Exploring Memory Interventions in Depression through Lifelogging Lens

Chengcheng Qu
Lancaster University
Lancaster, UK
c.qu3@lancaster.ac.uk

Corina Sas
Lancaster University
Lancaster, UK
c.sas@lancaster.ac.uk

Depression is a major affective disorder with significant socio-economic cost. Distinctive autobiographical memory impairments in depression include overgeneralization, negative-bias, and repetitive negative thinking. A few psychotherapeutic interventions have been purposefully designed to address these impairments, albeit they benefit from limited technological support. This paper reports an analysis of four memory-based interventions proven effective in the therapeutic practice targeting depression. We also explored the memory impairments addressed by these interventions. Our findings led to three design implications for digital tools in this space. We suggest the value of supporting enriched positive memory recall, negative memory reappraisal, and future episodic imagination.

Memory impairments, depression, overgeneralization, negative bias, rumination, lifelogging technologies

1. INTRODUCTION

With significant social and economic costs, depression is a major affective disorder impacting over 300 million people worldwide (WHO, 2012). Depression influences cognitive functions leading to distinctive memories impairments (Köhler et al., 2015). People living with depression have overgeneralized autobiographical memories with a strong bias towards negative events (Dalgleish et al., 2014). Several interventions have proven effective in addressing such memory deficits in depression (Table 1). These consist of Memory Specificity Training (MEST) (Raes et al., 2009), Concreteness Training (CNT) (Watkins et al., 2012), Competitive Memory Training (COMET) (Korrelboom et al., 2012) and Imagery Cognitive Bias Modification (CBM-I) (Holmes et al., 2013).

Most HCI research on depression has focused on developing computerised cognitive interventions, such as online Cognitive Behavioural Therapy (CBT) (Coyle et al., 2007 and Doherty et al., 2012). Limited work, however, has explored how memory technologies could support memory-related cognitive challenges in mood regulation, especially

for preventing and alleviating depression. This is surprising given that lifelogging technologies could capture and effectively support autobiographical memory retrieval through records of pictures, audio, or affective states of memories (Van den Hoven et al., 2008 and Sellen et al., 2010). This paper explores four psychotherapeutic interventions for memory impairments in depression and the feasibility of augmenting them with digital tools (Table 2).

2. RELATED WORK

2.1. Mental Health in HCI

Much HCI research has explored prevention, detection and treatment of mood disorders, with a focus on emotional and behavioural responses. For example, social media has been used to detect depression (Tsugawa et al., 2015), while digital affective diaries (Konrad et al., 2016) and expressive writing method (Pennebaker et al., 2017) have been developed to support monitoring and reflecting on one's experience. Technologies have usually been intended as aids for traditional therapeutic

Table 1. *Four interventions targeting memory impairments in depression*

Intervention	Main procedure	Addressed memory deficits
Memory Specific Training (MEST)	*Guided by trained therapists, this intervention presents a series of cue words, and asks people to retrieve as many specific memories as possible*	*Overgeneralization*
Concreteness Training (CNT)	*This intervention requires people to repeatedly imagine the sensory details, warning signs, and actions related to difficult events and to reflect on them in a concrete manner.*	*Overgeneralization, rumination*
Competitive memory training (COMET)	*This intervention asks people to identify a positive self-identity, enrich it iteratively and practice such imagination over several sessions.*	*Rumination, negative bias (negative self-image)*
Imagery Cognitive Bias Modification (CBM-I)	*This intervention asks people to imagine themselves involved in prescribed scenes. The scenes start ambiguously and are resolved positively.*	*Negative bias (future-oriented scenario)*

interventions, harnessing the potential of augmented reality (Wrzesien et al., 2015), interactive games (Coyle et al., 2011), or multimedia positive self-portraits (Mynatt et al., 2001). More specifically regarding depression, HCI work has focused on online CBT (Coyle et al., 2007 and Doherty et al., 2012) for delivering digital training content. Limitations of these approaches are twofold. First, they have focused mostly on the affective and behavioural aspects of mental health and less on its cognitive aspects. Second, the few studies exploring cognition-based interventions in depression, such as online CBT, have employed technologies with limited interactivity, personalisation, or user engagement (Doherty et al., 2012).

