Exploring and Designing for Memory Impairments in Depression

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ABSTRACT

Depression is an affective disorder with distinctive autobiographical memory impairments, including negative bias, overgeneralization and reduced positivity. Several clinical therapies address these impairments, and there is an opportunity to develop new supports for treatment by considering depression-associated memory impairments within design. We report on interviews with ten experts in treating depression, with expertise in both neuropsychology and cognitive behavioral therapies. The interview explores approaches for addressing each of these memory impairments. We found consistent use of positive memories for treating all memory impairments, the challenge of direct retrieval, and the need to support the experience of positive memories. Our findings open up new design opportunities for memory technologies for depression, including positive memory banks for active encoding and selective retrieval, novel cues for supporting generative retrieval, and novel interfaces to strengthen the reliving of positive memories.

CCS CONCEPTS

•Human-centered computing • Human-centered computing~ Human computer interaction (HCI)

KEYWORDS

depression, memory impairment, memory technologies, cues

1 Introduction

Depression is a condition with significant social costs whose interventions and support in both clinical settings and everyday life remain insufficient. Depression is well known for the dysregulation of affect, and also characterized by cognitive dysfunction including memory impairments such as *negative bias*, *overgeneralization* and *reduced positivity* [13,22].

While most HCI research on memory technologies has focused on memory impairments such as those associated with dementia, less work has focused on memory technologies for people living with depression. Memory impairments in depression are however fundamentally different, impacting not the loss of episodic memories but difficulties in retrieval of episodic memories through higher levels of autobiographical memories such as general events and lifetime periods. Another distinct body of work explored computerized interventions for depression such as online Cognitive Behavioral Therapy (CBT). Such interventions address memory impairment albeit not as the main focus, but rather through a subset of psycho-educational materials concerned with negative thinking patterns, and tools for tracking mood [9,10,16]. We argue that the specific memory impairments in depression and the new range of challenges they pose offer a rich opportunity to extend the HCI research agenda of memory technologies in new directions. This paper is an initial step towards exploring this space and focuses on the following research questions:

- How are the memory impairments in depression addressed through tailored interventions used in clinical and neuropsychological practice?
- What is the role of materials in these memory interventions and how are they employed in the therapeutic practice?

To address these questions, we report interviews with ten experts working in clinical and neuropsychological practice with people living with depression, including four neuropsychologists, for whom memory impairments will form a larger part of treatment, as well as therapists from other backgrounds, for whom memory impairments will form part of a wider treatment strategy. The main contributions of this work include a richer understanding of how memory impairments in depression are addressed in clinical practice and design guidelines for new memory technologies for people living with depression.

2 Literature Review

2.1 HCI Work in Depression Treatments

HCI work on depression has considered a range of systems aiming to support detection of depressive symptoms, management of short-term negative emotions, tracking of depressive symptoms, and online management of depressive symptoms over the long term. Work on diagnosing depressive symptoms has focused on analyzing online daily activities (e.g. Reddit [3,6], Twitter [5,50], Instagram [34]) to detect depression (e.g. postpartum changes [5],

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suicidal ideation [6], self-disclosure [3], severity of depression [50], and mental health issues in general [34]). Another strand of relevant HCI work has looked into interactive devices for guiding mindful practices to reduce high-intensity negative emotions in the short-term [4] or tracking depressive symptoms. This body of work builds mainly on positive psychology [26], utilizing lifelogging technologies [26] to better support coping strategies through expression [39] or increased social communication [52].

In addition to tracking, the design of computerized psychological treatments for depression has been explored by HCI research [10]. Such interventions tend to include psychoeducation sessions, requiring users to finish a number of achievable goals [9]. As these online mental treatments are highly structured in content-delivery and goal-oriented in user journey, designers of such systems normally choose highly structured and goal-oriented psychological treatments such as CBT or Solution Focused Therapy (SFT)[9]. To date, CBT is one of the most evidence-based and widely used approaches in both the clinical context and in internet-delivered therapy [10,16,42], and is currently as one of the first-line treatment options for mild to moderate depression, especially in the UK [16].

However, an important challenge of online CBT is the relatively high attrition rate. To improve user engagement, Doherty and colleagues [16] suggested a number of strategies including delivering more personalized and multimodal content, such as by allowing users to tailor their preferred treatment path. Accessing information through other modalities such as video [9], games [2,9,11], or conversation with robots [19] has also been suggested, especially to increase young people's engagement in treatment.

While current computerized depression treatments are primarily based on highly-structured interventions, other unexplored possibilities include free-form interventions which build on people's life-narratives [9]. Coyle et al. [10] suggested person-focused approaches which focus specifically on clients' sense of self, and how they construct the narrative of their life stories and how these could change thinking patterns for alleviating depression [13]. In addition, it has been suggested that the design of computer–aiding systems for clinical treatment should support a broad range of therapists, treatment settings and clients [9]; there is thus an opportunity to support a range of person-focused therapies by addressing common factors in depression.

Another challenge faced in the design of computerized systems is that as the treatment is associated with their illness, users may stop using the system after they feel like their depressive symptoms have improved [16]. However, quitting treatment early may mean that some cognitive impairments remain and raise the risk of relapse [13]. An interesting possibility is to investigate solutions, which can be used inside or outside of treatment to improve the resilience of people at risk of depression.

