Co-Creating Just-In-Time Adaptive Behavioral Activation Interventions: Defining Optimal Timing for Intervention Delivery to Reduce Depressive Symptoms using Clinical Expertise

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Abstract

Introduction: The existing JITAI apps are not based on the input of the target users and rely on quantitative models instead. Hence, improving JITAIs by accounting for the needs and preferences of patients regarding the intervention delivery is necessary. In this study, the JITAI depression apps that incorporate techniques from CBT, specifically Behavioral Activation, were considered. This study aimed to define an optimal timing for the delivery of depression JITAIs considering patients' moments of vulnerability/opportunity and receptivity

Methods: Six therapists from an online counseling service participated in focus groups where they shared their insights on the optimal timing of JITAIs delivery. Thematic analysis was used to process the data.

Results: Thematic analysis revealed six distinct aspects that need to be considered when optimizing JITAIs delivery. These aspects are frequency of notifications, context, optimal times for the notification delivery, tailoring notifications to different patients and their different struggles, and importance of patients' autonomy.

Discussion: The results emphasize how intervention delivery can be made more tailored to the patients' needs by incorporating the patients' preferred time of the day and context for receiving an intervention that can be specified in the app. Moreover, patients can upload their schedule to ensure their availability when the JITAI decides to send a notification. However, it is also stated

that there should be some optimal moments for the JITAI to send notifications such as whenever the patient is alone or cannot fall asleep.

Conclusion: While the study did not provide a straightforward answer on how to improve 'just-in-time' mechanisms due to complexity of the findings, it gave multiple suggestions. The main suggestion is to avoid making the app too deterministic while ensuring it is not completely random, thus maximizing the incorporation of patients' preferences.

Introduction

Depressive disorders have been an area of concern for decades. According to Lépine & Briley (2011), major depressive disorder has a lifetime prevalence of 10-15 % making it one of the most common mental disorders. Depressive disorders carry a high burden for affected individuals, decreasing their quality of life (Porras-Segovia et al., 2020). Low workplace productivity due to depression results in money loss creating a high burden for society (Simon et al., 2001). Cognitive-behavioral therapy (CBT) has been recognized as one of the most evidence-based therapies for treating depression (Sudak, 2012). This therapy uses a strategy called Behavioral Activation (BA) which allows an individual to start engaging in the beneficial and enjoyable activities that they previously avoided (Sudak, 2012). BA has been used effectively in treating depression, reducing depressive symptoms and improving the mood of patients. BA can be regarded as a cost-effective alternative to antidepressant treatment or a CBT treatment (Lejuez et al., 2011). However, many depressed people need to wait for months before they can receive this therapy due to a shortage of mental health professionals (Reins et al., 2013), while others are scared of the stigma associated with this disorder that stops them from seeking help (Latalova et al., 2014). According to a survey conducted in 21 countries, only 16.5 % of people suffering

from depression receive professional treatment (Thornicroft et al., 2017). Moreover, many patients who receive professional treatment are likely to relapse, which makes the task of mental health professionals more challenging (Akechi et al., 2019).

Therefore, there is a need for accessible mental health interventions to provide depressed patients with the support they need. Digital interventions such as mobile apps have potential to supplement traditional face-to-face treatments as they do not require mental health professionals and are therefore scalable and accessible (Porras-Segovia et al., 2020). Mobile interventions have been used to reduce many health-related concerns such as stress, anxiety, depression, and substance abuse (Oliveira et al., 2021). However, many mobile apps have high quitting rates meaning that people do not benefit from these interventions as much as they could (Teepe et al., 2021). Reasons for quitting these apps are intervention fatigue which may happen due to an intervention being too demanding or lack of personalization where the app does not satisfy the needs of the user (Teepe et al., 2021). Therefore, adjusting interventions to users' environment and their constantly changing needs instead of adopting a 'one-fits-all' strategy is necessary (Teepe et al., 2021). Powerful abilities of the current technology to track an individual's real-time internal state and context, providing flexible support in terms of both time and location, can make it possible to account for the changing needs and the context of the users (Huh et al., 2021).

An emerging form of personalized digital intervention are Just-in-time adaptive interventions (JITAIs). JITAIs are defined as "intervention design aiming to provide the right type/amount of support, at the right time, by adapting to an individual's changing internal and contextual state" (Nahum-Shani et al., 2018, p. 446). JITAIs may incorporate mechanisms from behavioral activation by tracking non-desirable behaviors or activities in the life of a depressed individual

that make them stressed or unhappy and suggesting more desirable activities which aim to improve depressive symptoms or well-being (Ross et al., 2023). JITAIs are focusing on two aspects: the 'just-in-time' aspect which is aimed at delivering an intervention at the right time and the 'adaptability' aspect which is responsible for choosing the most appropriate intervention for that time (Nahum-Shani et al., 2021). An example of a 'just-in-time' aspect is when technology that aims to combat alcohol addiction tracks the location of the user in order to send a notification whenever a person approaches a high-risk location e.g., a bar where the user used to consume alcohol (Nahum-Shani et al., 2021). An example of the 'adaptability' aspect is accounting for the weather when aiming to reduce a sedentary activity by offering an indoor physical activity when raining instead of an outdoor walk as the users are less likely to leave the house during the rain (Bidargaddi et al., 2020).

In order to develop a JITAI for depression, it is necessary to know what triggers negative episodes in depressed patients and when these people are most likely to need and receive support. Nahum-Shani et al. (2018) differentiate between states of vulnerability, opportunity, and receptivity. Vulnerability refers to adverse mental health states where an individual is more susceptible to risk factors or negative behaviors. Opportunity refers to favorable moments where an individual's context allows for an effective intervention delivery (Nahum-Shani et al., 2018). Receptivity refers to an individual's readiness or willingness to engage with an intervention (Teepe et al., 2021). A good moment for a JITAI is when there is either opportunity or vulnerability and the person is receptive (Nahum-Shani et al., 2015). When accounting for vulnerability/opportunity and receptivity aspects, it is possible to choose the most suitable moment when the intervention is likely to be beneficial for a depressed individual. An example of a favorable moment for an intervention delivery where these states are accounted for: a

student is experiencing a high level of stress (vulnerability)/she cannot fall asleep (opportunity) and she starts to scroll through social media (receptivity). Hence, defining conditions or situations that lead to the emergence of these states will allow to develop an effective JITAI for depressed individuals. However, little is known about how to operationalize or characterize these conditions or situations.

