as nausea or dizziness. These sessions were also rated slightly lower, receiving a grade of 6.

Table 6

Results of the DEEP sessions Evaluation Forms by caregivers.*

Date	Patient	Caregiver	Structured /Ad hoc	How did the patient feel before playing DEEP?	How did the patient feel after playing DEEP?	Remarks?	Overall grade
FPA							
11/06	P3	C5	Structured	Good	Calm/ relaxed	First time, exploratory	8
01/07	P3	C5*	Structured	Good	Good/session more challenging due to cold	Some initial difficulties	6,5
12/07	D	C6	Structured	Relaxed	Calmer	Progressed very quickly	8
12/07	M	C6	Structured	Relaxed/ calm	Energetic/ soothing	First time, shared screen sometimes blurry	8,5
13/07	D	C6	Structured	Relaxed	-	Controller did not respond consistently	9,5
De Verbinding							
24/04	P1	C2	Ad hoc	6/10	Relaxed/happy	Unable to complete, headset ran out of battery	6,5
27/04	P1	C2	Ad hoc	4/10	8/10	Abdominal strap stopped working after 10 minutes	8
01/05	P1	C2	Ad hoc	8/10	9/10	Unclear if client reached the end	8,5
26/06	A**	C1	Ad hoc	Calm	Nauseous	-	6
26/06	M	C1	Ad hoc	Relaxed	Good, slightly dizzy	-	7
26/06	P2	C1	Ad hoc	Calm	Relaxed	Abdominal strap not working well	7
26/06	C	C1	Ad hoc	Tense, but fine	More relaxed	-	-
26/06	Me	C1	Ad hoc	Good	-	-	-
28/06	J	C1	Ad hoc	Good	Good	Difficult, but well done	9
28/06	T	C1	Ad hoc	Good	Tired	Controls not working well	6
28/06	H	C1	Ad hoc	Good	Good		8
28/06	Ha	C1	Ad hoc	A bit tired	Dizzy		6
29/06	Jo	C1	Ad hoc	Fine	Feeling better	Found it very enjoyable	10
29/06	As	C1	Ad hoc	Good	Took a moment to	Controls worked	8

					adjust	better now	
29/06	Ad	C1	Ad hoc	Drowsy	Relaxed	Client feels better	7

Note. *C5 mentioned playing DEEP with P3 four times but forgot to complete the sign-up form twice.
**Many clients wanted to complete evaluation forms but not be interviewed. Therefore, they are indicated with initials instead of codes to prevent confusion during interviews.

Additionally, after each DEEP session, the clients completed a brief evaluation form. The results are presented below in Table 7. Overall, the DEEP sessions were positively rated by the clients, with most of them finding DEEP relaxing and a pleasant experience. However, some clients also mentioned that certain hardware did not work properly, which aligns with what was noted in the evaluation forms by the caregivers.

Table 7

Results of the DEEP sessions Evaluation Forms by patients.

Patient	Total DEEP sessions played	Rating of DEEP session	Additional comments
FPA			
P3	1 time		I often meditate to this music, it is very calming.
P3	2 times		Enjoyable again, just had some startup issues.
D	1 time		Exciting but also calming.
M	1 time		Without the controller, it becomes more challenging.
D	2 times		Beautiful underwater world. Challenging to focus on my breathing and navigate through the water/cave.
De Verbinding			
P1	1 time		Nice experience.
P1	2 times		I found it relaxing. Fun experience.
P1	3 times		It is a very beautiful and relaxing experience. Too bad, though, that you do not really know where the end is.
A	1 time		It feels like spacing out. I would like to do it more often.
M	1 time		Nice to experience.
P2	1 time		I think it could be a bit more thrilling.
Jo	1 time		I enjoyed doing it, but the controls were difficult. More exhaling than inhaling. The ending was not entirely clear.
Th	1 time		More soundtrack.
H	1 time		Nice experience.
As	1 time		It is good for my brain to be somewhere. This is very relaxing.
Ad	1 time	 *	Wooow!

J	1 time	☺	I do like to have it myself.

Note. * Had drawn a smiley with a big smile and checked it.

3.3 Pilot: Interview Caregivers, Patients and eHealth Advisor

3.3.1 Demographics

Five caregivers, including a psychologist, a sociotherapist, an eHealth facilitator, and two forensic social workers, three patients, and one eHealth advisor participated in the interview study. Although two caregivers did not conduct DEEP sessions themselves, they were involved in the pilot study from the beginning, therefore included to share their user experiences and explore implementation strategies of DEEP. Additionally, ten more patients completed DEEP sessions, but due to time constraints and varying levels of reflective skills, not all were included in the interview study.

Table 8

Table of General Background Characteristics of the Participants included in the Interview Study.

Participants	Gender	Age	Experience DEEP (# sessions)
Caregivers			
C1 - eHealth facilitator	M	43	12
C2 - Sociotherapist	F	24	4
C3 - Forensic social worker	F	48	0
C4 - Psychologist	F	26	0
C5 - Forensic social worker	M	62	4
Median		43	4
Patients			
P1 – De Woenselse poort	F	49	3
P2 – De Woenselse poort	M	43	1
P3 - FPA	M	37	3
Median		43	3

3.3.2 Codes and Subcodes

Table 9 below presents the retrieved codes and subcodes from the interview study. Each code is accompanied by a definition and the number of times it was mentioned by caregivers, patients, and the eHealth advisor.

Table 9

Overview of the Codes, according to Caregivers (n=5), Patients (n=3), eHealth advisor (n=1).

Codes and sub codes	Definition of code	Total[1]	Caregivers[2]	Patients[3]	eHealth advisor[4]
Code 1: User Group Characteristics	Aspects related to the traits and attributes of the patients and/or caregivers interacting with DEEP.				
Digital Skills	The ability of caregivers and patients to navigate, use, and interact with digital technologies effectively and confidently.	14	4 (5)	3 (5)	1 (4)
Lower Frustration Tolerance	A reduced capacity of patients to endure or tolerate challenging situations or stressors.	9	2 (6)	1 (3)	
Code 2: Experienced Benefits of DEEP	The positive outcomes and advantages that users perceive and report as a result of interacting with DEEP.				
Redirecting Attention	The act of shifting one's focus towards their thoughts and emotions during and after using DEEP.	4	2 (2)	2 (2)	
Relaxation	Sensation of feeling at ease during and after using DEEP.	11	4 (6)	3 (5)	
Breathing Control	Sensation of regulated breathing during and after using DEEP.	7	2 (2)	2 (5)	
Code 3: Hardware Components of DEEP	The practicality, ease of use, and accessibility of the physical hardware components of DEEP.				
User-Friendliness	The practical application and ease of use of the multiple components in the DEEP system.	10	3 (6)	3 (4)	
Accessibility and Applicability of the Abdominal Band	The ease of use and effectiveness of the abdominal band for a diverse range of patients.	21	4 (14)	3 (7)	
Readiness for Use	Configuration of DEEP components that allows for immediate use when desired.	8	4 (8)		
Code 4: Software Functionalities of DEEP	The user experience with DEEP's digital components and operating mechanisms.				
Game Difficulty Level	The level of challenge or complexity within DEEP.	8	4 (6)	2 (2)	
Joystick Reset Functionality	The use of the reset button in DEEP to return to the center position during gameplay.	3	1 (1)		
Breathing Instructions	The inclusion of in-game breathing instructions that assist users in mastering the necessary breathing techniques in DEEP.	13	3 (11)	1 (2)	
Long-Term Engagement	Sustaining the appeal and attractiveness of DEEP through the addition of new in-game functionalities.	31	3 (18)	3 (13)	
Code 5: Design of DEEP	Users' experiences with the visual representation of the components and elements of DEEP.				
Environment Experience	The perception of the visual and auditory	15	4 (9)	3 (6)	

	elements of DEEP's environment and accompanying effects.				
Enhancement Areas of Design	Sustaining the appeal and attractiveness of the design in DEEP through the addition of new environments and visual aspects.	11	4 (9)	1 (2)	
Code 6: DEEP's Alignment with Treatment	The process of aligning DEEP's purpose and functionalities with treatment objectives and content in clinical practice.				
Clarity of DEEP's Purpose	Gaining a clear understanding of the value of playing DEEP for the patient, including its contributions and mechanisms.	19	4 (14)		1 (5)
Psycho-Education on Breathing Exercises	Clarifying beforehand to the patient the value of performing breathing exercises and the positive outcomes they yield.	8	3 (7)	1 (1)	
Evaluating DEEP's personal relevance	The evaluating process to review user performance, assess their experience, and reflect on DEEP's personal significance over time in treatment context.	5	2 (4)		1 (1)
Wearables Devices Integration in DEEP	DEEP's ability to incorporate wearable devices into its system within the treatment context.	9	4 (8)		1 (1)
Mindfulness Techniques Integration	The capacity of DEEP to establish connections or interactions with mindfulness techniques, practices, or programs.	9	4 (4)	2 (4)	1 (1)

