mirrorU: Scaffolding Emotional Reflection via In-Situ Assessment and Interactive Feedback

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Abstract

We present mirrorU, a mobile system that supports users to reflect on and write about their daily emotional experience. While prior work has focused primarily on providing memory triggers or affective cues, mirrorU provides in-situ assessment and interactive feedback to scaffold reflective writing. It automatically and continuously monitors the composition process in three dimensions (i.e., level of detail, overall valence, and cognitive engagement) and provides relevant feedback to support reflection. In a 24-subject pilot deployment, we found that such scaffolding and feedback could help users compose longer reflections with more positive emotion words as well as more insight and causal words. We discuss how the literature on emotional writing informed mirrorU's design, and highlight the major findings as well as the lessons learned from the pilot study.

Author Keywords

Emotional reflection; expressive writing; scaffolding; critical reflection; well-being.

ACM Classification Keywords

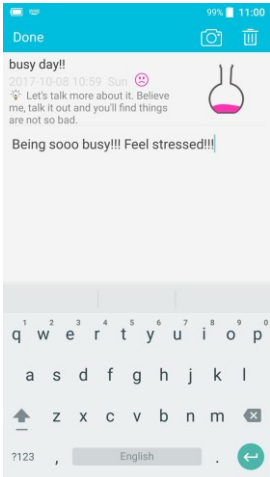H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Figure 1. The reflection writing interface.

Figure 2. A user initiates the reflective writing process by unlocking a phone using the slide-to-unlock gesture.

Introduction

A healthy physical flow means that we take in water and food from the environment, absorb nutrients for our body and expel wastes. Similarly, a healthy emotional flow means that we take in life events and experiences, keep nourishments for our mind and expel garbage. But many of us simply inhibit or hold back our thoughts and emotions, especially about negative experiences. Such emotional inhibition can result in a breakdown of one's social network, a decrease in working memory, sleep disruptions, and an increased risk for alcohol and drug abuse [3].

Keeping the flow of our experiences processed helps to keep us emotionally and physically healthy [3,8]. Emotional writing, aka expressive writing [8], is one way of accomplishing this. An increasing number of studies demonstrate that having people write about emotional upheavals (both positive events and negative events) can result in healthy improvements in psychological, social, and biological functioning [1,6,8]. While reflecting and writing about positive events can increase self-esteem, improve mood and ability to enjoy life [9], writing about negative or stressful events is also associated with significant reductions in stress and long-term improvements in mood [8]. The advance of Natural Language Processing (NLP) technologies enabled language explorations into previous writing studies. Such post-hoc textual analyses have revealed that the content quality of emotional writing matters—reflections with *more detailed descriptions*, *more positive emotion words* (e.g., happy, laugh), and *more insight and causal words* (e.g., understand, because, which suggest higher level of cognitive engagement) are associated with relatively higher improvements in

physical health and working memory [6], as well as drops in intrusive thinking about negative events [8].

Inspired by these psychological findings, HCI researchers have shown an increasing interest in designing systems to support reflection in different context. Many of them provide explicit support for everyday life reflection in written format [1,4,5]. These systems take different roles in supporting the reflection process, including semi-automating the diary entry creation by incorporating sensor data [4], providing memory triggers and emotion cues [4,5], and achieving better integration in everyday life [5]. However, relatively few research has been done on supporting and coaching the writing processing itself. While previous language explorations have shown that linguistic features of *unmediated* writing can predict improvements in mental and physical health, can we provide in-situ scaffolding to help people compose more critical and effective reflective writings? Moreover, can such *computer-scaffolded reflection* result in higher improvements in health and well-being?

In this paper, we present mirrorU (Figure 1), a system that provides in-situ assessment and interactive feedback to support daily reflective writing. Specifically, our system automatically monitors the reflection generation process in three dimensions (i.e. level of detail, overall valence, and engagement in cognitive process) and provide relevant feedback to scaffold the writing process. In a 24-subject pilot study, we found that such scaffolding and feedback could encourage participants to compose reflections with more details, more positive emotion words and more insight and causal words. We highlight the major findings as well as the lessons learned from the pilot study.
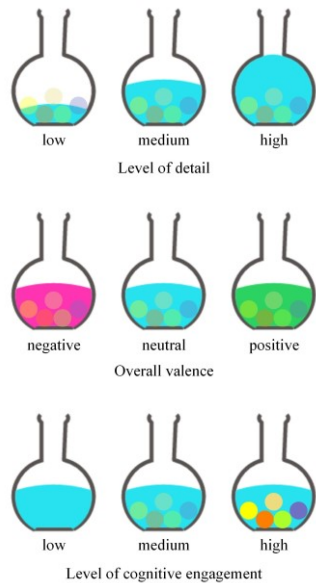
Figure 3. The visual representation of each dimension, at each of the three levels. To emphasize the visual changes for each dimension, the dimensions not being shown are set to 'average' or 'neutral'. There are 27 (3x3x3) possible states in the current implementation.