All the above issues motivate the exploration of new technologies as person-centric treatment of depression, with less pre-designed linearly-delivered training content, and less dependence on text and reading skills. This requires that the technology involve more of the client's self-relevant materials, and have a less explicit framing as "treatment for depression", but instead aim to raise the resilience of people at risk of depression.

2.2 HCI Work in Memory Technologies

Memory technologies have mostly focused on addressing episodic memory loss of non-clinical population or population in dementia. In particular, lifelogging technologies capture episodic memory to support later retrieval [23,45], reminiscence [15,48] or mood regulation [28]. HCI work supporting memory in dementia [1,21,32,33,44] explored lifelogging technologies such as SenseCam to capture episodic memories and support episodic retrieval through autobiographical memory system [43].

2.2.1 Systems supporting capturing and organizing cues for EM. Episodic Memory (EM) contains highly detailed sensorial information of specific life events, which could either decay soon or become integrated within the autobiographical memory system from where they can be vividly retrieved [7]. With the help of modern memory technologies (such as contextual sensors and massive digital storage techniques [46]), people get to record more and more sensorial memory cues (e.g., visual cues with camera [23,27,45], or verbal cues with microphones [15]) to keep their episodic memories in everyday life. However, such technologies could generate a huge amount of memory cues, which are impossible for users to review and directly make sense of them (e.g., 1500 images a day [27]). Thus, Sellen et al. [46] suggest to selectively capturing episodic events for addressing particular memory impairments. Some researchers suggest filtering valuable memories in the moment of capture, either automatically (e.g., by filter memories with high emotional arousal [45], or with users' own selection (e.g., self-crafted memory cues [44]).

As episodic memories cues accumulating over time, a framework is required to organize and represent captured cues. Recording captured memory cues and constructing them in a narrative representation is a method that works well with users' preferences and natural habits [40]. Such work includes narrative diaries of everyday events, modalities of cues include video summaries (pictorial [27]), animation that represents bio-sensing data [47], or combined multimedia memory cues [38].

2.2.2 Systems supporting cue-based remembering through AM. Autobiographical memory (AM) is the "remembered self" across the lifespan, which provides a long-term framework for episodic memories. Current memory technologies predominately support users' need in directly accessing episodic memories through the AM system, by representing memory cues that explicitly target

specific episodic memories[23]. Such supports in direct retrieval could benefit people with memory loss problem, to reconstruct forgotten memories for later reminiscence [48], memory sharing [29], emotion regulation [28] or alleviating dementia [32]. However, users receiving captured memory cues does not necessarily mean they can remember successfully. Since the captured cues are just collections of data for assisting the remembering process, but not the process itself. As stated in [24], remembering is a process of re-constructing the self-memory system and retrieving specific memories based on users' current beliefs. The retrieved memories will always be "twisted" by people's current dominant self-beliefs, and their current interpretation of the memory. Van den Hoven et al. [24] further suggested that AM technologies should be flexible in presenting memory cues for supporting memory retrieval.

2.3 Memory Impairments in Depression and Memory-Based Interventions

2.3.1 Autobiographical memory and self-identity. Retrieving through Autobiographical Memory System (AMS) involves the knowledge-base and people's self-identity [8]. The former contains memories across the lifespan at three levels of abstraction (Fig.1): lifetime periods (highly semantic), general events (part semantic, part episodic), and episodic memories [7,8] while the working-self [8] involves information about self-identify, and is critical for accessing each episodic memory. AMS supports two ways of retrieval: generative retrieval and direct retrieval. Generative retrieval is the memory searching process involving one's self-identity. As shown in Figure 1, the generative memory-searching process of non-depressed people starts with a cue activating the retrieval mode, accessing and evaluating memories at all three memory levels, and elaborating searching-cue iteratively, until a matched specific memory is reached. Direct retrieval is triggered through cues with direct links to specific episodic memory, involving thus less of the self-identity.

While reviewing psychology literature [13,22], consistent findings have shown that people living with depression have three distinctive AM impairments: *negative bias, overgeneralization*, and *reduced positivity*. These memory impairments mainly disrupt the generative retrieval process. A few memory-based interventions [17,31,41,49] have been designed to address such memory impairments in depression [22]. Figure 1 illustrates how negative self-identity, *negative bias*, and *overgeneralization* interact with each other and contribute to the impaired (generative) memory searching process.

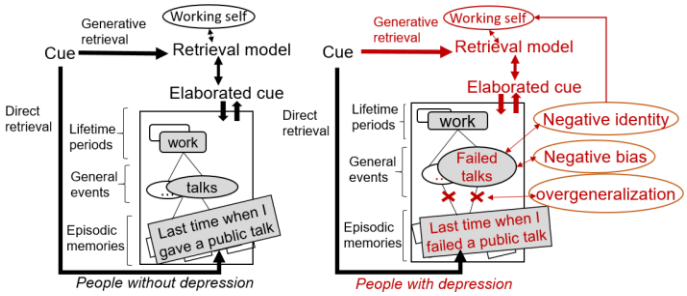

Figure 1. Memory retrieving in people without depression (left), and with depression (right)