[1]The total number of times a code was mentioned in all interviews. [2]The number of different caregivers that mentioned a code, and (#) the total number of times the code was found in all interviews with caregivers. [3]The number of patients that mentioned a code, and (#) the number of times the code was found in all interviews with patients. [4]The eHealth advisor that mentioned a code, and (#) the number of times the code was found in the interview with the eHealth advisor.

Code 1: User Group Characteristics

The user experience of working with DEEP was influenced by two aspects. Firstly, **digital skills** played a role as VR technology remained relatively new and unfamiliar to both caregivers and patients. One caregiver (C4) highlighted that "*some patients, due to prolonged stays within the facility, may not be well-acquainted with digital technology*." Among the patients, only two had prior experience with VR, while one patient was entirely new to this technology. This digital unfamiliarity also extended to some caregivers, with four of them sharing a similar lack of experience with VR technology. The eHealth advisor noted that VR technology might demand a certain level of digital proficiency, emphasizing the importance of considering the learning curve and the technology's capacity to complement existing activities. Secondly, **lower frustration tolerance** was evident among patients. They often showed a tendency to become easily irritable. This especially occurred when they were faced with technical issues or challenging situations. Two caregivers (C1, C2) recounted instances where patients displayed mild irritation, and as one caregiver pointed out, "*You can observe that some patients who become easily irritated may have had their progress in the game affected when things did not work as expected during a DEEP session*."

Code 2: Experienced Benefits of DEEP

Interacting with DEEP resulted in three benefits for patients. First, **redirecting attention**, during breathing exercises, patients' attention shifted away from their immediate surroundings, immersing them in DEEP's virtual world. One patient (P1) vividly described this experience, stating, "*You just get completely absorbed in that thing.*" This immersion provided a profound sense of escapism. It offered a welcome distraction from the clinical environment, and enabled patients to focus on breathing and relaxation. Second, **relaxation**, caregivers observed a noticeable increase in patients' relaxation levels while using DEEP. Patients sat calmly, free from nervous twitches, fully engaged in the game. This sense of relaxation persisted beyond the DEEP session. Caregiver C2 noted: "*The patient wasn't feeling too great initially but could later express feeling significantly calmer*." Patients sought DEEP in part due to this enduring relaxation effect, with one attributing it to DEEP's tranquil underwater world. Third, **breathing control**, patients reported improved control over their breathing while using DEEP. This resulted in deeper and more controlled breaths during the immersive experience. They valued the opportunity to practice controlled breathing. Caregiver C5 observed, "*I did notice a positive effect and gradual improvement. The patient found it easier to manage, indicating better control over his breathing*." However, the caregiver could not confirm these effects in daily life due to the limited timeframe and frequency of such occurrences.

Code 3: Hardware Components of DEEP

Regarding the hardware components of DEEP, users found them to be practical and **user-friendly**. Both the VR glasses and the abdominal band were comfortable to wear, and the inclusion of a spectator mode for caregivers to observe the sessions was also appreciated. Caregivers also found it convenient to assist patients during gameplay, enhancing their interaction. However, concerns were raised about the **abdominal band's accessibility and applicability**. It was noted that users with substantial bellies or improper diaphragmatic breathing techniques faced challenges in positioning the sensor correctly, impacting gameplay. A patient (P3) stated: "*Sometimes, you would suddenly sink to the bottom because the abdominal band stopped working. Then you had to restart everything while you were just getting into it.*". Some reported malfunctions, such as the breathing circle not functioning correctly or causing the game to freeze. Emotional concerns also arose, with caregivers occasionally feeling uncomfortable during

physical contact with patients while assisting with the band or controllers. Solutions to minimize these moments of physical contact were considered necessary. Additionally, caregivers stressed the importance of DEEP's components being **ready for immediate use**, suggesting improvements like external charging meters and a dedicated DEEP VR headset to streamline the startup process. Caregiver C4 stated that "*I would make the startup process shorter, so you can use it more quickly. If you think, 'I want to use it now,' and if you don't use it often, you really need five to ten minutes to figure out how it works again*." Three caregivers mentioned that figuring out how to start DEEP was a notable concern.

Code 4: Software Functionalities of DEEP

Regarding the user experience with DEEP's digital components and operating mechanisms, it became apparent that three caregivers found DEEP's **game difficulty level** to be straightforward, as long as the navigation worked properly. However, patients initially struggled with proper abdominal breathing, affecting their gameplay. Caregiver C1 noted, "*I did notice some people who breathed calmly could just continue without any problems, but that wasn't the case for everyone.*" To improve this, caregivers suggested **breathing instructions**, to guide patients in mastering the right breathing technique. Examples of these suggestions were adding a simple tips tool as "*try to breathe calmly*" and "*make breathing-related elements more prominent*". Teaching the breathing pattern through training and incorporating it into DEEP's gameplay was also suggested. This could benefit clients with varying tension levels according to caregiver C4. Another valued support provided by DEEP' system was the **joystick reset functionality.** This proved beneficial, particularly in situations where the abdominal band malfunctioned or patients encountered breathing difficulties. Caregiver C1 remarked, "*The reset button allows players to level up, and patients found it enjoyable to continue playing DEEP with the joystick*." This feature not only enhanced the user experience, but also instilled a sense of control and confidence in patients, offering them an alternative solution alongside their breathing technique. However, as users grew more proficient in DEEP, they found its gameplay could become repetitive according to both caregivers and patients, raising questions about **long-term engagement**. One caregiver (C2) expressed, "*After a few sessions, the novelty wears off, and it no longer serves as a tool for practicing breathing*." This concern was particularly relevant to younger patients who expected a more gamified experience. Proposed improvements by participants included the incorporation of progress indicators, clearer game completion signals, and the introduction of a point system. Allowing patients to practice the required breathing style before starting the game was also seen as beneficial. One patient (P2) suggested adding more interactive elements for a richer experience, while another (P3) recommended, "*It might be fun to add a difficulty level to it. That once you're doing really well, it becomes a bit more challenging, with more tunnels and movement variations.*"

Code 5: Design of DEEP

DEEP's virtual underwater **environment** received praise from both caregivers and patients for its visual appeal and calming effect. One patient (P1) expressed, "*Yes, it's as if you're really swimming in the ocean*." However, there were **enhancement areas for design**. According to a caregiver (C1) patients can face challenges with visualization, highlighting the potential benefit of incorporating relaxing visual elements into DEEP's virtual world. Additionally, there was a desire for diverse scenarios to cater to different preferences and maintain engagement, as repetitive scenarios could lead to monotony. Caregiver (C4) mentioned "*Adding diverse environments, while maintaining the same breathing focus but offering different routes or courses can be of added value*." Patients and caregivers also recommended adding more details within the virtual world to enhance its alignment with breathing and relaxation practices.

Personalization in DEEP's virtual world was deemed valuable, encompassing sound and environment customization to offer users a tailored and relaxing experience. Caregiver C3 mentioned, "*it would be best if people could choose an environment that they find comfortable and relaxing*".