Despite many attempts by the researchers to define these conditions, depressed people or mental health professionals who could contribute the most to the design process were never included in the previous studies. When it comes to JITAIs, previous studies mainly draw data from quantitative models. For instance, a systematic review of JITAIs highlights that these apps mainly rely on automated systems monitoring real-time quantitative data of the users which guide the decision-making process of when to send interventions, while the nuanced needs of these patients or the expertise of therapists regarding depression are not considered (Kim et al., 2023). Another quantitative study of Teepe et al. (2021) evaluated the effectiveness of the existing JITAI apps by counting the number of JITAI principles those apps employed where a higher number of successfully implemented principles correlates to a more effective system. Hence, conducting a qualitative study that engages patients and therapists in the design of a JITAI may support the construction of an evidence-based JITAI (Kim et al., 2023). For example, the previous studies that engaged the target group into the design process developed JITAIs that effectively managed undesirable behaviors. Huh et al. (2021) developed a JITAI in collaboration with kids and their parents to raise awareness on skin cancer, whereas Lee et al. (2023) developed a JITAI with pregnant women in order to enable healthy behaviors during and after pregnancy.

In order to develop effective and evidence-based behavioral activation JITAIs, the input of patients experiencing depression or clinical expertise of therapists is needed. Co-design is an approach that engages various stakeholders in the design process of different products, services or interventions to ensure that the final product meets the preferences of the target audience (Steen, 2013). Co-designing products or services has given promising results where users seem to be more satisfied with technologies where their preferences are accounted for (Pu et al., 2015). Hence, including patients and mental health professionals from the beginning of the design-process can make JITAIs more tailored to the needs of depressed people (Alqahtani et al., 2021). This study will only recruit healthcare therapists. As they work with many depressed patients and have a better understanding of the condition, they are an ideal group for contributing to the design process of interventions for patients (Dorow et al., 2018). This study is the first to explore and identify moments when depressed people need an intervention that will not only be based on what is already known about the depression but rather on the insights of therapists and their experience with depressed patients. This study aims to investigate:

- How do mental healthcare therapists define good timing for the delivery of JITAIs, considering their clinical expertise on patients' moments of vulnerability/opportunity and receptivity?

Methods

Design

A co-design approach was used in this study where therapists shared their insights and preferences regarding the timing of the intervention delivery and the type of intervention they thought the patients needed. To gather different ideas, focus groups were conducted. Participants were divided into two groups which resulted in two focus groups each consisting of three

therapists. Two sessions were conducted with the first focus group where the first session was more focused on the timing of the intervention and the second session on the type of intervention. Only one session was conducted with the second focus group, which focused on both the timing and the type of intervention, as the therapists did not have time for a second session.

Participants

The participants were recruited from Thubble, an online counseling service of Dimence mental healthcare institute in the Netherlands. The study included 6 therapists working at Thubble. Only licensed psychologists were allowed to participate in the study. In the sample, 4 participants were females, where 2 participants were males. The mean age of the participants was 36 (the range between 28-49 years old). An average age of working as a therapist was 5 years (the range between 3 and 9 years). However, an average experience of working as a therapist in online services was 2 to 3 years (the range between 1 and 6 years).

Materials

A short introduction video and a consent form were created (Appendix A). Additionally, a survey was made which included demographic questions and questions about experience with behavioral activation or JITAIs and attitude towards such interventions (Appendix A). An example of the question about the experience was “Were you or are you working with behavioral activation interventions?”. An example of the question about the attitude was “What is your general attitude towards just-in-time adaptive interventions?”. A focus group guide was made in order to make discussions more structured in two focus groups (Appendix A). Several types of questions were made which were more general ones regarding the patients’ condition and more specific ones about the timing preferences and the type of intervention preferences. An example

of a general question is “Maybe some moments your patients feel better or worse than other moments, how long do these moments last for them?”. An example of a specific question that is concerned with defining a good timing of an intervention is “In what situations or contexts would you find a behavioral activation JITAI particularly helpful? Please describe specific scenarios where this support could assist you/patients. And when would it not be helpful/needed?”. An example of a question regarding the type of intervention preferences is “What functions/exercises/activities can you imagine, as a therapist, to be useful in a behavioral activation JITAI addressing depressive symptoms?”.

Procedure

The introduction video was distributed via the representatives of Thubble which invited therapists to participate in the study. The video introduced the study to the potential participants and explained what was required of them. After sharing the introduction video with the potential participants, researchers obtained a list of therapists who were interested in participating in the study. At ethical approval of the study was obtained from the BMS Ethics Committee at the University of Twente (Request no.: 240170). After obtaining an ethical approval, an email was sent to all the participants with the consent form, a link to the Microsoft teams meeting, and a survey. Participants needed to fill the consent form before they joined the meeting. At the end of the meeting, they filled out the survey. The focus group sessions were conducted via Microsoft teams. All sessions were recorded and automatically transcribed. Collected data was securely stored on OneDrive student accounts and shared only with supervisors. All recordings were destroyed upon completion of the report, ensuring confidentiality and compliance with General Data Protection Regulations.

With the two meetings for the first focus group and one meeting for the second focus group, three meetings in total were conducted. The meetings lasted for an hour. In the first meeting with the first focus group or in the first half an hour with the second focus group, researchers introduced themselves, the study, and the main concepts that might be unfamiliar to the participants. A plan for the meeting was discussed. Afterwards, an actual discussion with the participants started. The discussion began with more general questions regarding the patients' condition. More specific questions regarding the timing of intervention delivery followed shortly.

In the second meeting with the first focus group or in the last half an hour with the second focus group, the preferences of patients and therapists regarding the type of intervention were discussed.

Data Analysis

The three interviews with participants were automatically transcribed and corrected for typos. The improved version of the transcript was used in order to further process the data. To analyze the data, thematic analysis was conducted. Thematic analysis is a technique used to identify, analyze, and present the patterns or so called themes found within the data (find citation here). In order to find the main themes in the data, the transcript first needed to be coded. The transcript was uploaded into an Atlas.ti software. Atlas.ti software is a software used to process qualitative data (source). The transcript was manually coded by highlighting quotes in the transcripts that were important for answering the research question. After all the important quotes were highlighted in a transcript and put into the right codes, similar codes were synthesized into themes. Finally, the report was created using the previously identified themes to

interpret the data and uncover patterns useful in drawing conclusions and answering the stated research question.

Results

Survey Responses

In regards to the question about the experience of therapists with BA interventions, all kinds of responses were obtained where therapists had worked with BA interventions regularly, very often, sometimes or not at all. However, all six therapists indicated that they had a positive attitude towards digital mental health care services. In regards to the attitude towards BA JITAIs, five therapists had a positive attitude and one therapist had a neutral attitude. All participants indicated that they could imagine JITAIs as an addition to their practice.