2.3.2 Three memory impairments depression and targeting interventions. Psychological work has identified three memory impairments in depression [13]: *negative bias, overgeneralization* and *reduced positivity* and four main tailored interventions [22]. Concreteness Training (CNT) trains people's ability to look back at specific events in concrete manner to reduce *negative bias* and *overgeneralization.* Memory specificity training (MEST) trains people's ability to retrieve episodic memories to address *overgeneralization*. While Competitive Memory Training (COMET) trains the ability to retrieve positive memories for building positive identity for addressing *negative bias* and *reduced positivity*. Cognitive Bias Modification-Imagery (CBM-I) trains people's ability to cope and practice positive interpretation through imagination for addressing *reduced positivity.*

Negative Bias [13]. Findings have also shown [13] that people with depression tend to have negative self-identity, which contributes to the *negative bias.* They tend to pay attention to negative materials or to interpret vague scenarios in a negative manner, which leads to the retrieval of a larger number of negative memories compared to the non-depressed population. This process strengthens the access path of negative memories from the memory system making negative memories easier to retrieve and positive ones harder to retrieve. As time goes by, the imbalanced remembered self (AM) continues to fuel a stronger negative self-identity. Several memory interventions have been developed to address *negative bias* [22], including COMET [31] and CNT [17]. While COMET helps clients to construct a positive self-image to guard against the negative one, CNT helps depressed clients to disengage with their retrieved negative memories by analysing them in a concrete manner.

Over-generalization [12,13]. People living with depression have difficulties in accessing both specific episodic memories, and their specific details through the generative retrieval process. As shown in Figure 1, the memory searching process starts from accessing the higher levels of AMS such as lifetime periods and general events, albeit unlike non-depressed individuals, the depressed ones tend to finish the searching process before reaching the episodic memory level. In addition, as mainly negative memories could be retrieved due to *negative-biased*, the retrieved abstract, negative memories further contribute to an abstract and negative life summary (e.g., "My life is a total

failure"). People with depression do not have problems with the direct retrieval of episodic memories, as their memories are not lost, but simply harder to access [51]. As suggested in [22], MEST [13,41] and CNT [17] are interventions to address overgeneralization. MEST can help users to enhance specific memory retrieval with emotional word-based cues, while CNT help users to retrieve details in their specific negative memories and analyze them more concretely.

Reduced Positivity [13]. Due to the negative self-image, positive memories of people with depression are less vivid and emotional-intensive, so they contribute little to users' mood even when retrieved successfully [13]. In addition, as depression draws attention to negative material, fostering rumination and negative mood, it can also contribute to worsening moods while reviewing positive memories. Apart from clinically depressed people, healthy people with sad moods [30], or depression history [14] are also facing this risk. As suggested in [22], COMET [31] helps users build positive self-image by repeatedly imaging positive experiences or retrieving positive memories, while CBM-I [49] helps users to practice their ability to interpret neutral scenarios positively. These three memory impairments, as indicators of depression, may persist even after a depressive episode is resolved, contributing to the next depressive episode [13].

3 Methodology

We conducted semi-structured interviews with ten experts in clinical or neuropsychological practice, with at least six years of experience of working with people living with depression. The study aimed to explore their practices of addressing memory impairments in depression. Participants have on average 15 years of experience (range 6-30) in working with their clients living with depression, using either clinical or lab-based treatments. Participants are mainly female (eight are female, and two are male).

As shown in Table 1, eight participants have experience of treating depression in clinical context. Two in four neuropsychologists focusing on depression and its memory impairments have clinical experience in treating depression, while the other two practice in lab-based research. Seven among the eight clinical experts have experience of using CBT with their depressed clients, while the other one performs clinical memory-based training (MEST) for treating depression. Five participants have Ph.D. degrees in Psychology. Six participants were from the UK, while the other four were from mainland-Europe (Belgium and the Netherlands).

Expertise	Role	Context
Clinical expert (8)	CBT therapists: P1, P2, P3, P6, P8, P10 Psychiatric nurse: P4	Private practice (2) Hospital(5)
Neuro-psychologist (4)	Memory training for depression: P5, and P9 MEST expert: P6 MEST expert (clinical): P7	Lab Hospital (4)

Table1. Participants: expertise, role and context

Participants were recruited through email advertisement from CBT associations or online database of clinical practitioners and researchers. The semi-structured interviews were carried out individually through phone or Skype calls. During the interviews, we asked participants about their practice and how they addressed memory impairments in depression. We also asked about their challenges in conducting the treatments as well as engaging treatment-recipients.

Interviews lasted about an hour, were audio recorded and fully transcribed. We used a hybrid approach [18] for analyzing and coding the interview data. A conceptual framework developed from prior literature provided initial categories, for example, type of memory impairments, the main practice of each memory impairment, and usage of personalized material. The above framework was refined from interview data, and new codes emerged and identified themes were discussed through researchers for consistency.

4 Findings

We now report clinical *approaches* we have found in addressing each *memory impairment*, together with what *type of memory* (negative or positive) these approaches employ, as well as which *memory processing stages* targeted by each approach.

4.1 Approaches Addressing Negative Bias

Negative bias refers to the pervasive negative-tone of depressed individuals' life-narrative, which is due to their preference for paying attention to negative materials and negative interpretation. People living with depression also tend to retrieve negative memories much faster and easier compared to positive ones [13,22]. Their negative memories with high-accessibility (and positive memories with low-accessibility) further enhance the negative perspective of life-stories as well as increased rate of provoking rumination.