2.2. Memory Technologies

Much HCI work has explored the value of lifelogging technologies in memory augmentation, by supporting memory capture and retrieval. Such technologies harnessed wearable sensors including, for example, SenseCam (Hodges et al., 2011), narrative clip (Viet Le et al., 2016) or biosensors (Sas et al., 2013) to cue retrieval of autobiographical memories. Such exhaustive and multimodal capture underpins the effectiveness of lifelogging technologies in addressing memory impairments (Sas et al., 2015). Lifelogging tools have also been explored in relation to progressive neurological disorders, which lead to significant memory impairments, such as Alzheimer's disease and dementia (Harvey et al., 2015, Allé et al., 2017 and L. Lee and K. Dey, 2008).

However, unlike other conditions involving memory challenges, memories of people living with depression are not necessarily impaired but rather difficult to access from the autobiographical memory structure (Conway, 2005). As Conway identified in his autobiographical memory model, the accessibility of specific episodic memories depends on one's working self, which is a complex set of self-images and active goals. Difficulty in memory retrieval is an important marker of depression (Dalgleish et al., 2014). Such difficulties consist of overgeneralized memories leading to biased interpretation and imagination of future events, as well as negative-biased memory retrieval. More specifically, people with depression have unique difficulties in retrieving specific episodic memories. They have a high tendency to truncate their memory-searching process and only recall overgeneralized memory in a negative tone, with a low level of specificity (Williams et al., 2007). Another distinctive memory impairment in depression is that negative memories are faster and richer to retrieve, while positive ones are slow and difficult to retrieve, less vivid and low in emotional response (Dalgleish et al., 2014). Thus, people living with depression may benefit little from simply reviewing sensory details of their memories prompted by lifelogging-based cues. They require a rather complex process to enhance their abilities in recalling and reflecting on their memories, to re-experience positive emotions associated with their happy memories and disengage with the negative emotions from their sad memories.

3. METHOD

Our study consists of an analysis of the four identified memory-based interventions proven effective in alleviating depression in lab settings. The selection of the four interventions: CNT (Watkins et al. 2012), MEST (Raes et al., 2009), COMET (Korrelboom et al., 2012), and CBM-I (Holmes et al., 2013) is based on the findings of a recent meta-analysis of autobiographical memory based interventions for depression (Hitchcock et al., 2017). Our analysis aims to reveal the main cognitive challenges addressed by these interventions, in terms of the cognitive abilities targeted by each intervention, especially for coping with emotional events and memories. The aim is to explore if and how lifelogging tools could better support these interventions.

Table 2. Four interventions and their potential of integrating with lifelogging technologies.

Intervention	The key value to memory abilities	Input		Output	
		Current	*Lifelogging-augmented*	*Current*	*Lifelogging- augmented*
MEST	*Enhancing specific memory recollection*	*Emotional cue words*	*Bank of emotional memory cues*	*Verbal discussion*	*Visualize a bank of recollected specific emotional memories.*
			Personalized emotional cues		
CNT	*Reviewing memories and change viewpoint*	*Audio training& first-aid relaxation guide*	*Bank of negative memories to be analysed*	*N/A*	*Identify user's negative thinking pattern. Detect and offset rumination from an early stage*
			An interactive guide for reflection on negative memories		
COMET	*Enhance positive memories recollection, build a positive self-image*	*Self-generated materials*	*Bank of positive memories across the lifespan*	*Imagery positive self-image*	*Visualize an ideal self-image with enriched sensorial details.*
CBM-I	*Enhance positive current/ future imagination with everyday scenes.*	*Neutral scene via audio or pictorial materials*	*Personalized ambiguous scenes from "editing" users' everyday neutral scene*	*N/A*	*Visualize users' imagination as training result (e.g. painting).*