Code 6: DEEP's Alignment with Treatment Protocols

To align DEEP within treatment context, several aspects emerged from the interviews. First, the **clarity of DEEP's purpose**, was emphasized as crucial, with some patients initially struggling to grasp it. Caregivers expressed concerns that patients sometimes prioritized game competitiveness over diaphragmatic breathing control, showing uncertainty about DEEP's objectives. Caregiver C5 mentioned "*I think you should discuss the underlying intention; you don't do it just for the sake of doing it, but because it has an effect on your entire being*". To address this, potential solutions were proposed. One caregiver (C1) suggested translating DEEP's goals into everyday situations that patients could relate to, ensuring that DEEP's objectives resonated with their specific needs. For instance, DEEP could be linked to individual goals such as stress management or emotional regulation in particular scenarios. Caregiver C2 elaborated on this, stating, "*When you find yourself in a particular situation, it's essential to know how to use your breath to manage your emotions. This exercise can be quite beneficial in such cases, especially if it provides clear, step-by-step instructions. It could also be helpful to incorporate it into real-life scenarios and provide practical examples*." Another approach was to incorporate interactive videos that effectively conveyed how breathing impacted emotions and how DEEP could assist. The eHealth advisor highlighted the value of clear communication, narratives, and storytelling to convey DEEP's purpose and potential benefits effectively. Second, four caregivers stressed the significance of making patients aware of the benefits of breathing exercises through **psycho-education on breathing exercises**. Which can encourage their engagement with DEEP and the integration of these practices into their daily lives. Caregiver (C1) provided a simple illustrative example, asking patients to consider whether they are in a "*green*" or "*red*" state and how they can use controlled breathing to return to a "*green*" state in specific situations. Third, the evaluation of DEEP's personal relevance was mentioned by two caregivers as a way to track the impact of DEEP sessions on patients. One caregiver (C4) suggested that this could be done similar to the current pilot evaluation forms, stating "*by quickly and succinctly filling in information, you can eventually have a comprehensive overview. This approach allows you to clearly see differences, such as when someone initially rates their state as a six but leaves with a nine, indicating the positive impact of the session*". Another caregiver (C3) highlighted the importance of assessing the personal relevance of DEEP for a patient over time. For raising the question of whether continued DEEP sessions are necessary once relaxation and breathing goals are achieved. Implementing a reflection feature after DEEP usage could establish an ongoing feedback loop, which is crucial for continuous assessment and improvement as emphasized by the eHealth advisor. Fourth, participants emphasized the potential of **integrating wearables** with DEEP. One caregiver (C1) proposed linking DEEP with wearables to provide users with visual feedback on their physiological responses, which could serve as additional motivation for breath control and provide valuable input data for the DEEP system. However, three caregivers expressed reservations about the feasibility of such integration, considering the patient population's readiness and interest in these advanced features. Last, integrating DEEP with **mindfulness techniques** was discussed. Caregiver C3 mentioned "*if patients are already engaged in Mindfulness, DEEP could fit in nicely or be offered as an alternative*." DEEP could complement the exercises patients receive from psychomotor therapy (PMT), and vice versa. A patient (P3), who regularly practices meditation, viewed DEEP as an additional form of meditation and expressed a desire to continue both practices in the future. The eHealth advisor noted that Mind district also has a module for mindfulness.

3.4 Desk Research

3.4.1 Key points of Recent VR Technologies

In total, thirteen VR-technologies have been found. Table 6 presents an overview of the key points identified in these technologies, along with a description and an example. For a more detailed overview of the functionalities, various components, and a link to the website of the technologies, please refer to Appendix E.

Table 10

Key points of Comparable VR Technologies uncovered through Desk research.

Key points	Description	Example	Included in
Hardware Components			
Breathing Measurement System	A device or equipment employed to measure the users' breathing patterns while they engage in VR experiences.	Touch controllers, Wind Sensor Rev.c, Flex sensor, ECG sensor, Touchpad, Gear VR-controller, Biosignalplux sensor, Respiration sensor PROComp2, Heart rate sensor and Biofeedback waistband.	Flowborne, Kana, BreatHero, BreatheVR, Guided Meditation VR, JeL, Respire VR, Flowly, Virtual Reality Mindset
Software Functionalities			
Breathing Exercises in an App	A supplementary feature, allowing users to practice deep breathing exercises with an app alongside the VR game to enhance relaxation and mindfulness.	In the Flowborne app, users can choose a diverse selection of breathing exercises and perform these exercises in a meditative journey (Figure 3).	Flowborne, Kana
Associate Learning on Breathing Techniques	Promoting the desired breathing pattern by using associate learning on in-game objects.	In BreatHero, each breath technique is used to deal with a specific in-game enemy.	BreatHero
Guided Breathing Instructions	Instructional guidance provided during a VR experience to assist users in maintaining coherent breathing patterns in sync with the game.	In Flowly, users can view their measured heart rate, along with accompanying graphs that provide visual guidance to help them maintain the correct breathing pattern.	Flowborne, Flowly, Respire VR, BreatHero
Engagement Tasks and Exercises	Specially designed activities and exercises aimed at actively engaging users and facilitating their learning or relaxation processes.	In Kana, users can choose from five different games with a variation in duration and purpose such as dive down and deep underwater.	Kana, Virtual Reality Mindset, Flowly, Inner Focus, VRelax, BreatHero, Flowborne
Phased Gameplay	A design approach in which the gaming experience is structured into distinct phases or stages, each with its own set of objectives, challenges, or gameplay mechanics.	In Inner focus, there are three stages to the experience — Flow, Focus and Reflect.	Inner Focus
Customizable VR Environment Settings	Configuration options allowing users to personalize the VR environment to their preferences before starting the experience.	In Guided Meditation VR, regarding the experience users can pre-set the duration, stimuli (lights and visuals) and choose an environment.	Guided Meditation VR
Goal Setting	Goal setting is the process of defining clear, achievable	In Virtual Reality Mindset, the user can only make progress and achieve the in-	Kana, Inner Focus, Virtual Reality Mindset

	objectives for breathing control and creating a plan to reach them.	game goal by actively managing their stress level, which is measured in real-time through HRV.	
Interpersonal Synchronization	The practice of attaining physiological synchronization between two users by means of collaborative interactions.	In JeL, when two breathing patterns get synchronized a glass-sponge structure emerges, see Figure 4.	JeL
Performance Indicators	The process of observing a user's performance regarding gaming elements in VR and delivering personalized guidance based on their achievements and objectives.	In Inner Focus, a scoring system is present that evaluates how closely users achieve preset relaxation goals, for different stages, motivating users to improve their scores through focused breathing and stillness.	Inner Focus
Dashboard with Biometric Data	A computer interface that presents users with biometric data and valuable insights obtained from measurement systems.	Inner Focus uses a customizable dashboard with biometric data from various sensors for real-time analysis and personalized VR experiences tailored to users' emotional states and goals.	Virtual reality mindset, VRelax, Inner Focus, Flowly
Design			
Diverse VR Environments	A range of virtual reality scenarios available for users to select from.	In Exhale XR, the user can choose from 75 relaxation environments.	Flowborne, Vrendle, Exhale XR, Kana, BreatHero, VRelax, Guided Meditation VR, Flowly, Virtual Reality Mindset
Avatars	Digital avatars that replicate users' actions and interactions within the virtual reality environment.	In JeL, the game makes use of Moon Jellyfishes as they have a simple and recognizable form, along with their meditative aesthetic.	JeL
System delivery			
Implementation Specialist	An expert capable of bridging their expertise, experience, and skills with the utilization of VR tools, techniques, and knowledge.	In Kana, the specialist is trained and certified by Kana to effectively utilize the tools in practice, with this training consisting of various modules.	Kana
Demo Kit	A bundled set of resources or tools offering a preview of the features and advantages of a technology for demonstration purposes.	In Flowly, users can request a Demo kit of Flowly VR.	Flowly
Transfer of Learning Procedures	Methods to apply and integrate skills acquired in the virtual game into real-life situations	In Virtual Reality Mindset, a Feedback Canvas as a reflective tool is used to translate daily life experiences to game objectives and vice versa.	Virtual Reality Mindset, Kana, Inner Focus
e-learning	Digital learning materials centred on the theoretical foundations of the intervention.	In Virtual Reality Mindset, an e-learning module was utilized to educate users about stress and the necessary biofeedback mechanisms.	Virtual Reality Mindset

Figure 3

Different breathing exercises in the app of the VR biofeedback game Flowborne (13).