Related Work

The interest in the expressive writing paradigm has grown over the years—there are over 200 studies published in English language journals [8]. In this paradigm, people are asked to reflect and write about the emotional events for several minutes on a daily or weekly basis. Compared with writing daily routine topics, writing about emotional events can result in significant reductions in distress and healthy physical improvements [8]. The power of writing, however, cannot be explained by a single cause or theory. One promising explanation is based on A-to-D Emotion Theory [6], which suggests that verbally labeling an emotion is like applying a digital technology (language) to an analog signal (emotional experience)—only when the event is adequately represented in language format, it can be cognitively understood and resolved, which can further release the cognitive capacity it takes up. Results of recent textual content explorations via NLP technologies are consistent with this theory: writings with *more detailed descriptions* (suggesting adequate language representation of events), *more positive emotion words* (suggesting positive reappraisal of events), and *more insight and causal words* (suggesting deeper cognitive process) are associated with higher physical and psychological improvements [6,8].

Research in HCI has shown the potential of systems to support everyday life reflection. Echo [1] supports both recording new life events and reflecting upon previously recordings, and can improve well-being as assessed by four psychological metrics. Pensieve [5] uses prior Facebook status posts or general prompts as *memory triggers* and asks users to write down their reactions. Similarly, AffectAura [4] leverages multi-modal affect recognition and visualization techniques to provide *affective cues* for users to reflect and write about the most

intense emotional experience. Our work advances and can work together with state-of-the-art approaches by enabling in-situ scaffolding and coaching for the writing process itself. We address the research gap by exploring 1) whether such scaffolding can help people generate more detailed writings with indicators of stronger positive valence and deeper cognitive process; 2) whether such technology-scaffolded reflection can result in higher health improvement compared with unmediated reflections.

Design of mirrorU

mirrorU's has two main functions: to remind people to reflect, and to scaffold people's writing during composition time. Users can initiate the reflective writing process by unlocking a phone using the slide-to-unlock gesture (Figure 2). We modified the unlock gesture to enable 1) single-slide unlock journaling of current mood; 2) quick start of emotional writing. This design is inspired by previous work [11], which indicated that such unlock journaling was perceived as less intrusive and could yield greater frequency compared with traditional collection method (e.g., notification). We believe this design can lower the threshold to start writing. Meanwhile, journaling the current mood can further stimulate them to continue writing more to explain their selections.

When a user starts writing about the emotional event, mirrorU continuously monitors the writing process in three dimensions: level of detail, overall valence, and engagement in cognitive process. We use an *emotion-bottle* metaphor to visualize the progress in these dimensions (Figure 3). mirrorU also provides relevant textual feedback to encourage the user to write more details, more positively, and better engage in the cognitive process. This design is in part inspired by
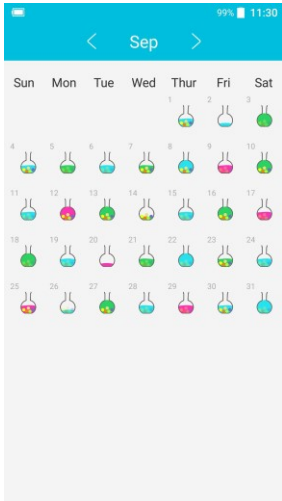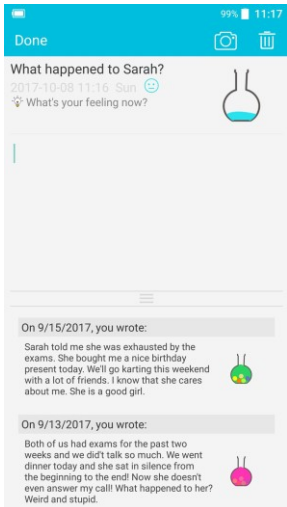
findings on providing feedback in student reflective writing [1], which suggest instant quality feedback can help students construct longer and higher quality reflective responses in large classrooms. The user can optionally add a photo or a video in addition to texts.

mirrorU also encourages users to revisit and reflect on previous reflective writings. This feature is designed upon previous research findings that *repeated exposure* to a writing topic is a more potent strategy than topic-switching in the expressive writing paradigm [10]. A user views her previous *emotion-bottles* in a calendar view (Figure 4), and can select any entry for further reflection and writing (Figure 5).