We identified a few approaches from both clinical and neuropsychological practices to address the above problems, including reducing negative effects of retrieved negative memories and increasing clients' ability to encode and retrieve positive memories.

4.1.1 Analyze and learn from negative memories. Both CBT therapists and neuropsychologists help their clients to analyze negative memories once being retrieved for disengagement. These approaches aim to make negative memories less negative and easier to be disengaged from future retrieval. The selected quotes provided in this section are illustrative of the identified common themes. Findings suggest two ways of supporting the analysis and reflection on negative memories. For example, some therapists directly inform their clients about their problematic thinking style, P8 (CBT therapist): *"the thinking errors [could be] jumping to*

conclusions, thinking more negatively towards yourself and other people, or you are harsher on yourself then you are to other people". Another approach is to provide detailed scaffolding questions for guiding clients in analyzing and learning from their retrieved negative memories, P1 (CBT therapist): *"they need to learn what is it that creating the negative experience? What is that about? Is that about the type of people they attract? Is it something about them, which causes these things to go wrong? They will need to explore that, and then they might do differently in the future"*. This quote provides evidence of therapists' effort to encourage identification of unhealthy thinking patterns, to support disengagement from negative memories, and future healthier emotional or behavioral responses.

4.1.2 Reframe clients' negative interpretation and emotional response, and encode reframed memory. Another approach for disengaging negative effects of negative memories is found in both clinical and neuropsychological practices. P5 (neuropsychologist) gave an example of possible approaches according to the Cognitive Bias Modification methodology [49]: *"for example, imagine 'a cup of coffee behind a rainy window'. The depressed persons' standard interpretation would be 'I feel isolated', but the alternative interpretation would be: 'it is a lovely afternoon, we are enjoying a lovely cup of coffee'. So you [could] expose clients to this kind of negative images, and then align them to interpret the meaning of these images [and reframe them more positively]"*. We also found similar approaches for reducing negative-biased interpretation through reframing negative memories mentioned by P1: *"a client [was] upset because [her] friend had a job she was also applying for, and she thinks it is unfair. However, I prompted her by saying: 'okay you told me that you are upset and worried about this, but is there another way of viewing it?' That could offer them [options to reframe their interpretation] and view the situation differently; [so that they could] reframe their emotion response and feel more positive about it"*.

The idea of this reframing process is to help clients to both reframe their memories less negatively and to encode the reframed memories in their memory system. As these negative memories could be less negative if retrieved in the future, depressed clients could disengage with these memories more quickly and easily over time.

4.1.3 Encourage switching attention from rumnination to retrieved memory itself. As depressed individuals have higher tendency to avoid retrieving details of their memory and rather distract themselves through rumination [13]. An approach for addressing this problem has been mentioned mostly by neuropsychologists while conducting memory-based intervention (MEST) [41]. Three neuropsychologists (P5, P6, P8) mentioned their approach in guiding the clients to focus on the memory itself until it is successfully retrieved with as many concrete details as possible. For example, P7 (clinical MEST therapist): *"sometimes clients do start to ruminate about their negative memories. Then [as therapist], you say, 'OK, I guess it's very difficult for you. However, just think about this family dinner and let us see what details are in there'. Therefore, you distract them from 'thinking' about the memory, by retrieving details of that memory"*. This quote indicates an approach for disengaging from rumination, by encouraging clients to fully engage with the memory retrieval instead of allowing their attention and cognitive resources to engage in rumination.

Negative-biased, unbalanced life-perspective in depression is also contributed by the low-accessibility of depressed individuals' positive memories. Therapists thus suggest building a stock of positive memories to help and encourage clients to encode positive memories over time, as a process of enriching the collection of retrievable positive memories. Such positive memory banks could also help users to increase their positive memory retrieval and thus create a balanced view of life-perspective. We have identified three strategies in utilizing positive memories:

4.1.4 Encourage active behaviors for encoding positive memories. If clients cannot draw from a rich collection of positive memories, therapists would finesse the choice altogether by creating opportunities for positive events and encouraging their purposeful encoding. For example, within the treatment, several therapists deliberately introduce specific activities such as arts or craft that are likely to induce positive emotions and encourage clients to actively encode them as positive memories. P2 has mentioned her approach as: "*I help them trying to retrieve the positive memory of the treatment […] we are trying to get (clients) to realize that they are making gains right now*". The above findings suggest opening up new design opportunities to better support such cue creation. P10, a CBT therapist, has also mentioned: "*I guide users to create artworks in the treatment, so my clients can take them back home and retrieve the happy moments in the treatment*". This quote indicates the important value of a tangible cue of a positive activity, which can trigger later positive memory retrieval.

While positive memories can be created as part of the treatment, they can also be made within clients' everyday life, since negative bias impairs depressed individuals' abilities to pay attention to positive materials. P2 describes this process as: "*(they feel like) their whole life is always negative, it's hard for them to realize that positive things can happen, or even that positive things are happening currently* ". CBT therapists thus encourage their clients to increase their ability to be present and pay attention to current positive events and to encode such memories in specific detail for easier later retrieval. For example, P3 (CBT therapist has mentioned): *"[I use techniques, such as] ten [five] fingers, [for] pointing out things that [clients] are grateful for in the present moment, or things they do that nurture them, to balance the things to displease them"*. P3 encourages clients to take notice and encode all daily emotional events: "*encouraging clients to notice positive things happening in their life, unpleasant things in their life, as well as the difficulties, could tackle their overgeneralized autobiographical memories"*.