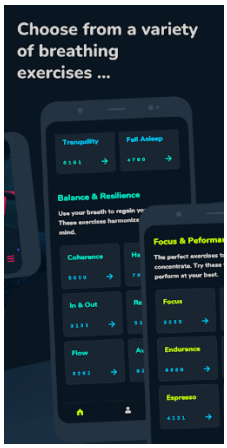


Figure 4

Moonfish Avatars in the VR bio-responsive game JeL (30).

DEEP shares similarities and differences with other VR technologies identified in the desk research. Similarities include the shared design, such as the virtual underwater world, with five of these technologies, aligning most closely with Flowborne and JeL. Additionally, both DEEP and these technologies promote the adoption of a desired breathing pattern through diaphragmatic biofeedback, with four also incorporating environmental responsiveness to breathing patterns.

Several differences can be identified as well. First, eight of the examined technologies offer users multiple environment choices, catering to individual preferences, including natural landscapes and surreal meditation spaces. Second, three of these technologies provide personalization options, allowing users to customize timing, stimuli, and avatars according to their preferences. Third, six technologies include assignments and challenges within virtual environments to facilitate practice and reflection, such as inducing stress or using in-game objects for learning breathing techniques. Fourth, variations exist in how measurement data is presented during and after gameplay, with some offering real-time measurements within the game (e.g., Flowly) and others providing post-game dashboards with measurement data (e.g., Inner Focus). Last, two solutions use try-out kits and involve specialists during implementation to align the VR technology closely with the target audience.

4 Discussion

4.1 Principal Findings of the Study

The main goal of this study was to investigate how DEEP can better align with the needs of forensic inpatient care in order to explore its effective integration into practice. Participants initially found DEEP to be an innovative way to teach patients new skills and reported positive experiences, highlighting its ability to redirect attention, induce relaxation, and improve breathing control. However, during the pilot, its usage fell short of expectations. To establish DEEP as a more integral part of patient care and increase its utilization and adoption in practice, several aspects need to be addressed. First, participants stressed the importance of clearly articulating DEEP's purpose and mechanism to enhance intrinsic motivation among patients. Second, streamlining the deployment of DEEP is essential. Caregivers highlighted the difficulties associated with integrating DEEP into their workflow and the technical skills required for VR usage. Therefore, improving DEEP's user-friendliness and readiness for use is crucial. Third, to maintain patient engagement with DEEP over the long term, there is a need to address issues related to maintaining focus during gameplay. Insights from similar VR technologies, particularly regarding gamification elements, can inform these improvements. The DEEP Development Team has also prioritized enhancing long-term engagement[2]. The study's findings underscore the need for improvements to enhance both intrinsic and extrinsic motivation for DEEP's utilization and adoption in the context of forensic care.

4.2 Clear Articulation of DEEP's Purpose and Mechanism

An important finding from this study is the need to clarify DEEP's purpose and mechanism for end-users. This has been identified as a potential obstacle to the effective utilization of DEEP within forensic care practice. It involves ensuring that patients have a clear understanding of what DEEP is and how it can benefit them in their treatment context, which, in turn, increases the likelihood of user adoption and benefit. This challenge aligns with established technology acceptance models such as the Technology Acceptance Model (TAM) (31) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (32), both of which emphasize the importance of perceived usefulness by users. Moreover, participants in this study stressed the importance of straightforward and relatable communication regarding DEEP's purpose and mechanisms. This is especially critical for forensic patients who may face challenges related to abstract reasoning and imagination (33). Caregivers recommended translating DEEP's objectives into practical, everyday situations to make the technology more relevant and relatable to patients. For example, they suggested using specific moments when a patient experiences high breathing rates as illustrative examples during explanations of what DEEP can offer to them. Furthermore, caregivers proposed providing psycho-education on the potential benefits of DEEP, which could motivate patients to actively engage with the technology. In addition to these suggestions, refining the communication strategy was seen as vital. This could involve incorporating interactive videos and storytelling to effectively convey how breathing impacts emotions and how DEEP can assist in managing them. By implementing these strategies, user understanding of DEEP's purpose and functionality could be improved, potentially leading to increased adoption and effective utilization of the technology in clinical forensic settings.

[2] After the pilot study, an informal focus group session with the DEEP Development and Research team was conducted to exchange information on the current status and explore potential improvements. During this session, it was revealed that the development team will prioritize long-term engagement when implementing new elements, as discussed on Wednesday, August 30th.

4.3 Streamlining the Deployment of DEEP

Caregivers emphasized the need for easier deployment of DEEP in the forensic care context. Currently, the initial setup and calibration of DEEP were perceived as time-consuming and challenging, especially for users unfamiliar with VR technology. As a result, DEEP was not consistently integrated into their workflow due to time constraints and daily clinic demands. This aligns with existing literature highlighting the importance of user-friendly and intuitive technology to minimize adoption barriers (26, 34). In a study by Staras et al., the importance of adapting interventions to specific settings while preserving their core components was highlighted using the CFIR framework (35). One adaptation approach to enhance user compatibility, drawn from the diffusion of innovations theory incorporated within CFIR, involves integrating the intervention with the clinic's workflow. Collaborative efforts between investigators and clinic staff can facilitate these adaptations. To improve DEEP's integration into clinical workflows and lower deployment barriers, caregivers made several recommendations. First, streamlining the setup process by developing a dedicated VR headset exclusively designed for DEEP. This concept is supported by successful implementations in other technologies identified during desk research, such as Flowly (36). Second, employing external charging meters on the hardware components to ensure that the technology is fully charged and ready for use when deployed. Third, providing refresher courses on DEEP usage to ensure that the necessary knowledge is always readily available. Desk research showed that Kana uses an implementation specialist for this purpose. Additionally, it may be valuable to conduct a clinical workflow assessment before implementing DEEP, as suggested in the study by Staras et al., as well (35). This assessment can help identify potential areas for improvement to better integrate DEEP into existing care processes and to find the optimal way of deploying it. In the study the following steps were recommended (1) the identification of discrete workflow components, (2) a workflow assessment, (3) triangulation, and (4) stakeholder proposals of intervention implementation before implementation. This approach addresses potential barriers and ensures the intervention's effectiveness and reach. It is essential to consider the entire CFIR framework, not just the innovation aspect, as it encompasses multiple interrelated factors. In conclusion, addressing streamlining the deployment of DEEP in the forensic psychiatric care context is crucial to increase its adoption and utilization by caregivers.

4.4 Enhancing and Sustaining Long-Term Engagement with DEEP

Another finding highlighted by the study is the challenge of maintaining long-term engagement with DEEP. While initial enthusiasm and motivation were high, maintaining consistent usage over an extended period presented difficulties. This is a common issue in digital health interventions, particularly in clinical settings (37). Caregivers observed that as the novelty of DEEP diminished, patients showed less inclination to use it for practicing breathing exercises. This underscores the necessity for ongoing strategies to rekindle patient interest and motivation, especially for interventions intended for extended treatment periods. Gamification has shown effectiveness in enhancing user engagement and motivation over time (38, 39). Since DEEP is a serious game, it could potentially explain the initial enthusiasm observed among participants. However, further incorporation of gamification elements has the potential to amplify this effect. Both patients and caregivers contributed ideas on how DEEP could implement gamification. For instance, a patient suggested adding additional interactive elements to the environment, such as interacting with underwater creatures. Also, several gamification elements emerged from desk research. Such as associate learning on in-game objects, a point system, and engagement tasks and challenges. To illustrate how DEEP could integrate gamification, consider the example of associative learning on breathing techniques. This feature would link different deep breathing exercises to specific elements (corals) within the virtual environment. Players would then be required to synchronize their

breathing with these environmental cues to master the necessary breathing pattern. To ensure that the new elements continue to contribute to DEEP's goal, they can be linked to Behavior Change Techniques (BCTs). These techniques are replicable components of interventions designed to alter the processes that regulate behavior (40). This example is related to the category of associations, specifically related to the BCT's prompts and cues, as well as associative learning.