4. FINDINGS

4.1. The Challenge of Recollecting Specific Episodic Memories

MEST and CNT both pointed out that people living with depression suffer from categorical memory recollection in a negative tone. The overgeneralization process stops individuals from reflecting on what had happened, but instead keep processing abstract negative memories. Overgeneralization, as an indicator of depression, could persist even after remission from depression and potentially contribute to the next depressive episode. As an intervention specifically targeting this cognitive vulnerability, MEST trains participants' ability to retrieve specific episodic memories in detail. It provides word-based cues associated with different emotional valence, to break people's categorical negative thinking. CNT trains participants' abilities for reviewing specific negative memories and for re-evaluating them to mitigate against overgeneralization.

4.2. The Challenges of Building a Positive Self-image

People living with depression tend to have negative views of their lives, keep revisiting their negative life events, and feel like only bad things happened in their life. The negative-biased view contributes to their negative self-image, as pointed out and addressed by COMET. According to Conway's autobiographical memory theory (Conway, 2005), people evaluate and interpret their present and future scenarios by retrieving relevant memories. Therefore, as addressed by CBM-I, people who hold a negative view of their lives tend to interpret events in a consistently negative way, which contributes to their low motivation and hopelessness. During COMET intervention, participants first identify negative self-identity and imagine an incompatible positive self-identity. They then strengthen this positive self-image by progressively adding verbalisation, body postures, background music, and facial expressions. CBM-I exposes participants to neutral scenes, presented acoustically and visually, and asks participants to imagine a vivid positive ending to the described neutral scenes. This intervention also engages people in positive imagination.

4.3. The Challenge of Disengaging from Negative Thoughts

Due to cognitive weaknesses such as negative bias and overgeneralization, people living with depression have difficulties in disengaging from repetitive negative thoughts. CNT supports people to review and reflect on specific difficult events and

analyse the triggers of negative emotions. This intervention also encourages participants to explore alternative solutions and to alter the viewpoints of their upsetting memories. COMET trains participants' ability for retrieving positive memories as alternative material against negative thoughts. The increased accessibility of positive memories could reduce the possibility for negative memories to hijack one's cognitive resources.

To summarise (Figure 1), these findings indicated that memory-based interventions could benefit from lifelogging technologies. Key here is to identify the right cue content, which should (i) address negative bias (Dalgleish et al., 2014), (ii) address the identified challenges of the above interventions, and (iii) leverage the potential of lifelogging tools to enable personalized, self-tailored and more engaging interventions (Doherty et al., 2012).
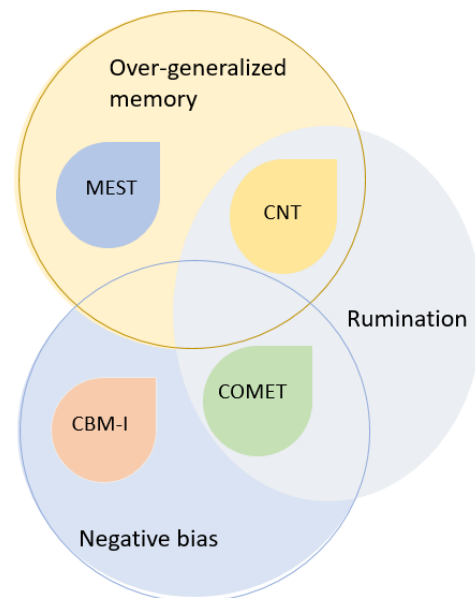

Figure 1. This figure illustrates target symptoms of each intervention: MEST and CNT target overgeneralization. COMET and CBM-I aim to reduce negative bias, while CNT and COMET aim to reduce rumination.