4.1.5 Encourage positive memory retrieval to disengage from rumination. We found a prevalence of this approach in both CBT therapies and neuropsychological treatments. For example, P4 (psychiatrist nurse applying CBT therapy, has mentioned his approach of using clients' positive memories to help them disengage from rumination: *"[…] I use his past successes [to help him] feel balance and distract him from his pre-worry about his physical health"*. P6, as a neuropsychologist with background in clinical CBT therapist, also suggested the importance of having available positive experiences for depressed clients to engage with and to distract from negative thinking: *"the most important thing for clients to shift their bad habits of negative [ruminative] self-thinking, thinking […is to] have enough positive collectable experiences where they do manage to disengage from that ruminative thinking and to experience, [and] shift their attention or focus to something else"*. An interesting outcome is that although these memories could be cued through modalities other than words, findings indicate limited visual or tangible material being used to facilitate positive memory retrieval.

4.1.6 Encourage positive memory retrieval to create a balanced view. Therapists (both neuropsychologist and CBT therapists) further mentioned the importance of a positive memory bank for increasing clients' ability to retrieve such memories and to build a more balanced view of life. For example, P5 as neuropsychologist has suggested *"[positive memory bank is useful], as they [clients] can thus look back and say 'well no, I am not always a failure in my life, not everyone in my relationship rejected me'".* P2 (CBT therapist), has also agreed the value of positive memory bank in promoting balanced life-review*: "[addressing negative bias is all about] get them to see balance, challenge their negative thoughts, so […] having them describe the situation in the past that have gone better is more powerful than just say 'everything will be alright'".*

Other CBT therapists have also suggested the positive memory bank by providing illustrative examples of its value, P1: "*I let them feel balance about their life, so they feel like 'something good happened' […] I do have the capability to have good experience in a relationship […] because it had happened*". P4 also mentioned using positive memories as a counterexample to break clients' negative life perspective: " *I pick out some of the [past] successes […] so he was able to acknowledge [that he is not a failure as he thinks]*". P5 further suggested that, such positive memory bank could help clients to practise and improve their abilities in positive memory retrieval: "*this kind of bank of memories, with very enriched contextual details, could help [them] to increase (the accessibility of) these memories with creating more memory traces [for retrieving them]*".

4.2 Approaches Addressing Overgeneralization

People living with depression do not only tend to retrieve their past in a negative manner, but also in an overgeneral style. The overgeneralized memory, as a cognitive marker of depression, refers to the cognitive dysfunction affecting the retrieval of episodic memories and their details [12,13,41]. *Negative bias* and *overgeneralization* reinforce each other and contribute to a profound negative life summary and self-perception (an example given by P4: "*my whole life I have struggled"*) and of the world (an example provided from P1: *"all my relationships failed"*).

4.2.1 Training clients' ability to retrieve specific memories through the generative retrieving process. This approach is mainly applied in neuropsychological treatment, as neuropsychological findings [22,41] suggest that, breaking this negative overgeneralization model by training clients' ability to retrieve episodic memories through the so-called generative retrieving process (section 2.3). Training the generative retrieving process consists of supporting clients to move from high-level autobiographical memories such as lifetime periods, and general events towards retrieving specific-level episodic memories. Generative retrieval is mostly prompted by what we identify to be new types of cues: generic, and word-based. For example, in neuro-psychological memory-based treatment (MEST [41]), clients practice memory retrieval with emotional word-based cues, such as "successful" or "disappointed". Such cues should be generic rather than specific to ensure that only the generative retrieving process is activated, rather than direct retrieval usually cued by photos. Cues also have to involve certain emotional valence (neutral, negative, positive), as the difficulty in memory-searching of depressed people is much more severe from emotional cues [41]. As we found in MEST protocol, MEST therapists trigger clients' memory retrieval through standardized word-based cues, such as "enthusiastic" (positive cues), "telephone" (neutral cues), "stressed" (negative cues). Once clients come up with a memory (the first attempts is normally not specific enough), therapists would guide them to retrieve more specific details through scaffolding questions, until a specific episodic memory (normally an event that has lasted for less than 24 hours) is retrieved. Details of such scaffolding process are further outlined.

4.2.2 Providing scaffolding to help generative retrieval. This approach is usually takes place in MEST training. This approach aims to scaffold clients' generative retrieval process and help them address their inability to access episodic memories. For example, P6 (neuropsychologist specialist in MEST): *"when the client starts with 'I am never happy', [then I will say] 'Can you think of a time when you felt happy in the past?' 'When I went on vacation' 'OK that's a little more specific' [so this is how] you help your clients to work through that hierarchy: from vacation to the trip to the seacoast, and then to a specific trip to the seacoast which lasts a week. Then I ask and challenge the client to come up with a specific day or event or moment in that one-week trip to the seacoast"*. P6 also suggests leveraging social support particularly

though group intervention *"the nice thing [of working in a group] is that not only [the] trainer is challenging the clients, but the clients are also challenging each other"*.