To enhance engagement and maintain DEEP's alignment with the needs and expectations of patients and caregivers, adopting a User-Centered Design (UCD) approach for ongoing DEEP development could be beneficial. UCD involves iterative development cycles that take into account user feedback, preferences, and characteristics, allowing for continuous improvements (41). The DEEP development team can incrementally adjust DEEP's in-game software, actively collect and integrate user feedback, and measure engagement to identify necessary improvements. Perski et al.'s systematic review on measuring engagement with digital behavior change interventions highlights the potential of real-time, technology-driven measurements (42). These measurements can be integrated into DEEP to assess patient engagement immediately after a session and after several sessions. This evaluation helps determine whether DEEP remains suitable and personally relevant to the patient in their treatment context, aligning with recommendations from caregivers and the eHealth advisor. For example, patients with lower engagement scores due to finding DEEP too easy and desiring more challenge could adjust the difficulty level. By closely monitoring user engagement, DEEP can develop strategies to improve sustained engagement based on user feedback after DEEP sessions, ensuring DEEP's alignment with individual patient needs throughout the intervention and in treatment context. Future longitudinal studies may be valuable to provide insights into the timeline for achieving meaningful and engaging usage of DEEP. This can include when patients develop proficiency in breathing control and express a desire for new elements. Additionally, these studies can shed light on DEEP's long-term effects, such as stress reduction and emotional regulation. This information can be used to develop use cases and user journeys for DEEP, which can be useful when introducing DEEP to new patients.

4.5 Strengths and Limitations

This study employed a qualitative multi-method approach, with the different methods all based on the same topic of DEEP's integrated system. This may have strengthened the quality of this research project, as different methods allow for different angels and nuances in the research findings. However, several methodological considerations merit discussion.

First, the pilot introduced an innovative research approach. Its exploratory nature granted participants the flexibility to utilize DEEP at their convenience within the clinic. However, as evidenced by logbook data and interview feedback, this voluntary approach also posed challenges, resulting in limited DEEP usage. Consequently, the findings carry a degree of tentativeness, primarily rooted in initial experiences rather than long-term utilization. To address this concern, a multifaceted data collection approach, including session evaluations, logbook data, and interviews, was incorporated in this study to deepen the insights obtained during the pilot. Further research is needed to investigate DEEP's long-term usage and to strengthen the findings. It is also worthwhile to explore DEEP's potential in other forensic care settings, such as outpatient and community care. Combining quantitative methods to measure adoption rates and their impact with qualitative research to gather insights could provide a more comprehensive understanding. If DEEP proves valuable in these contexts, it could benefit patients during transitions to lower-security care levels.

Second, the qualitative interviews in this study involved a relatively small group of caregivers and forensic inpatients. This approach allowed for a deep exploration of their experiences and perspectives regarding DEEP and its implementation. However, it may have introduced a selection bias towards more enthusiastic participants, partly due to DEEP's novelty and the voluntary nature of the pilot study. This potential selection bias could lead to a lack of diversity in viewpoints within the forensic psychiatric inpatient care context. To address this limitation, future research should consider a larger and more diverse sample to ensure a broader representation of perspectives, experiences, and organizations within this setting. To mitigate potential selection bias during the interviews, our protocol was designed to elicit a range of perspectives, including feedback from both DEEP users and those with critical viewpoints regarding its improvement. Nevertheless, open-ended questions posed some challenges during patient interviews, which contributed to relatively short average interview durations. To facilitate responses, we provided concrete examples (43), such as DEEP's virtual world, abdominal band, and VR glasses, to stimulate reactions and ideas while maintaining concise interviews (27).

Third, this study highlights the value of engaging multiple stakeholder types to obtain a comprehensive understanding of the context. The pilot's frequent visits allowed for continuous feedback collection, maintaining a close connection to practical concerns and ensuring that the technology effectively addresses real issues (27). Additionally, involving diverse stakeholders, including an eHealth facilitator and implementation advisor, introduced a broader range of perspectives and needs for integrating DEEP within the treatment context. By actively engaging stakeholders from various backgrounds and encouraging their input on DEEP's implementation and technology enhancements, the study underscores the importance of collaborative and participatory development practices. While multiple stakeholder types were involved, it is worth noting that there was only one eHealth advisor part of this study and the setting concerned only two forensic care organization in the Netherlands.

5 Conclusion

In conclusion, this thesis emphasizes the potential of experiential interventions like DEEP to enhance patient well-being, relaxation, and breathing control within forensic treatment. However, to better align these interventions with the forensic care context, it is essential to address key factors: articulating the intervention's purpose and mechanisms for its end users, streamlining the deployment, and maintaining a commitment to ongoing enhancing engagement and evaluation of the technology. These findings contribute to the optimization of DEEP and demonstrate the broader importance of tailoring digital health interventions to the unique needs and expectations of clinical contexts.

Acknowledgement

I would like to thank the Dimence Group for granting me the opportunity to conduct my master's thesis within their organization. Additionally, I want to thank my daily supervisor for her guidance and collaboration throughout the project. This study was conducted in close partnership with two inpatient clinics of Transfore and De Woenselse Poort. I would like to thank them as well for their participation in the pilot study and their willingness to share their experiences with DEEP!

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Appendix A: Materials for the Pilot Study

A.1 Logbook template pilot study

Bezoek aan organisatie:	**Datum**	**Aantal inclusies**	**Alle DEEP onderdelen nog goed?**	**Genoeg formulieren aanwezig?**	**Vragen vanuit de zorgverleners**	**Opmerkingen**	**Vervolg nodig?**

A.2 Evaluation form DEEP session patients

1. **Wat is je voornaam?**

2. **Hoe vaak heb je DEEP nu gespeeld?**

3. **Vond je deze DEEP-sessie leuk?**

4. **Wil je nog iets kwijt over DEEP?**

A.3 Evaluation form DEEP session caregivers

Datum	Voornaam patiënt	Voornaam zorgverlener	Structureel of ad hoc?	Hoe voelt de patiënt zich bij binnenkomst?	Hoe voelt de patiënt zich na DEEP?	Opmerkingen?	Rapport cijfer sessie

A.4 Informed consent patients

Toestemmingsformulier

- Ik heb het VR-spel DEEP een keer uitgeprobeerd.
- Ik heb genoeg uitleg gekregen over hoe DEEP werkt.
- Ik heb genoeg uitleg gekregen over het onderzoek.
- Ik begrijp dat er geen persoonlijke gegevens van mij worden gebruikt tijdens het onderzoek.
- Ik weet dat ik kan stoppen wanneer ik wil. Dit heeft geen invloed op mijn behandeling.
- Ik weet dat aan het einde van het onderzoek in een interview naar mijn mening wordt gevraagd over DEEP en het onderzoek.
- Ik weet dat het afsluitende interview wordt opgenomen en later wordt uitgewerkt door de onderzoekers. Ik weet ook dat de opname daarna wordt verwijderd.
- Ik doe mee met het onderzoek.

Naam: .....

Handtekening: ..... Datum: .....

Ondergetekende, verantwoordelijke onderzoeker, verklaart dat de hierboven genoemde persoon zowel schriftelijk als mondeling over bovenvermeld interview is geïnformeerd. Zij verklaart tevens dat een voortijdige beëindiging van de deelname door bovengenoemde persoon, van geen enkele invloed zal zijn op de zorg die hem of haar toekomt.

Naam: .....

Handtekening: ..... Datum: .....

A.5 Informed consent caregivers

Toestemmingsformulier

- Ik heb genoeg uitleg gekregen over hoe DEEP werkt.
- Ik heb het VR-spel DEEP gebruikt met mijn patiënt(en).
- Ik heb genoeg uitleg gekregen over het onderzoek.
- Ik begrijp dat er geen persoonlijke gegevens van mij worden opgevraagd naast dit interview.
- Ik weet dat ik altijd mag bepalen om te stoppen met het interview en vragen niet hoef te beantwoorden.
- Ik weet dat het afsluitende interview wordt opgenomen en later wordt uitgewerkt door de onderzoekers. Ik weet ook dat de opname daarna wordt verwijderd.
- Ik doe mee met het interview.