Thematic analysis

Initially 32 codes were created. Out of 32 codes, 14 codes were deleted as they did not relate to any of the other codes and could not make an additional theme. When merging similar codes to themes, 6 themes were identified consisting of 3 codes (Figure 1). The six themes contain 18 codes and 46 quotes, which are displayed in Table 1 and Appendix B.

Figure 1

Example of the Theme 'Structured and Context-Aware Interventions' with its 3 Codes and 6 Quotes created in Atlas.ti

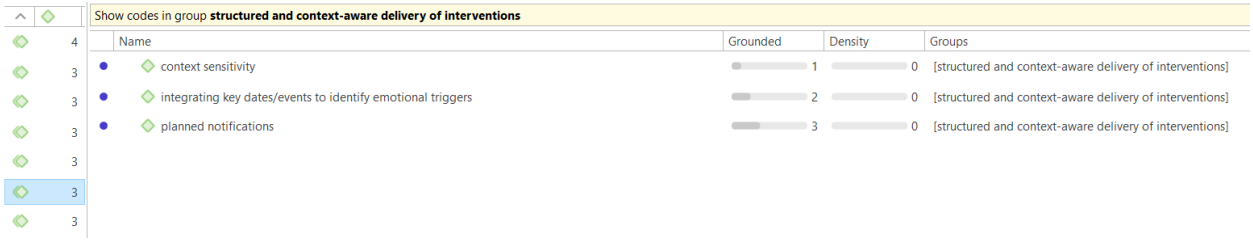

Table 1

Overview of Themes identified during the Thematic Analysis with the corresponding to them Codes and the Number of Quotes in each Theme

Theme	Theme definition	Codes	n of quotes
Mood fluctuations variations and daily challenges in depression	How the mood of depressed patients may change throughout the day depending on what a particular patient has struggles with	- Morning difficulties - Daily energy fluctuations - Environmental and situational influences	6
Notification frequency optimization	How frequent the notifications need to be in different stages of treatment/therapy	- Reduction of notifications over time - Gradual build-up - Consistent monitoring	9
Optimal timing for intervention delivery	Moments for intervention delivery where vulnerability/opportunity and receptivity would be insured	- Moments of isolation - Insomnia - No motivation to start a day	9
Structured and context-aware delivery of interventions	How integrating the schedule, routine, and background information of the client into the app can make the timing of intervention delivery more personalized	- Planned notifications - Integrating key dates/events to identify emotional triggers - Context sensitivity	6
Strategic timing for reinforcement interventions	How to tailor notification messages towards different phases the clients are in (active vs. inactive patient)	- Positive reinforcement in active patients - Negative reinforcement in non-active patients - Balancing positive and negative reinforcement	7
Promotion of autonomy	The importance for clients to actively decide with the app what they want to do and how they want to do it to avoid dependency and bring behavioral change	- Dependency on the app - Encouraging active thinking - Clients with control	9

Mood fluctuations variations and daily challenges in depression

The theme addresses how the mood of depressed patients may change throughout the day depending on what a particular patient struggles with. The theme mentions different types of patients.

Morning difficulties. As for the first type of patients who have the lowest mood in the morning due to anticipation of a long day, their mood may improve by the end of the day when the client is preparing to go to bed. Here the participant addresses why morning can be difficult for certain patients:

> *'If you look at depression, there's often a lack of something: a lack of will, a lack of energy. So, when you start the day, it's usually quite difficult to do so.'*

Additionally, participants state that certain patients feel anxious to start their day prolonging the time they stay in bed (Appendix B).

Daily energy fluctuations. For other patients the mood may change regardless of the time of the day and is more dependent on energy or circumstances (Appendix B).

Environmental and situational influences. As for the third type of patients, the depressive mood may occur later in the evening:

> *'May it be because it's getting dark outside which might amplify the darkness on the inside?'*

Moreover, some clients have a better mood on weekends, as they do not have any responsibilities, while others feel especially lonely on weekends as they have nothing to do and no one is around (Appendix B).

Notification frequency optimization

The theme addresses how frequently JITAIs need to be sent to the patients in order for

the patients to be receptive. Several codes were identified which address changes in frequency depending on the stage of the treatment.

Reduction of notifications over time. It is stated that notifications should almost resemble a bell curve over the course of the treatment (Appendix B). During the treatment, JITAI aims to stimulate the patient as much as possible. As the treatment progresses, the frequency of notifications should slowly decrease:

> *'To start with more structure and helping the clients start to behave, to activate more and then slowly build it off.'*

Gradual build-up. Besides decreasing the notifications as the treatment progresses, participants state that the treatment should also start gradually where JITAI sends very few notifications in the beginning and slowly increases them. Therapists claim that it is necessary to start slowly, as many activities, especially cognitive ones, are too demanding for the patients in the beginning of the therapy:

> *'So if it's something that addresses the cognitive capabilities, it is very difficult for them and I think less is more, especially in the beginning.'*

Additionally, setting small goals in the beginning is important, as patients may become impatient after not seeing the progress quickly which will result in loss of motivation (Appendix B)

Consistent monitoring. Participants also suggest that patients should be given short questionnaires every week to track their well-being regardless of the stage in the treatment (Appendix B).

Optimal timing for intervention delivery

This theme describes moments for intervention delivery which assure vulnerability/opportunity and receptivity of depressed patients. The therapists were asked to

imagine what they think the best moment for intervention delivery would be if they were depressed. Therefore, this theme addresses more universal moments that apply to most of the depressed patients regardless of their current mood or stage they are in the treatment.

Moments of isolation. When a patient is alone and can't reach anyone, this moment should be considered as an optimal time to send an intervention, as he or she is in a very vulnerable state at this moment. The JITAI in this case is considered as a small reminder that the patient is not alone:

> *'It doesn't really matter where I am, whether I'm at home, whether I'm somewhere on the go. But the main thing is that I'm alone and that I can't reach anyone… I'm not able to connect with others and I feel really, really sad about that. That would be a moment where I would be, first of all, happily surprised that something or someone is thinking of me.'*

However, even when having people around can make some patients feel lonely. One of the participants states that it is more of an internal feeling that can be combated if there is something or someone who can relate to you and give you the right support where JITAI comes in handy (Appendix B).