4.2.3 Training abilities in retrieving details of specific episodic memories. This was mentioned by neuropsychologists as focusing on in-depth specific memory retrieval after their clients identified and retrieved a specific, episodic memory successfully, P6 *"when [clients] come up with specific memories, we challenge them to come up with extra contextual sensory perspectival details, with their specific memories"*. One neuropsychologist further provides suggestions of how she would use such a guiding process within a mobile application: *"[The app would] train participants to retrieve positive events and retrieve them fully detailed, by asking users to describe details of those events: normally at least 15 details"*. P8, as a CBT therapist utilizing behavior activation who also acknowledged the value of MEST training, has put effort in integrating MEST elements into her CBT treatment. In this respect, she suggested positive immersion in the retrieved memory, and its specific details: "*[…] close your eyes, and imagine this [experience], imagine it, and pause with this, and feel […] I expose them [clients] to their positive feelings, make them open up and let these feelings enter their system"*.

4.2.4 Encourage retrieving positive memories to break negative thinking style. This approach was specifically found in CBT therapies in training overgeneralization (more than half of the interviewed CBT experts). As in treating depression, traditional clinical treatments such as CBT emphasize changing negative thinking patterns due to negative-biased overgeneralization, therapists thus predominately address *overgeneralization* by driving clients directly to specific positive memories. They also use positive memories that are retrieved by the clients as counterexamples for breaking the over-generalized thinking style and negative life summary. Findings indicate two ways of triggering positive memory retrieval. Some CBT therapists trigger it with simple questions by directly challenging clients' negative thinking, P2: *"really? Don't you have any positive memories? Is that true?"* or P1: *"so are you saying that you never get enjoyment out of doing things?"* These quotes illustrated therapists' efforts to make clients realize the problem of their negative, overgeneralized thinking, and start retrieving positive memories against such thinking. The second method for triggering positive memory retrieval consists of guiding the clients to retrieve specific life events that are generally enjoyable, P1: *"maybe […] there will be a time that you have experienced a good relationship?"*, or bring awareness to such positive memories as reflected directly in clients' accounts during the treatment, P8: *"when he was describing what happened at work when I heard something good […] I stopped him"*. CBT therapists also mentioned the value of knowing clients' background as a way to better prompt this retrieving process, P2: *"[if I know their background well] I would say 'what about the day when you got married?' or ' How about the day when your kids were born?'"*.

4.3 Approaches Addressing Reduced Positivity

As suggested by [13], even if depressed individuals can successfully retrieve a positive memory, such memories are less vivid and emotionally-intensive, impeding depressed individuals from experiencing the positive emotions associated with it. We report three main strategies identified for addressing this problem.

4.3.1 Helping reconstruct, visualize, and retrieve associated positive emotions of positive memories. Both neuropsychologists and CBT therapists have mentioned this approach. It consists of first helping clients to retrieve many details of specific positive memories, P9: *"just think of an event […] imagine it including some of the details, for example […] what happened exactly, […] as well as how they were feeling […], in 5 to 15 details"*. The second step is to help clients through scaffolding questions to retrieve positive emotions associated with these memories, otherwise, as P8, a CBT therapist described, their clients would just "*jump over it"*. This step focuses on positive emotions, as such memories are important in helping depressed individuals to experience rather than avoid specific memory details [13], P8*: "so it is using the image vividly, and feel what he [client] feels at this moment. To open up and to let it enter the system"*. The most used scaffolding questions include, P8: *"when I heard something good, [like a compliment or nice interaction] I stopped him and instead of [let him] just going over it, I asked him to do some imagery [and] stand still to feel the feelings or imagine the situation again"*. P8 further illustrated details of her scaffolding questions to support reliving this memory: *"[I] say 'close your eyes, and imagine this experience. Imagine it and, really pause with this, and feel.' So it is using the image vividly, and feel what he feels at this moment. To open up, and to let it enter the system"*. This quote illustrates the value of slowing down and paying attention to one's positive memory, which can open up new design opportunities supporting such rich reliving process.

4.3.2 Enhancing retrieved positive memories with positive cognition model, and help encoding reframed positive memories. This approach has been suggested only by one CBT therapist, P3. She reported her efforts to enhance these positive memories by integrating positive cognition model with these memories [20], and help their clients to encode enhanced positive memories in their memory system: *"[I] encourage users to encode their memory holistically. Get clients retrieving things that they are grateful for […] and encourage them to use the CBT model to break these moments down, create an emotional memory involves emotion, cognition. So whenever you retrieve this positive memory, not only you will retrieve the memory itself, you will also retrieve the full [CBT] model behinds it"*. As indicated above, this approach aims to lead clients to repeatedly retrieve their positive memories to encode future positive memories in a holistic manner.

4.3.3 Utilizing positive memories to build better self-identity. More than half of the interviewed participants mentioned the importance of boosting users' self-identity. Some therapists

specifically identified their approaches of utilizing positive memories for this propose, P1: *"I use that [positive memories provided by my clients] to help them feel a bit more confident about themselves, like, "you know, you do have the capability to have good experiences in a relationship […] because it had happened once"*. However, such an approach for boosting self-identity is currently supported only by verbal conversations, with limited efforts focused on capturing these powerful positive memories linked to one's sense of identity. We argue that purposefully encoding these emotional events as they occur during the therapeutic session can later provide valuable cues for key positive memories weaved in one's sense of self.