Naam: .....

Handtekening: ..... Datum: .....

Ondergetekende, verantwoordelijke onderzoeker, verklaart dat de hierboven genoemde persoon zowel schriftelijk als mondeling over bovenvermeld interview is geïnformeerd. Zij verklaart tevens dat een voortijdige beëindiging van de deelname door bovengenoemde persoon, van geen enkele invloed zal zijn op de zorg die hem of haar toekomt.

Naam: .....

Handtekening: ..... Datum: .....

Appendix B: Interview Guide Caregivers

Interview caregivers Woenselsepoort/ Transfore Juli 2023 Geslacht: Leeftijd: Functie:	
Introductie Welkom! Vandaag ga ik je/jullie een aantal vragen stellen over de VR-game DEEP die je de afgelopen 2 maanden hebt kunnen gebruiken bij jouw patiënten op de afdeling. Je/jullie hebt hiervoor ook intekenformulieren na de DEEP sessies ingevuld als het goed is. In dit interview komen we hierop terug en willen we graag bespreken wat je/jullie ervaringen zijn geweest met DEEP, zodat wij weten wat nog nodig is om DEEP goed te integreren in de forensische praktijk. Daarnaast zou ik je/jullie willen vragen of je het goed vindt dat ik een geluidsopname maak van het interview van vandaag. Ik verwacht dat het interview ongeveer 45/60 minuten zal duren en de vragen zullen betrekking hebben op de gekozen inzet van DEEP (timing/ aantal), verbeteringen van het systeem en een reflectie op de pilot zelf. Je/jullie gegevens zullen anoniem verwerkt worden en als je een vraag liever niet wilt beantwoorden, mag je dit aangeven. Is dat helder?	
TEKENEN INFORMED CONSENT Heb je voor nu nog andere vragen aan mij? Oké, dan gaan we beginnen.	
STARTEN OPNAME	
INNER SETTING DOMAIN	**De eerste vragen gaan over de manier waarop DEEP is ingezet op jullie afdeling en jullie ervaringen met de DEEP-sessies in het algemeen.** 1. Hoe vaak heb je DEEP ingezet bij patiënten op de afdeling? 2. Hoe was het om DEEP met de patiënten te gebruiken? a. Wat ging goed? b. Wat ging niet zo goed? Wat was lastig? 3. Heb je DEEP met name structureel of ad hoc ingezet? a. Waarom heb je voor deze inzet gekozen? 4. Hoe zag de praktische inrichting van het spelen van DEEP eruit? Denk aan ruimte en middelen. a. Hoe werkte dit voor je? 5. Paste DEEP bij je dagelijkse werkzaamheden? a. Waarom wel/ niet? b. Dacht je er regelmatig aan?
INDIVIDUALS DOMAIN	**De volgende vragen gaan over hoe jullie en de patiënten DEEP hebben ontvangen en gebruikt.** 6. Aan wat voor patiënten heb je DEEP aangeboden? En aan wie niet? a. Waarom heb je voor deze patiëntgroep(en) gekozen? 7. Wat heb je gemerkt bij de patiënten die DEEP vaker dan één keer hebben gespeeld? a. Heb je het idee dat ze de diepe ademhaling vaker in hebben gezet,

	buiten het spelen van DEEP? b. Heb je het idee dat ze zich ontspannen voelden na de sessies? 8. In hoeverre past DEEP bij alle zorgverleners/ al je collega's? a. Werd het door sommigen juist meer of minder gebruikt? b. Waarom past het wel/ niet bij iedereen?
INNOVATION DOMAIN	**In dit onderzoek willen we ook kijken naar hoe we DEEP verder kunnen verbeteren zodat het zo goed mogelijk past bij de forensische praktijk. We zijn benieuwd naar jullie ideeën hierover.** ***Vragen over de huidige variant:*** 9. Wat vond je van het spel in DEEP? a. Was het moeilijk of juist makkelijk om het spel te gebruiken? b. In hoeverre kan het spelen van een spel nuttig zijn voor patiënten om nieuwe vaardigheden te leren? c. Hoe aantrekkelijk vond je de vormgeving en geluiden van DEEP? 10. Wat vond je van de verschillende hardware onderdelen buikband/ bril? a. Hoe waren deze onderdelen in gebruik? b. Hoe keken de patiënten hiertegen aan? 11. Heb je ideeën hoe je de patiëntgroep betrokken kan houden bij interventies als DEEP? 12. Kun je mij iets vertellen over hoe DEEP je inzicht gaf in de emoties van de patiënt? a. Zo ja, welke aspecten van het ontwerp hebben hier volgens jou aan bijgedragen? b. Zo nee, welke elementen van het ontwerp waren onduidelijk of verwarrend? 13. Ken je nog andere technieken/ middelen om ademhaling mee te verbeteren? Wat vind je daarvan als je dit vergelijkt met DEEP? a. Mist DEEP hier iets in? Of zijn er punten uit die technieken die DEEP zou kunnen toevoegen? 14. Hoe denk jij over de integratie van DEEP met andere technologieën als wearables, breathing apps? a. Heeft dit volgens jou een meerwaarde? ***Brainstorm stuk*** Tot slot zou ik graag met je/jullie willen brainstormen over hoe DEEP verbeterd kunnen worden. Heb je ideeën hoe DEEP nog beter of interessanter gemaakt zou kunnen worden voor de (forensische) patiëntengroep? En op welke manier?
OUTER SETTING DOMAIN	**De volgende vragen zullen ingaan op het toekomstig gebruik van DEEP.** 15. Is de huidige versie van DEEP een technologie die je buiten onderzoek verband zouden willen blijven gebruiken op de afdeling? a. Zo ja, hoe zou je dan ondersteund/ geholpen willen worden? Wat zijn volgens jou belangrijke zaken om rekening mee te

	houden? b. Zo nee, wat is er nog nodig om DEEP volgens jou wel in te kunnen zetten op de afdeling? Wat zijn volgens jou belangrijke zaken om rekening mee te houden?
PROCESS DOMAIN	**Tot slot willen wij graag kort reflecteren op de pilot.** 16. Hoe heb je de pilot met DEEP ervaren? a. Wat vond je zinvol/ interessant? b. Wat vond je minder zinvol/ lastig? 17. We hebben pilotmaterialen ontwikkeld om jullie zo goed mogelijk te ondersteunen bij het gebruik van DEEP. a. Wat vond je van de instructies rondom het gebruik van DEEP? b. Wat vond je van de handleidingen rondom de inzet (e.g. voor- en nabespreking) c. Hoe vond je het dat de onderzoeker(s) wekelijks langskwamen? Heb je nog dingen die je ons zou willen meegeven voor het onderzoek? Heb je nog punten die je graag zou willen toevoegen?
STOPZETTEN OPNAME + BEDANKEN VOOR DEELNAME	

Appendix C: Interview Guide Patients

Interview forensic inpatients Woenselsepoort/ Transfore Juli 2023 Geslacht: Leeftijd:	
Introductie Welkom (naam patiënt) fijn dat je meedoet aan dit interview! Vandaag ga ik je een aantal vragen stellen over DEEP: de game gericht op ademhaling die je hebt kunnen gebruiken op de afdeling. Wij willen graag van jou leren om DEEP te kunnen verbeteren en daarom zijn we benieuwd naar wat jij van DEEP vindt. Er zijn geen goede of slechte antwoorden, dus je mag helemaal eerlijk zijn. Mag ik het interview opnemen? Het interview duurt ongeveer 30 minuten. Is alles helder voor jou?	
TEKENEN INFORMED CONSENT Heb je voor nu nog andere vragen aan mij? Oké, dan gaan we beginnen.	
STARTEN OPNAME + DEEP nogmaals laten zien/ foto's printen van de verschillende onderdelen.	