Insomnia. Many patients need support at night when they either wake up in the middle of the night or cannot fall asleep. This is a vulnerable moment as they are alone in their bed and can't reach anyone at this time. They are usually lost in their thoughts and start ruminating (Appendix B)

No motivation to start a day. Getting out of bed may also be a vulnerable moment for many depressed patients. Some of the patients do not have any activities planned for the next day which results in demotivation to start the day as they have nothing on their schedule:

For me it would be and then mostly in the morning I think. Also, because that's the moment where I'm like, OK, what am I gonna do this day? And if I'm in a bad mood, I might lean to laziness or just, you know, like, distraction, phone, whatever. And maybe if I get a little reminder, like, hey, you are busy with this, why don't you do this or something motivating.'

However, the patients that do have many things that have to be done, may procrastinate the entire day as they do not have energy or motivation for any of those things. Additionally, some of the patients start comparing themselves to other people who manage to have things done which makes them feel even worse (Appendix B). Hence, it is suggested that morning can be a good time for receiving a notification, as it is still early enough to change the day for the better and give a good feeling to a patient at the end of the day.

Structured and context-aware delivery of interventions

The theme talks about how integrating the schedule, routine, and background information of the client into the app can make the timing of intervention delivery more personalized.

Planned notifications. Uploading a schedule into the JITAI app could ensure that the patient would be getting personalized support that would result in receptivity. For example, when the app knows that the patient is busy doing something else, it will not send an intervention and nudge a client to another activity. Taking spontaneity may ensure that the patient will be receptive when the intervention is delivered:

'Tailor the app…if you for example upload your planning or your activities from the week, then it's easy to nudge that.'

'But there is information… what the client can give you. So if you build that into the app, you take away a little bit of the spontaneity in a way, but you do know when the client is

available or receptive to it'

Integrating key dates/events to identify emotional triggers. Additionally, adding key dates into a calendar and describing how they may impact the patient, may give the app more context into what is happening to the patient:

'Such a period, for example the birthday of a loved one that they lost. Then if we would measure patients frequently, then this would be visible changes in mood.'

In this case the app can send an intervention on that day, as the patient might need more support than on any other day.

Context sensitivity. Knowing the context where the patient wants to receive an intervention is also important. Both patients may be working, however the first patient prefers to receive an intervention on weekends as he is busy with work that is giving him enough activation, while the second patient prefers to receive an intervention at work as he feels that he is close to burn-out and needs support (Appendix B).

Strategic timing for reinforcement interventions

When patients just start JITAIs, they are more inactive and it is harder to stimulate them. When the treatment progresses, patients become more active and engage into more activities without the help of the app. However, it is important to stimulate patients when they are both active and inactive. For the purpose of the research, all depressed patients were hypothetically divided into two distinct groups where the first group is depressed inactive patients and the second group is depressed active patients. The theme is about how to tailor notification messages towards these two groups.

Positive reinforcement in active patients. When patients achieve some progress, JITAIs should not stop sending notifications. Participants claim that there are two reasons for that.

Firstly it is that the focus in the app is already so much on the negativity where the positive aspects get overlooked. Secondly, it is important to encourage a patient to continue those interventions to reflect on the progress and make an actual behavioral change:

> *'So also when they're happy, I mean, you could even stress that it is a very, very important phase, to then, you know, not think 'well, I'm happy, I don't need these interventions anymore', I think it's even more important when you're happy to still receive these moments to really incorporate what you've worked on.'*

Negative reinforcement in non-active patients. While active patients need to be stimulated by encouraging messages, non-active patients need to be activated by the app giving a message to the patient that they will be feeling less depressed after completing the JITAI (Appendix B). Participants suggest that the frequency of notifications should increase in case patients stop responding to JITAIs. Sending a personalized notification to a patient who became really inactive over the course of the treatment is what is needed to get the patient back to the treatment (Appendix B). Therefore, sending notifications to depressed patients who do not engage in any of the activities is required.

Balancing positive and negative reinforcement. Therefore, balancing positive and negative reinforcement in the app is important, as most of the depressed patients will be in both of those phases. Here the participant explains why it is important to support patients when they are feeling depressed and when they are feeling good:

> *'I think it could be similar if they are feeling good and to act on it and have positive experiences from that could be rather helpful to be more resilient, to be more positive. But also the other point when they are feeling depressed to have this notification or the push notification then. So I think for me both would be valuable'*

Promotion of autonomy

The theme talks about the importance for clients to actively decide with the app when they want to receive notifications and how they want to receive them to avoid dependency and bring behavioral change. While the previously mentioned themes discussed the nuances in regards to how to optimize frequency of notifications or how to strategically time those interventions to achieve the best results, this theme emphasizes the importance of active thinking in patients and proposes that when debating whether to deliver an intervention, it is better to give control to the patients.

Dependency on the app. Some patients may get used to JITAI giving them frequent notifications with options which takes away their ability to make their own decisions. As a consequence, patients may become dependent on the app:

'You don't want to have this covariance that if you take out a thing that gives you options that then the client regresses. So I think it's also very important to encourage the client to think actively as well. Because elsewise, I see a risk that clients become quite dependent on the app.'

Encouraging active thinking. Letting patients decide what to do and when to do it, can help avoid a problem of depressed patients becoming dependent on the app. Additionally, the participant states that the behavioral change can be achieved only when the patients think actively with the app.

> *'The frequency of these nudges let's say lessens throughout therapy, but that critical thinking or active thinking kind of stays because in the end, that's what they need afterwards too in order to make a behavioral change part of their lives'*

For example, a message like this *'So let's think about a time, where, what is it that you'd love to be doing. Now go find a moment and execute that!'* would make a patient think more actively rather than the message that offers a specific activity to the patient and the time when it should be executed (Appendix B).

Clients with control. Participants should be able to regulate the frequency of the notifications, the type of notifications they want to receive and the context where they are getting those interventions:

> *'Just ask the clients while setting up the app, how frequent and when…because all our answers were it depends, it depends on the client and I think the clients do have the best sense of when would I be more receptive and how often and how pushy do I want it to be…They can do it themselves.*

Participants state that giving the patients control over how frequently they want to receive notifications or how pushy they want those notifications to be, can make patients engage with the app more and make them achieve the best results (Appendix B).

Discussion

This research investigated potential needs and preferences of patients in regards to the timing of intervention delivery. It addressed patients' moments of vulnerability/opportunity and receptivity, using the clinical expertise of mental health care therapists. The results offer valuable insights into the delivery of JITAIs by looking at six distinct aspects such as frequency of notifications, context, optimal times for the notification delivery, tailoring notifications to different patients and their different struggles, and importance of patients' autonomy. Additionally, survey responses indicate that all therapists are open to digital mental health

services, and can imagine it to be an addition to their practice. This indicates that during the interviews, the therapists were intrinsically motivated to share their input regarding JITAIs.