4.4 Current Clinical-Usage of Materials

Study findings indicate that current depression treatments are predominantly based on conversations. Some therapists use standardized materials in their treatments, such as printed paper of ABC worksheet [53] and feelings wheel [54] in CBT (P2, P3) or word-based cues in MEST training (P6, P7). Other therapists select materials that may cue their clients' positive past experiences. For example, P4 choose songs and visual objects to remind his clients of their significant life events, integrating materials that are relevant to each specific client's background. In most case, therapists are the ones to provide training materials, but occasionally clients' written diaries are also required as part of the treatment (P3, CBT and P6, P7, MEST).

4.4.1 Self-relevant materials. P4 has specifically mentioned the value of self-relevant materials, for example, as visual cues: "*things that could trigger a retrieval, like photograph albums […] an old dictionary or an old textbook. (They could) unlock other memories […] Once I used some normal computer magazines from the 1990s, because a client was working in IT industry [during that time], [it's the type of magazine that] you could have bought in any stores*". P4 also utilizes the audio cues such as songs: "*you could almost consider that as a signature. These are a personalized set of stimuli or triggers [One time I played an old song in front of my client] when the music came, because they are her brothers' favorite artist, she suddenly felt herself upset [for feeling the time spent with him] as quickly as it started*." From CBT perspective, that's (P4):"*something that is worth the grasp and makes her reflect on this retrieval*". These quotes illustrate the importance of vivid visual and audio cues, as specific memory cues could trigger rich sensorial direct retrieval [8,24]. One concern is that such sensorial memories could worsen clients' mood with potential harming impact and that care should be taken in designing and using them with clients.

Some CBT therapists also asked clients to write diaries mostly on sheets of paper as material to trigger retrieval in the next training session, P3:*"and we used a lot of stories to illustrate that it's not always the case, and the diaries show what he feels for sensing"*. Neuropsychologists also mentioned written diaries as important part in MEST training, P6:*"the diary is just on a piece of paper, within the support group, they help each other inside […] If they do it as homework, they will write them down, or they talk about it during the training session or in a group interventions context"*. Interestingly, no participant has mentioned helping their clients to collect and store these individual diary notes into a diary notebook for later retrieving.

4.4.2 Standardized materials. Other self-relevant materials include self-generated personal triggers from general training materials, such as the feeling wheel mentioned by P3 (utilizing feelings wheel [54]): *"(I) let clients identify triggers [such as] pleasant and unpleasant triggers. Then I get them to validate the feelings they noticed. After that, I let them to realize where they identify in the body, and then get them to notice the input, and then help them to cope with the next step"*. P2 also mentioned using paper-based ABC worksheet [53] to help her performing cognitive behavior therapies. The idea of these standardized materials is to trigger clients' personal feelings of thoughts.

MEST [41] also uses a list of standardized word-based cues for helping clients practicing generative memory retrieval, usually from neutral word-based cues to more challenging positive word-based cues. MEST also utilize negative cue words for training clients' cognitive flexibility in memory retrieval, especially in disengaging from rumination [35].

5 Discussion

We now revisit the research questions and highlight the novelty of our findings. As suggested in prior research [24,46], memory technologies should be designed to strategically address users' memory impairments and support related memory functions, albeit we know little about how these can be achieved for people living with depression..

Previous work suggests that most memory technologies focus on supporting memory impairments at EM level by triggering direct retrieval (e.g., episodic memories, lost or forgotten [15,23,27,32,45]). This however, is not a memory impairment associated with depression [51]; depression is associated with three distinctive impairments at AM level [13]. By exploring psychological approaches addressing these impairments, we found a few lab-based interventions [22], which have been however limitedly adopted in clinical contexts. We now report findings on how approaches from both clinicians and neuropsychologists address each memory impairment in their work with people living with depression.

We have found that: 1) For the negative bias, clinicians appear to use approaches focused on improving clients' ability to retrieve both positive and negative memories, reframe negative memories, as well as encode both newly generated positive memories and reframed negative ones. 2) For addressing overgeneralization,

neuropsychological approaches mostly help clients to improve their ability to retrieve episodic memories with enough specific details, while CBT approaches addressed negative-biased overgeneralized thinking (e.g., breaking a negative thinking pattern) by improving clients' ability to retrieve positive memories opposing their negative thinking. 3) Reduced positivity was addressed through increasing clients' ability to retrieve positive memories, fully relive and enhance them, as well as to encode these enhanced positive memories for later retrieval.

We have also found that clinical approaches mainly use standardized training materials, while some therapists utilize sensorial materials to trigger emotional response of certain memories for addressing them specifically. However, these specific cues may come with potential risk of harming clients by triggering strong, negative feelings that are, described by P1: "*too painful [for clients] to even talk about*". While other clinicians utilize users' written diaries as part of training, however yet integrate them for long-term tracking and enhancement of training effects.

6 Design Implications

We now discuss the design opportunities for addressing the key challenges of each memory impairment in depression: *negative bias, overgeneralization* and *reduced positivity*.