INNER SETTING DOMAIN	1. Hoe vond je het om DEEP te spelen?
	    1. Wat vond je leuk/ goed gaan?
	    2. Wat vond je minder leuk/ lastig aan DEEP? *Evt. evaluatieformulier bespreken*
	2. Heb je DEEP op vaste momenten gebruikt of heb je DEEP alleen gebruikt als jij dit aangaf/wilde?
	    1. Hoe vond je het om DEEP op een vast moment te gebruiken?
	    2. Of hoe vond je het om zelf aan te kunnen geven dat je DEEP wilde gebruiken?

INDIVIDUALS DOMAIN	**De volgende vragen gaan over hoe jullie en de patiënten DEEP hebben ontvangen en gebruikt.**
	3. Vond je het prettig dat je begeleider erbij was als je DEEP gebruikte?
	    1. Zo ja, waarom? (hielp dit jou ergens bij?
	    2. Zo nee, waarom niet?
	    3. Zou je DEEP ook alleen willen gebruiken? Waarom wel/niet?

INNOVATION DOMAIN	**Wij zijn erg benieuwd hoe we DEEP nog beter kunnen maken daarover gaan we nu een paar vragen stellen. (foto's laten zien van de verschillende onderdelen)**
	4. Was DEEP een makkelijk of moeilijk spel om te spelen? En waarom?
	5. Wat vond je van de onderwaterwereld?
	    1. Kreeg je er een bepaald gevoel bij?
	    2. Wat vond je van de rustgevende muziek?
	6. Hoe vond je het om VR bril te dragen?
	7. Hoe vond je het om een buikband te dragen?
	8. Wat voor emotie voelde je tijdens het gebruik van DEEP:
	    1. Blij/vrolijk?

	2. Rustig/ontspannen? 3. Gestrest? 4. Bang? … let eens uit? 9. DEEP kan je helpen om beter en dieper adem te halen. Heeft dat jou geholpen? 1. Wat merkte je hiervan? 2. Denk je dat je de ademhalingsoefening uit DEEP ook op andere momenten kunt gebruiken? 3. Heb je dat ook soms gedaan? 10. Vind je dat een spel zoals DEEP bij jou past? Waarom wel of waarom niet? 11. Stel je zou DEEP mogen veranderen. Hoe zou DEEP nog leuker of beter kunnen zijn?
OUTER SETTING DOMAIN	**Stel, DEEP zou voor langere tijd bij jullie op de afdeling staan…** 12. Zou je DEEP willen blijven spelen? 1. Hoe zou de begeleiding jou daarbij kunnen helpen? 13. Zou je DEEP aanraden aan andere patiënten op de afdeling?
PROCESS DOMAINv	**Tot slot willen we graag weten wat jij van dit onderzoek vond. Dus het spelen en beoordelen van DEEP.** 1. Hoe vond je het om DEEP (een paar keer) uit te proberen? 2. Hoe vond je het om de evaluatieformulieren in te vullen na het spelen van DEEP? a. Wat ging goed? b. Wat ging minder goed/ wat vond je lastig? Heb je nog vragen aan mij? Heb je nog punten die je graag zou willen toevoegen?
STOPZETTEN OPNAME + BEDANKEN VOOR DEELNAME + AANBIEDEN KLEINIGHEIDJE	

Appendix D: Interview Guide eHealth Advisor

Interview eHealth/ innovation advisor GGzE Juli 2023 Geslacht: Leeftijd:	
Introductie Welkom! Vandaag ga ik je een aantal vragen stellen over hoe jullie technologie en in het bijzonder VR inzetten binnen jullie organisaties. Daarnaast willen we met je nadenken over de barrières die jullie tegenkomen bij het introduceren en implementeren van nieuwe technologie. Ook willen we graag bespreken welke strategieën jullie zoal inzetten om deze barrières en uitdagingen op te lossen. Tot slot willen we met je nadenken over hoe DEEP kan worden ingezet binnen de forensische psychiatrische afdelingen. Ik verwacht dat het interview ongeveer 30-45 minuten zal duren. Je gegevens zullen anoniem verwerkt worden en als je een vraag liever niet wilt beantwoorden, mag je dit aangeven. Tot slot wordt er een geluidsopname gemaakt van dit interview, zodat we dit gesprek later nog kunnen uitwerken. Daarna wordt de opname vanzelfsprekend verwijderd. Ga je hiermee akkoord?	
TEKENEN INFORMED CONSENT Heb je voor nu nog andere vragen aan mij? Oké, dan gaan we beginnen.	
STARTEN OPNAME	
INNOVATION DOMAIN	**De eerste vragen gaan over de soorten technologie die jullie aanbieden en welke voordelen en barrières jullie zijn tegengekomen tijdens de inzet en implementatie. Tevens willen we jullie mening vragen over DEEP.** 1. Welke technologieën/eHealth bieden jullie op dit moment aan binnen De Woenselse Poort? 2. Welke technologieën worden het meest gebruikt? a. Welke voordelen van deze technologieën worden het meest genoemd? b. Welke barrières zien jullie bij de inzet van bepaalde technologieën? 3. Wat vinden jullie van DEEP als eventuele VR-toepassing voor de Woenselse Poort? a. Vinden jullie DEEP een zinvolle toevoeging aan de forensische zorg? b. Wat kan er verbeterd worden aan DEEP om het beter te laten aansluiten bij de afdelingen? c. In hoeverre gebruiken jullie andere technologieën gericht op ademhaling binnen de organisatie?
INNER SETTING DOMAIN	**Nu willen we meer ingaan op de manier waarop jullie technologie aanbieden en inzetten binnen jullie organisatie.** 4. Hoe gaat het introduceren van nieuwe technologieën in zijn werk? 5. Welke rol vervult eHealth en technologie op dit moment binnen jullie organisatie?

	a. Op welke manier zetten jullie technologie in? b. Hoe zijn jullie tot deze manier van inzet gekomen? 6. Wie bepaalt welke nieuwe technologieën worden aangeschaft en waar deze worden ingezet? a. In hoeverre worden patiënten bij dit proces betrokken? b. In hoeverre worden behandelaren/begeleiders bij dit proces betrokken? 7. Stel DEEP zou worden aangeschaft door GGzE/De Woenselse Poort: a. Hoe zouden jullie DEEP introduceren binnen de forensische afdelingen? b. Hoe zouden jullie DEEP inzetten [behandeling/bestaande eHealth-blokken/ad hoc]? c. Wat is er nodig om DEEP succesvol te implementeren binnen de forensische zorg?
INDIVIDUALS DOMAIN	**De volgende vragen gaan over wie betrokken is bij de inzet en implementatie van technologie binnen jullie organisatie.** 8. Welke rol vervult de organisatie zelf tijdens het introduceren en implementeren van nieuwe technologieën binnen jullie organisatie? a. Welke rol vervullen teamleiders? b. Welke rol vervullen behandelaren/psychiaters/begeleiders? c. Welke rol vervullen patiënten? d. Zijn er nog andere personen betrokken bij dit proces?
OUTER SETTING DOMAIN	**De volgende vragen zullen ingaan op de randvoorwaarden, zowel maatschappelijk als organisatorisch die jullie zijn tegengekomen in jullie werk met eHealth en technologie.** 9. Zijn er maatschappelijke ontwikkelingen die volgens jullie bijdragen aan het meer gebruik maken van technologie in de forensische zorg? a. Zijn er ook ontwikkelingen die dit tegenwerken? b. Zijn er regels, richtlijnen of beleidsmaatregelen waar jullie vaak rekening mee moeten houden in jullie werk?
PROCESS DOMAIN	**Tot slot willen wij graag met jullie kort reflecteren op wat we zijn tegengekomen tijdens onze pilot studie. Ook zijn we benieuwd naar jullie ideeën over de processen die nodig zijn om tot een succesvolle implementatie van technologie binnen de forensische zorg te komen.** 10. Wat zijn volgens jullie de belangrijkste strategieën om nieuwe technologieën succesvol te implementeren? 11. Wat zijn volgens jullie de grootste valkuilen bij het implementeren van nieuwe technologieën? 12. Hoe zouden jullie DEEP implementeren, als deze zou worden aangeschaft door de organisatie?