The theme *'Notification frequency optimization'* describes how the frequency of notifications should resemble a bell curve. This is suggested to be an effective strategy as the behavioral activation therapy is especially hard in the beginning as it requires the patient to change their long-standing dysfunctional behaviors by engaging into new positive behaviors (Verywell Mind, 2023; Therapist Aid, 2023). By starting slowly, the patients who have difficulties in the beginning of the therapy to do any of the activities have the time to adjust to a new routine. Meanwhile, by decreasing the frequency of the interventions slowly, the patients can start activating more themselves which is important for the behavioral change. According to the study of Michie et al. (2009) that examined the effectiveness of different behavior change techniques in health interventions, a gradual reduction in support helps patients to internalize the behaviors, making them more likely to engage in these behaviors independently.

The theme *'Structured and context-aware delivery of interventions'* describes how to make JITAIs more context-aware by incorporating the schedule of the patients into the app or asking them about their preferred context to receive notifications. By letting the JITAI access the patient's calendar, it is possible for the app to find the window between the activities the patients already have planned and send a notification when the patient is available. In a study conducted by Wanf et al. (2021), participants provided calendar availability data over four weeks, which was used to adapt the timing of JITAIs delivery. That approach demonstrated significant improvement in user engagement and response rates. These findings suggest that by tailoring notification delivery to predicted opportune moments based on the calendar data, user engagement with the JITAIs can be improved. Moreover, incorporating the key dates into the

app that are relevant to the patient such as the death day of a loved one or upcoming stressful events can allow the app to send the just-in-time notifications. This way the app knows that on certain days the patient may need more support than usual and can adjust notification delivery respectively. Additionally, the patient may indicate where they prefer to receive the notifications. For example, if the patient knows that they are close to burn-out, they are more likely to prefer to receive the notification when they are at work rather than at home when they are surrounded by their family. It may be because stressed patients are more likely to benefit from interventions relieving work stress when completed at work. The study of Peiró, J. M. (2008) that explored the effectiveness of context-specific interventions such as workplace meditation found that such interventions are effective as they address stress in real-time, within the environment where it is often experienced.

The theme *'Optimal timing for intervention delivery'* is about specific moments where intervention delivery would be considered 'just-in-time' by most depressed patients which are social isolation, difficulties falling asleep at night, and challenges with leaving the bed in the morning. According to the study of Elmer et al. (2020), the reasons why depressed people feel especially low when they are alone can be lack of social support or lack of distraction from the negative thoughts. Moreover, people with depression often feel alienated as no one around can understand their feelings. Social isolation and feeling of loneliness can contribute to depression making them important factors to consider when designing JITAIs (Elmer et al., 2020). Hence, whenever the patient is alone, JITAI should send a notification reminding them that they are not alone. JITAI could send such a notification by tracking the amount of time the patient is engaging with their phone e.g., scrolling through social media, which would indicate that the patient is alone or feeling lonely. Moreover, many depressed patients struggle with falling asleep

as they start ruminating. Nighttime rumination, or the tendency to continuously engage with negative or distressing thoughts at night, is particularly relevant in the context of depression. Research of You et al. (2021) demonstrated that nighttime rumination can severely decrease sleep quality which can exacerbate depressive symptoms making it a vicious cycle. Hence, the app should track the sleeping patterns of the patients, sending a notification if the JITAI detects that the patient has not fallen asleep after an hour or more. Lastly, many depressed patients wake up without a drive to start a day. Hence, receiving a JITAI in the morning with an exciting activity, such as going for a walk, could stimulate the patient to get out of the bed and start the day. Bergouignan et al. (2016) found that doing small pleasant activities in the morning can improve the mood and enhance the energy levels.

The themes *'Strategic timing for reinforcement interventions'* and '*Mood fluctuations variations and daily challenges in depression'* are about how to tailor notifications to different patients and their different struggles. Some depressed patients are more active than others and despite being depressed they can be more easily stimulated than more inactive patients. However, the JITAI should send the same amount of notifications to these different patients as the increasing activity of the patient should not be an indicator that the patient is not depressed anymore and that the JITAI should stop sending the notifications. Without encouragement, the patient may become quickly demotivated and get back into an old routine. Moreover, depressed patients may encounter different struggles where some patients feel more depressed in the morning, while others feel more depressed when it gets dark outside. Hence, it may be difficult to find the universal time point throughout the day when most of the depressed people would consider the notification to be 'just-in-time'. JITAI can ask patients to specify what time of the day they want to receive a notification.

Limitations

This study has several limitations. Firstly, researchers had to rely on the clinical expertise of mental health professionals instead of directly interviewing patients to gather data, which makes the descriptions of the themes more of the therapists' perceptions rather than the direct needs of depressed patients. Secondly, the data was processed by a single researcher which might introduce bias to the obtained themes. Lastly, only six therapists were participating in the study and all of them were recruited from the same online service company, making it difficult to generalize the results. These therapists might have similar views on many aspects due to working together. In future research, it is necessary to include multiple researchers to ensure inter-rater reliability and involve patients and diverse therapists to increase generalizability.

Implications

When accounting for all six aspects that should be considered when timing the delivery of the JITAI, there is no straightforward answer to what is a good time for the JITAI delivery. The findings demonstrate that some moments can be regarded as optimal moments for intervention delivery such as a morning intervention. However, due to the differences in patients' preferences, some patients may exhibit dissatisfaction with the morning intervention. The results state that sending the interventions at completely random times is not recommended and suggest uploading a personal schedule or key dates. Hence, the function that accounts for the personal preferences of the patients is important at all times. However, it may take away the spontaneity of the notifications which is an important factor to optimize JITAIs. The study of Nahum-Shani et al. (2018) used micro-randomized trials to optimize JITAIs where participants were receiving notifications randomly to find the most suitable times for intervention delivery. This creates the

dilemma where the designers of the JITAIs should decide whether to let the users or the app determine when to send interventions. In order to solve this dilemma and implement JITAIs into clinical practice, several tailored programs could be created. Patients would complete surveys about their preferences, lifestyle, and personalities before using a JITAI, allowing the app to choose a suitable program for the patient's specific needs. This approach minimizes the burden of a patient by automating intervention delivery without solely relying on randomization. Therapists can help with deciding what program would suit the patient, considering their knowledge on patients' needs. Constant monitoring of the patients is needed, with the therapists always having access to the data from the app which can ensure safety of the patients. However, it is also needed to implement strict data privacy protocols to protect patient information. The novelty of this research lies in its approach to find a good time for the JITAIs delivery by using the daily experiences of therapists with the patients, making it practically meaningful.