6.1 Positive Memory Banks for Active Encoding and Selective Retrieval

Our findings indicate the significant and pervasive use of positive memories for addressing all memory impairments in depression. However, an important outcome is that the value of these positive memories is associated less with their retrieval, and most with their active and purposeful encoding. For example, clients are encouraged to notice and record positive daily events, or positive memories marking progress in their treatment progresses, as well to plan and engage in pleasurable events. Clinical practice however provides limited support for the caption and materialization of these memories. We can think of novel classes of memory technologies to purposefully support *active encoding* by identifying positive affective experiences, prompting their elaborate encoding, and rewarding the growth if these positive memories as a powerful resource to draw from in future. Moreover, as the precious moments, fewer and farther apart when depressed people do experience positive moods, are particularly valuable for prompting encoding, biosensor-based interfaces thus could offer new exciting opportunities in this space. In a critique of the total recall enabled by lifelogging, memory technology researchers have called for the importance of *active* curation, i.e., active process of annotating memory records [25]. With respect to depression, our findings further emphasize the importance of active, or purposeful user engagement, by extending it earlier in the memory processes at the encoding stage.

Our findings also emphasize the importance of selective retrieval of positive memories, an aspect less recognized in HCI memory work. Previous findings have shown that retrieving positive memories can be problematic for depressed clients [13,14] who at the time of retrieval are experiencing negative moods, as it can trigger rumination [37], and comparison with one's past worsening thus the present negative mood [30]. We argue for the importance of novel technologies that can adapt the retrieval of positive memories to the current emotional state of the depressed person and particularly address rumination. For example, we can imagine technologies that prompting people to identify and retrieve positive memories as counterexample for the ruminative thoughts. In turn, this can support a more balanced perspective of life including both positive and negative experiences, and increase the accessibility and value of positive memories for breaking ruminative thinking patterns. We can also think of novel memory technologies that can address the challenge of direct retrieval which, as an effortless process, can easily be hijacked by rumination [13,14].

6.2 Novel Cues for Supporting Generative rather than Direct Retrieval

Our findings indicated that memory impairments in depression disrupt the generative retrieval process [12,13,51], Therefore, people living with depression may benefit more from interventions and technologies supporting generative retrieval rather than those supporting their unimpaired direct or cue-based retrieval[51]. In other words, the main challenge of people living with depression is accessing the episodic memory level within the autobiographical memory system rather than remaining stuck at the lifetime periods or general events levels. If they successfully overcame this challenge and managed to access an episodic memory, they have fewer difficulties recalling its specific details through the traditional cue-based, direct retrieval. As a result, people living with depression not only benefit less from the types of cues usually explored in memory technology research, but such cues can also be counterproductive: by prompting direct retrieval these cues interrupt the generative retrieval, preventing them from the opportunity to practice the latter process (which has shown positive effect in alleviating depression [22,41]).

Most technology-based cues, and in particular those captured through lifelogging technologies, record episodic events, and therefore supporting the direct retrieval. However, people living with depression need a new type of cues to prompt their generative retrieval. The only evidence we have about such cues is provided by MEST intervention where generic cues, often word-based are used to support it. Interestingly however, we have seen therapists' efforts for augment such cues with content relevant for their individual clients such as magazine from the 1990s when the client was working in IT industry. We argue that such important cues can in fact be supported by technologies, as long as their content remains generic, i.e., about lifetime periods or general events, rather than specific. i.e., about episodic

memories. For instance, we can imagine new techniques for integrating, summarizing, or visualizing technology-captured episodic cues into high-level representations of general event or lifetime periods within which the specific episodic content remains unrecognized. We can also imagine new techniques for identifying among one's lifelogging data ontologies of objects inferred from distinct yet related episodic events, which can be used to construct cues for generative retrieval. This would imbue these cues with much needed self-relevant content. Or we can think of such cues for generative retrieval as consisting of meta-data of captured emotional episodic events. Findings also indicate that these cues for generate retrieval work better when accompanied by scaffolding questions. For this, one can imagine conversational agents [19] which guiding the memory search towards the episodic level of AMS.

6.3 Novel Interfaces Stregthening the Reliving of Positive Episodic Memories

We have already discussed the importance of selective retrieval of positive memories while accounting for people's current emotional states, and that in negative moods, such retrieval should be carefully leveraged. In contrast, the moments when depressed people experience neutral or positive moods can be fully leveraged for prompting retrieval of positive memories. In addition, findings also indicated that such positive memories are not only difficult to access but they also are less vivid and experientially embodied. Such insights open up new design opportunities for memory technologies. We can imagine novel, rich, expressive and multisensorial interfaces that could strengthen the *felt-life* quality [36] during retrieval of one's positive memories. In turn, such increased reliving could further strengthen positive self-identity.

7 Conclusion

Our study explored three memory impairments in depression such as *negative bias*, *overgeneralization*, and *reduced positivity*. By interviewing 10 clinical and neuropsychological experts, we identified effective approaches for addressing the challenges of these impairments; approaches grounded in both theory and clinical practice. Our findings open up new design opportunities for memory technologies tailored to the needs of people living with depression. These include positive memory banks for active encoding and selective retrieval, novel cues for supporting generative rather than direct retrieval, and novel interfaces to strengthen the reliving of positive memories.

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