	13. Op welke manier zijn jullie nu nog betrokken bij de inzet van technologieën binnen de Woenselse Poort? Heb je nog dingen die je ons zou willen meegeven voor het onderzoek? Heb je nog punten die je graag zou willen toevoegen?
STOPZETTEN OPNAME + BEDANKEN VOOR DEELNAME	

Appendix E: Desk research Table Overview

Name VR technology	Aim	Underlying biofeedback (BF) mechanism	Sessions/ games/ environments (duration in minutes)	Gamification elements*	Hardware and software	Similarities and differences with DEEP	Link to website
FLowborne	Meditative breathing game with biofeedback support that teaches a calming breathing style in an intuitive way.	Breath-based biofeedback	6 (8)	Dynamic change of visual cues: changing colors and landscapes in the environment.	**Display hardware**: Quest, Quest 2, Meta Quest Pro App (Google Play store) Touch controllers	**Similarities**: breath-based biofeedback & visual BF cues environment. Same design (underwater). **Differences**: multiple sceneries and levels, guided breathing within the levels, app version available, breathing exercises within the app & measurements of breath using belly controllers.	Flowborne - Breathing, Meditation and Virtual Reality (VR) Biofeedback
Kana Virtual Reality	Kana VR aims to help individuals gain control over their personal stress system, promoting balance, resilience, and energy in a playful and	Heart Rate Variability biofeedback	5 (45-60)	The VR world continuously adjusts in real-time based on the measured stress state at that moment.	**Display hardware**: KANA VR glasses, HTC Vive (study context) ECG sensor (chest band)	**Similarities**: learning skills to cope with stress and relaxation for everyday life situations. **Differences**: Kana specialist (practical implementation). Kana	Kana Virtual Reality - Kana

	effective way on a tropical island setting.				App	Daily Life exercises to discover and practice with personal stress system in everyday life.	
BreatHero	BreatHero is a faster-paced Virtual Reality (VR) action game that combines breathing techniques with the combat elements of action games.	Breath-based biofeedback	4 (4)	Breath feedback that creates a sense of synchrony between the player's breath and in-game objects, visualization, or sound. And each breath technique is used to deal with a specific in-game enemy.	**Display hardware**: Oculus VR headset Wind Sensor Rev.c and Flex sensor (within belt) abdomen	**Similarities**: imitative Breathing Feedback. **Differences**: based on three breathing techniques: Kapalabhati, Box Breathing, and Full Yogic Breathing. Also, Associate Learning on Breathing Techniques.	Only research papers. Breathero: Not Another Slow Breathing Game — Exploring Faster-Paced VR Breathing Exercise Games (researchgate.net)
VRelax	VRelax is a relaxation tool against stress, burnout, anxiety, and depression.	Heart Rate Variability biofeedback (trough wearables)	-	-	**Display hardware**: VRelax glasses (Pico) GRIP monitoring app for caregivers and VRelax app for patients	**Similarities**: sensory stimuli (lights, sounds and imagery) by relaxation environments. **Differences**: multiple landscapes, which can be chosen by the user itself. Dashboard with biometric	VRelax | VR Mental Health

					Dashboard biometric data	data. Interactive exercises in environments.	
BreatheVR	BreatheVR is a virtual reality app that visually rewards users to help them achieve a relaxed state through deep breathing.	Breath-based biofeedback	1	Leaves in the virtual reality environment rise after exhaling.	**Display hardware**: Gear VR and Oculus Go Mic to detect breathing patterns.	**Similarities**: encouraging the user to get into a pattern of diaphragmatic breathing. Incorporates similar gamification elements. **Differences**: no route is taken in the game.	BreatheVR — Neon (discoverneon.com)
Exhale XR	The Exhale XR mission is to provide exciting, quality ways for the immersionist to relax and rejuvenate at their own convenience.	-	75 titles, as DLC's.	Interactions with the game to meditate.	**Display hardware**: HTC Vive - Oculus - Quest - Meta - Windows Mixed Reality. App Android APP IOS	**Similarities**: practice deep breathing in a surreal world. **Differences**: sleep assist functionality, multiple environments with different relaxation methods.	Virtual Reality Relaxation | Exhale XR
Guided Meditation VR	A virtual relaxation app to bring peace, joy, and calm back into the daily life.	-	27 environments (2, 5, 10)	Customized meditation experience (time, stimuli and spots).	**Display hardware**: Gear VR, Go Touchpad, Gear VR-controller	**Similarities**: practice deep breathing in a surreal world. **Differences**: no gaming element, music visualizer to relax within these environments, option for quick meditation.	Environments - Guided Meditation VR

Inner Focus	Inner Focus' immersive experience platform leverages emotional data to improve relaxation, by fulfilling a three-stage exercise of flow, reflect and relaxation.	Physiological data: heart rate, pupil dilation, galvanic skin response (perspiration)	3 phases	Scoring system: preset relaxation goals. Collecting physiological data to personalize user experience.	Display hardware: Quest, Quest 2, Meta Quest Pro VR-controller to perform exercises. Dashboard that can be customized to fit each case.	**Similarities**: creates a sense of peace. **Differences**: three phases of relaxation (flow, focus and reflect), historical statistics, personalized tips.	Inner Focus: Using Virtual Reality and Data to Improve Healthcare | EPAM
JeL	A bio-responsive, immersive, interactive, generative art installation designed to encourage physiological synchronization between the users.	Respiratory synchrony	1	A glass-sponge structure will emerge when the immersers breathing patters get synchronized.	**Display hardware**: HTC Vive HMD Biosignalplux respiration sensor Desktop Computer with NVIDIA GeForce GTX 970. Video projector.	**Similarities**: design/ lay-out underwater world (coral, fishes). **Differences**: interpersonal synchronization where two participants interact by collaborating. Corresponding avatars (Moon Fish).	Only research papers. ResearchGate
Respire VR	Respire is an immersive art piece that brings together three components: an immersive virtual reality (VR)	Breath-based biofeedback	1	The frequency and patterns of breathing data guide the arousal of the musical agent,	Display hardware: HTC Vive HMD Respiration sensor PROComp2	**Similarities**: capture attention and promote mindfulness. **Differences**: connects breathing with movement,	Respire - Kıvanç Tatar (kivanctatar.com)

	environment, embodied interaction (via a breathing sensor) and a musical agent system to generate unique experiences of augmented breathing			and the waviness of a virtual ocean in the environment.	Multi-Agent Systems (MAS)	sound, and visuals in a smart way. Measures breath using a respiration harness. Musical agent to generate unique experiences of augmented breathing.	
Vrendle (In use at GGzE)	Vrendle is a VR technology that caters to therapy, training, and relaxation. It features a library of 360-degree VR videos specifically designed to promote relaxation and allow patients to disconnect from the outside world during treatments.	-	5	-	**Display hardware**: PICO VR bril Vrendle GO app	**Similarities**: sensory stimuli (lights, sounds and imagery) by relaxation environments. **Differences**: multiple environments. Option to design new environments. In use in mental care institutions.	Virtual Reality (VR) therapie » Maak kennis met Vrendle
Flowly	A VR application for people with chronic pain, anxiety and insomnia who are seeking to take control of their	Heart Rate Variability biofeedback	Multiple relaxation environments (10-15)	As the HRV improves, the more constellations form and the aurora lights grower.	Display hardware: Flowly Heart rate sensor App (community)	**Similarities**: breathing exercises focused on meditation and relaxation. **Differences**: shows the heart rate. Guided sessions. Also, a connect	Flowly: relaxation training for your nervous system

	health.				Portal	function. Option for a Flowly Demo Kit.	
Virtual Reality Mindset	Utilize stress levels as a key factor in successfully completing challenging tasks.	Heart Rate Variability biofeedback	4 sessions (60) The sessions consist of +/- 40 minutes of 'gaming' and 20 minutes of coaching	Elements in the game continuously adapt to the measured level of stress.	**Display hardware**: HTC Vive Biofeedback waistband Laptop (overview heart rate and respiratory rate)	**Similarities**: recognizing stress and using it in daily life situations. **Differences**: perform challenging assignments in different levels. Additional e-learning which helps to change the mindset about stress. Desktop version with measurements.	Virtual Reality mindset training - TIGRA

***** *Gamification involves engaging the user with or within the environment in some way.*