Conclusion

This study aimed to define an optimal timing for the delivery of depression JITAIs considering patients' moments of vulnerability/opportunity and receptivity by accounting for the six distinct aspects. These aspects are frequency of notifications, context, optimal times for the notification delivery, tailoring notifications to different patients and their different struggles, and importance of patients' autonomy. These findings suggest that the 'just-in-time' mechanisms in JITAI apps that currently exist for treating depression can be improved. However, this study did not give a straightforward answer on how to do that as many aspects should be taken into account when timing an intervention. The main suggestions that are given are regarding how to ensure that all the preferences of the patients are taken into account, while avoiding making the app too deterministic by letting the JITAI decide when the patient needs an intervention.

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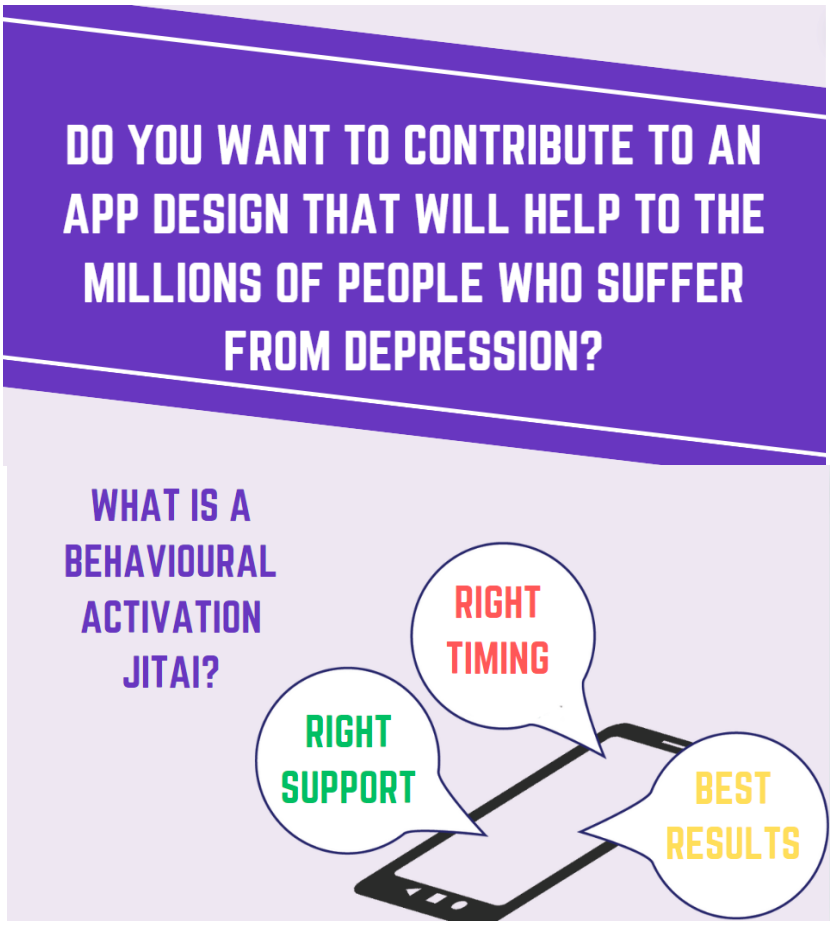
Appendix A

Introduction video (screenshots)



Consent form

Welcome to this research study about Just-in-time Adaptive Behavioural Activation Interventions!

We are interested in understanding your opinion, needs, preferences and suggestions related to the possibility of integrating Just-in-time Adaptive Behavioural Activation Interventions (behavioural activation JITAIs) into depression treatment.

In today's and the second online focus group, we will ask you some questions related to this topic and you are welcome to discuss your thoughts with the other participants. The sessions will be conducted in English and will take about 60 minutes each.

In this short survey, we will ask you for your consent to participate in the study.

Please enter your full name here ….
(Your name will not be shared with anyone besides the research team and is just important to enable us to identify that you agree to all of the conditions relevant to your participation.)
With the following answer, you give your consent to the procedures of and participation in this study, namely:

I am older than 18.

I could ask questions regarding the content and procedure of this study and my questions were answered well.

I had enough time to decide whether to participate in this study.

I understand that my participation in this study is voluntary.

I understand that I can withdraw from the study or stop my participation at any point in time without giving a reason for it.

I also understand that I can withhold answers for specific questions at any time without giving a reason for it.

I have been informed about the possible risks and benefits of my participation in this study.

I understand that the focus groups will be recorded and that the recordings will only be accessed by the research team and destroyed after finishing the thesis.

I understand that there will be an additional questionnaire to collect more general data about me as a person.

I agree to the storage and use of anonymised data in transcripts, survey results and the thesis paper.

I am aware of the possibility that the finished thesis will be presented or published.

☐ I read the points thoroughly and give my consent to everything said.

If there are any questions after the end of this survey, I am aware that I can contact the researchers via the following contact details:

Farid Chakhssi: 088 – 2011201 / f.chakhssi@thubble.nl
Jannis Kraiss: +31534897512 / j.t.kraiss@utwente.nl
Xeniya Peratinskaya: x.peratinskaya@student.utwente.nl
Stina Marie Schröerlücke: s.m.schroerlucke@student.utwente.nl

If there are issues regarding ethical concerns, you can also always contact the University of Twente ethics committee:

ethicscommittee-hss@utwente.nl

Survey for therapists

In this short questionnaire, we would like to ask you for some additional information that will help us to define the sample of this study in more detail.

You will need to answer some demographic questions first. Afterwards, there will be some questions related to your working experience and history as a therapist. Lastly, you will find some questions that are related to your attitude of working with online or digital mental health services.

1) What is your gender?
   Male
   Female
   Non-binary/third gender
   Prefer not to say
2) What is your age? (Please enter in numbers e.g., 36)
3) How many years are you working as a therapist? (Please enter in numbers)
4) How many years are you working as a therapist in online services? (Please enter in numbers)
5) Were you or are you working with behavioural activation interventions?
   Not at all
   Sometimes
   Regularly
   Often
   Very often
6) What is your general attitude towards digital mental health care services?
   positive
   neutral
   negative
7) What is your general attitude towards behavioural activation JITAIs?
   positive
   neutral
   negative
8) Would you be open to integrate behavioural activation JITAIs into your practice?
   No, I do not think they will be helpful.
   Yes, I can imagine using this type of intervention as an addition to my practice.

Yes, I could imagine this type of intervention to be capable to substitute (parts of) my practice.

9) You are welcome to use this last text field to express any remaining thoughts regarding behavioural activation JITAIs.