5. DESIGN IMPLICATIONS

5.1. Supporting Sensory Rich Positive Recall (Challenge 1, 2)

As pointed out by MEST and COMET, people living with depression face difficulties both in retrieving positive memories and in reliving associated positive emotions. They tend to have insufficient positive memories to build a confident self-concept against their negative one. Therefore, one can think of new tools for capturing and archiving positive events across the lifespan. Such a multimodal bank of positive memories, captured through biosensors could be deliberately tagged with sensorial contents, for example, audio, visual, or haptic, close to the

moment of encoding. Such a positive memory bank has the potential to contribute to vivid positive self-imagination. It can also strengthen people's memory processing abilities, especially the encoding of positive episodic memories. This in turn can safeguard people from the offset of depression.

Unlike generic cues used in MEST intervention, this positive memory bank, with enriched personal memories could provide powerful self-relevant cues (Sas, 2018) simulating the memory-encoding context, which also harnesses the context-dependent quality of memory for better recall when the contexts of encoding and retrieval are similar (Tulving, 1973). Personalized training modules, as pointed by previous online mental health intervention research (Doherty et al., 2012) is also important for user engagement. In addition, a bank of positive memories could support the visualisation of users' training progress and provide them with a sense of achievement.

5.2. Supporting Reflection on Negative Memories (Challenge 3)

The above interventions point out a design space for supporting reflection on mood journal. As previous HCI studies about mood journals revealed (Konrad et al., 2016 and Hollis et al., 2017), simply reviewing previously written memories is not enough for mood regulation. Designers of such systems also need to consider the mood dependent context and human memory weakness (Sellen and Whittaker, 2010). For example, findings from mood journal studies (Konrad et al., 2016) have shown that reflecting on positive memories in sad moods could potentially taint the happy memories and induce joy-killing thoughts. Findings also indicated that revisiting negative memories from digital affective diaries (Hollis et al., 2017) contributes little to both momentary and long-term mood improvement, although it has proven effective in pencil and paper based studies (Pennebaker et al., 2017) for inducing re-appraisal, self-distancing and wellbeing.

Thus, it would be useful to support users to reflect on their memories in a more structured manner by replacing their previous free-style of reflection. For example, CNT inspires a design opportunity for a novel interactive system that explicitly facilitates reflection and sense-making, by integrating natural language processing techniques such as conversational agents for guiding such reflection in a concrete style. If used along the lifespan, the system may allow early identification and correction of negative thinking patterns. The system is promising for detecting negative thinking patterns at early stages of rumination. Such a system could thus offsetting the negative influence of recalling traumatic events, and potentially preventing the depressive episode to set off.

5.3. Supporting Positive Reinterpretation and Imagination (Challenge 2)

Our findings indicate the value of CBM-I training in supporting the positive interpretation of generic ambiguous events. As suggested in HCI mental health research (Doherty et al., 2012), personalisation is key to user engagement. We can thus think of exploiting lifelogging technologies for collecting self-relevant everyday neutral events or "editing" anticipated ambiguous future events to train positive interpretation. For example, when users want to reflect on an emotional event, the system could remove the colour of a captured pictorial cue and ask users to i) colour the picture themselves, and then ii) draw an imaginary positive ending of this ambiguous scene. This process, inspired by mandala colouring as art-therapy (Palmer et al., 2014) could lead users to an engaging future-oriented positive imagination practice. Authoring tools can also be envisaged to assist people in capturing their interpretation of such events over their entire lifespan. Users could thus pay more attention to their everyday scenes and be more engaged in the present (Keyes, 2014).

We argue that technologies such as lifelogging are well suited to address the negative bias in depression. However, more effort should be put in leveraging potential of such technologies to address overgeneralized memories, especially identifying positive memories as material to guard against negative overgeneralization. In addition, identifying neutral events to train positive interpretation could also have great potential in addressing memory impairments in depression.

6. CONCLUSION

This work explores the potential of lifelogging technologies to support memory-based interventions in depression. We report an analysis of four such interventions. Findings identified the cognitive challenges targeted by each of them, as well as their training procedures, materials and main limitations. We employed a "lifelogging lens" to this analysis and identified three design implications addressing the challenge of negative bias of memory retrieval and interpretation in depression.

7. ACKNOWLEDGEMENT

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