Focus group guide

Focus Group Guide for Therapist-only Sessions

Session 1

1. ***Start recording after making sure everyone in the meeting has already filled in the consent form.***
2. ***Explain just-in-time behavioural activation adaptive interventions (using the presentation) and ask for questions related to the main concepts. Also quickly mention the original plan to have 2 sessions: This session on just-in-time and a second on functionality and adaptability, and explain the alternative if things take less time than expected. (~ 10 minutes)***
3. ***Discuss the just-in-time aspect (see [guiding] questions below). (~ 40 minutes)***

Questions: When/just-in-time aspect (Xeniya)

- Maybe some moments your patients feel better or worse than other moments, how long do these moments last for them?
- What do your patients do if they stay home when they are in a very bad mood?
- Do you think there is a change in the amount your patients use their phone when they are depressed in comparison to when they are feeling good?
- *In what situations or contexts would you find a behavioural activation JITAI particularly helpful? Please describe specific scenarios where this support could assist you/patients. And when would it not be helpful/needed?*
- *What do you think is a good time for exercise? When being depressed or when feeling better?* (imagine you receive a notification when you are feeling unhappy, will you open it at that time, you think? Why not? *If not, what do you think could be a better moment for engaging with the intervention?)*
- *How about a good mood? Do you think it would also be useful to receive an exercise (intervention) when feeling neutral/happy and not only when feeling depressed? Why/ why not?*
- Which context would be good for receiving an intervention? (home/work/doesn't matter)

- What time of the day would be good for completing an intervention? (BA intervention)? (right after waking up, before going to bed, during the day, during some fun activities, when they are bored)?
- How engaging do you think the app should be? (if an app was sending them notifications from time to time during the day, or you think once a day would be more than enough?)
- Do you think sending a push notification would be better (shown on a screen where you have to complete it right away) or a disappearing notification in the form of a reminder?
- How do you feel about having the option to access a personalized intervention whenever a person wants to assess it (on-demand option)? Additionally, what factors do you think are important to consider when developing such a tool to ensure it meets the needs of your patients effectively?
- *Do you see your patients engaging with the JITAIs daily?*

If we are way faster than expected (only ~ 20 minutes When-discussion, we could continue with the What-discussion in this session! → Skip to Step 3 Session 2!

4. ***End the session with room for questions regarding this session, and explain to the participants that there will be additional questionnaires sent to them after this session to gather some more general information. Talk about planning a second session for the What/functionality and adaptability aspect. (~ 10 minutes)***

   Qualtrics link:

   https://utwentebs.eu.qualtrics.com/jfe/form/SV_b8cRdMKuN7RgGTY

Session 2

1. ***Start recording after making sure everyone in the meeting has already filled in the consent form.***
2. ***Ask for questions that came up in the meantime. (~ 10 minutes)***
3. ***Discuss functionality and adaptability aspects (see [guiding] questions below). (~ 40 minutes)***

Questions: What/functionality and adaptability aspect (Stina)

- Have you already used some types of online/digital/mobile apps/interventions before when it comes to depression treatment? What was your experience? Can you remember

certain factors and functions you liked or disliked? Did you miss any functionalities or adaptibility features you could imagine to be effective?

- What is your experience with behavioural activation as a treatment approach to depressive disorders?
- What functions/exercises/activities can you imagine to be useful in a behavioural activation JITAI addressing depressive symptoms? (Might be useful to give some examples if participants do not have ideas directly. Examples could be oriented at the basic building blocks of behavioural activation such as recording positive/meaningful activities and reminders regarding those.) Does this depend on certain factors like context or the state users/patients are in? How long should these behavioural activation exercises take?
- How do you think the JITAI could and should be able to adapt to patients' personal needs based on the functions we talked about know?
- How do you think that a new intervention with functions mentioned in the earlier discussion could support your (daily) work with your patients? Can you imagine behavioural activation JITAIs as a helpful addition to your therapeutic practice? Why? Why not?

4. ***End the session with room for remaining questions, thank for participation, ask new participants (who did not take part in session 1; OR if the second session is not necessary everyone) to fill in the additional questionnaire, and offer the researcher contact for potential questions and if interested in research progress. (~ 10 minutes)***

   Qualtrics link:
   https://utwentebs.eu.qualtrics.com/jfe/form/SV_b8cRdMKuN7RqGTY

   Contact details:
   Farid Chakhssi: 088 – 2011201 / f.chakhssi@thubble.nl
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Appendix B

Table 2

Overview of all the themes, its codes and all the quotes that correspond to the these codes

Theme	Codes	Quotes
Mood fluctuations variations and daily challenges in depression	Morning difficulties	*"If you look at depression, there's often a lack of something: a lack of will, a lack of energy. So, when you start the day, it's usually quite difficult to do so'*
		'If a client is at home in the morning and he/she has difficulties getting out of bed because he or she is depressed'
		'Clients have difficulties getting out of bed and that they really need some time to get started in the morning when they are feeling depressed or anxious to start their day. That's why I immediately thought about the morning'
	Daily energy fluctuations	*'There's also a group of clients that face difficulty throughout the day. When you look at, you know, the way the energy fluctuates during the day'*
	Environmental and situational influences	*'May it be because it's getting dark outside which might amplify the darkness on the inside?'*
		'Sometimes I have a client who's depressed and he loves the weekend because finally, you know, there's no pressure to do stuff, but there's another client who is always super depressed on the weekends because there's nothing to do and there are no friends'
Notification frequency optimization	Reduction of notifications over time	*'It could also be preferable to think about kind of like a build up in how much you stimulate a client and then a slight built down of encouragement of interventions.'*
		'It can be used as a supportive tool to gain more insights, but for a specific period during the treatment…not throughout the whole. And then the just-in-time intervention can of course pop out during that specific period of the treatment and then hopefully the client, at the end of the treatment, can do it more themselves'

		'To start with more structure and helping the clients start to behave, to activate more and then slowly build it off'
		'You can keep the normal curve in mind when you think about notifications, intensity, it's like that'
	Gradual build-up	*'Cause you don't wanna feel **** and you want to feel good as soon as possible. But like, yeah, celebrate the little moments, but also maybe divide things up or reach your goal with baby steps'*
		'So if it's something that addresses the cognitive capabilities, it is very difficult for them and I think less is more, especially in the beginning.'
		'If it's like activities that get them moving, physically moving, then please as much as possible. But if the activities are demanding of their attention and cognitive capabilities, that's very taxing for them in the beginning and those need to be spaced.'
	Consistent monitoring	*'It would be really good if clients can answer at least maybe once or a few times a week, a sort of short questionnaire'*
Optimal timing for intervention delivery	Moments of isolation	*'It doesn't really matter where I am, whether I'm at home, whether I'm somewhere on the go. But the main thing is that I'm alone and that I can't reach anyone. I'm out of touch with myself as it often is with depression and so I'm also out like... I'm not able to connect with others and I feel really, really sad about that. That would be a moment where I would be, first of all, happily surprised that something or someone is thinking*

		of me.' *'So I've got a big time difference. So that is also the time that I wouldn't be able to reach friends from back home or family or whatever.'* *'I'm really sad or I'm feeling really low, I think it's when even if there's company around, because then you can also feel lonely or even especially lonely, then there's a little device saying, 'hey, you're not alone, or you can do something', or, yeah, just little spark throughout the very low mood day.'* *'I was thinking like if you manage to get out of bed or you have a family and everyone's left the house and you're alone.'*
	Insomnia	*'When I'm alone by myself, lost in my thoughts in the middle of the night.'* *'Mostly they haven't gone to sleep yet. People with depression or they wake up in the middle of the night and start ruminating and then they sleep bad. And because of the bad sleep, they feel bad during the day. It doesn't improve the mood to get bad sleep. So that was my context; the middle of the night, ruminating.'*
	No motivation to start a day	*'For me it would be and then mostly in the morning I think. Also, because that's the moment where I'm like, OK, what am I gonna do this day? And if I'm in a bad mood, I might lean to laziness or just, you know, like, distraction, phone, whatever. And maybe if I get a little reminder, like, hey, you are busy with this, why don't you do this or something motivating.'* *'I was thinking of getting up and I know I have to do a lot of things on my schedule and have no energy to do so and that I start ruminating about that how will I manage*

		during the day how can I get my things done so that I have a good feeling at the end of the day that I check my boxes. So for me, I think the morning would be a good moment.' *'Like a long day ahead of you, other people do manage to get things done, you're the only one who doesn't get things done and you're comparing yourself to others and all of those thoughts there may be like late morning to be specific. It is a moment I was thinking of. And it's still like early enough in the day to get something out of your day or if you are still sitting in your pajamas. Or maybe you're still in bed, then you can change today.'*
Structured and context-aware interventions	Planned notifications	*'Like in the evening, I'm so busy with preparing dinner, feeding my kids, bedtime, all of that. So between five and seven or eight I might hear my phone make a noise, but I'm not attending to my phone, so only after eight I'm available again, for example.* *'But there is information… what the client can give you. So if you build that into the app, you take away a little bit of the spontaneity in a way, but you do know when the client is available or receptive to it'* *'Tailor the app…if you for example upload your planning or your activities from the week, then it's easy to nudge that and maybe to….Like I have been in a situation and then the negative thoughts come in. But actually the app knows that you've been to this activity, or at least that was the plan. So to check in how did it go or well done for doing that.'*
	Integrating key dates/events to identify emotional triggers	*'Such a period, for example the birthday of a loved one that they lost. Then if we would measure patients frequently, then this would be visible changes in mood.'* *'Someone is dreading something like if I know, oh, this weekend they're going to their family again and they're a bit scared of it, then like the Friday before that would be a*

		good time to send like a bit of motivation.'
	Context sensitivity	*'If someone wants to be more active. Yeah, then it doesn't help to send an activation JITA when they're at work, right? Because they can't go for a walk. So then you would place those on the weekends. But if someone needs to slow down their work, if they're getting close to burnout, or maybe then at work would be a good time, right? 'Hey, slow down!''*
Strategic timing for reinforcement interventions	Positive reinforcement in active clients	*'If someone's feeling good, right, you want to put the focus on that too, because the focus is on the negativity too much already. So if someone's feeling well, yeah, that should get some attention too, and maybe even more than the negative points.'*
		So also when they're happy, I mean, you could even stress that it is a very, very important phase, to then, you know, not think 'well, I'm happy, I don't need these interventions anymore', I think it's even more important when you're happy to still receive these moments to really incorporate what you've worked on.'
	Negative reinforcement in non-active clients	*'But I do think that if a client is really low that that's actually the right moment to give a helping hand.'*
		'if a patient is really or a client is really inactive, then for example it would be nice to send them a notch or a message like 'Hey, maybe it's good to …' and then a personalized activation'
	Balancing positive and negative	*'Cause if things are going well, you wanna encourage them to keep on going, if things*

	reinforcement	*are not going well then, yeah, something needs to happen, you want to be nice or whatever. So I would also say both'* *'Client one needs a different kind of notch or a message more like you're doing very well. Keep going, keep the spirit up and client two can benefit more from the directive approach to be more engaged in activation'* *'I think it could be similar if they are feeling good and to act on it and have positive experiences from that could be rather helpful to be more resilient, to be more positive. But also the other point when they are feeling depressed to have this notification or the push notification then. So I think for me both would be valuable'*
Promotion of autonomy in clients	Dependency on the app	*'I think because I'd be a bit careful about the idea of making them dependent on these 'checking in' and 'what's my score like?', 'am I doing well?', which would in my clinical opinion very much be counterproductive on trusting how you feel.'* *'You don't want to have this* *covariance that if you take out a thing that gives you options that then the client regresses. So I think it's also very important to encourage the client to think actively as well. Because elsewise, I see a risk that clients become quite dependent on the app.'* *'You don't want to make that too dependent like you want to encourage, you want to help, but it shouldn't be reliant on.'*
	Encouraging active thinking	*'Active thinking is also something that really can help a depressed client get out of this, you know depressive cloud that they're in. So would it be also possible to implement provoking questions instead of offering everything, just asking. So let's think about a*

	Clients with control	*time where what is it that you'd love to be doing. Now go find a moment and execute that!'* *'Someone needs a bit more encouragement when they start and that you know the active thinking can also start from the beginning of therapy, with the extra encouragement like, hey, you can do this. You can do that.'* *'The frequency of these nudges let's say lessens throughout therapy, but that critical thinking or active thinking kind of stays because in the end, that's what they need afterwards too in order to make a behavioral change part of their lives'* *'So you could maybe put an option at first, like hey, we could do it this way or that way.'* *'Just ask the clients while setting up the app, how frequent and when…because all our answers were it depends, it depends on the client and I think the clients do have the best sense of when would I be more receptive and how often and how pushy do I want it to be…They can do it themselves.* *'You are automatically correcting for the intrusiveness, because ideally you would not want this thing to be a deal breaker, like ,'oh God! This thing is sending me stuff again!' That doesn't really meet the well-being of the client or the willingness to participate any further.*