Quality prediction algorithm
We leverage the SVM machine learning classifiers with linear kernels to monitor the quality of writing. We define the writing quality in three dimensions and each dimension has three degrees: level of detail (low, medium, high), overall valence (negative, neutral, positive), and level of engagement in cognitive process (low, medium, high). Features include word unigram (i.e. whether a word is present), word count, part-of-speech count (e.g., whether a proper-noun is present), and a variety of statistics generated by LIWC [7], a linguistic analysis tool which was initially created to analyze essays from emotional writing studies and can calculate the usage of words or word stems in various categories, including negative/positive emotion words, insight words, causal words, verbs, self, etc.

To train the models, we first built a corpus via collecting the emotional writings from 37 participants. They were asked to write about their daily intensely emotional experiences for one month. They did not get any system feedback during the writing process. In total, we got 772 writing samples. Two raters independently labeled the samples in three dimensions based on a coding rubric which was built upon the findings from previous studies on linguistic analysis of emotional writings [6,8]. The agreements between them were high (Cohen's kappa was 0.83 for level of detail, 0.87 for valence, 0.79 for level of cognitive engagement). Disagreements were settled by discussions between the two raters.

We trained three classifiers, one for each dimension we wanted to monitor, using the ratings on that dimension. Since each dimension has three degrees, each classifier is a three-way classification model. After training the three classifiers, we conducted leave-one (writing sample)-out validation. The overall accuracy was 85% across three dimensions (86% for level of detail, 93% for valence, 76% for cognitive engagement), which indicated that the classifiers were able to predict the state of the current draft in these dimensions.

Textual feedback generation
In addition to visual feedback, mirrorU also provides relevant textual feedback based on the current draft to support reflection. For example, when the emotion conveyed in the current draft is very negative, the system tells the user "*everything has two sides and let's try to see things in a positive light*". When the draft is lack of detail, the systems encourages the user to "*write more about it and then free your mind*". mirrorU pre-loads N hand-crafted responses (N>5) for each state (a total of 3x3x3=27 states). Based on the state of the current draft predicted by the classifiers, mirrorU randomly selects one out of the N responses during runtime to maintain the diversity of feedback.

Pilot Deployment and Major Findings

We conducted a 24-participant pilot deployment to investigate the usability and efficacy of mirrorU. We applied a between-subjects design with two conditions: no-feedback (**NF**) and in-situ-feedback (**IF**). Participants installed the assigned version of mirrorU and were asked to reflect and write about their positive or negative emotional experience three times per day for one week. We recruited 24 participants (10 females) via personal connections, Wechat, and Facebook, with the promise that their writings will not be linked to their names. Their ages ranged from 19 to 56 (mean=26.7). In total we collected 456 writing samples.

In the rest of this section, we highlight the major findings as well as the lessons learned in our pilot deployment. We defer the in-depth analysis of the experimental results to future work.

Finding 1: *The quality feedback can help participants write longer reflections with more positive emotion words, more insight words and more causal words.*

Overall, the participants generated an average of 19 reflective writings, or 2.7 per day: 2.9 for IF users and 2.5 for NF users (no significant difference). We use word count as the metric for the level of detail, since previous research shows that it correlates indirectly with the number of details in experience sampling. We use the number of positive words and the number of insight and causal words as metrics for the overall valence and the level of cognitive engagement, following previous studies on linguistic properties of emotional writings [8]. T-tests on the outputs of LIWC [7] showed that IF participants wrote significantly longer (35.9 vs. 23.2, $p<0.01$) reflections with more positive emotion words (8.2% vs. 5.4%, $p<0.05$) and more insight and causal words (5.1% vs. 3.0%, $p<0.05$). These results confirmed that providing in-situ scaffolding during composition time can impact the both the writing behaviors and the final contents.

Finding 2: *The quality feedback is perceived by participants to be helpful.*

We interviewed participants to understand how they perceived the system feedback and how the feedback changed their reflection. Overall, participants responded positively and found both the emotion-bottle metaphor and the textual feedback to be helpful. Sample responses include:

- *"I always fill up the bottle and it is like a reward—you write more, you get more."* [S10]
- *"It encourages me to dig deeper why I was mad…I often felt calm and relieved afterwards."* [S3]

Finding 3: *The current color representation for emotion can be confusing.*

Participants all agreed that the textual feedback was helpful in encouraging them to change perspectives and seek benefits when writing about negative events. However, three participants complained about the color representation in the current visualization design. Specifically, using green color for positive emotion and blue color for neutral emotion can be confusing. To address this problem, we added an emoticon (Figure 1 and Figure 5, below the subject line) to represent the current valence in addition to the color coding in the emotion-bottle. In the future, we will further explore metaphors to better represent emotions in this context.

Finding 4: *Participants occasionally game the system.*

We observed minor gaming behaviors (e.g., typing random letters) by analyzing user interaction logs and interviewing participants. The main reason they reported was "*feeling curious how the system works*" [*S1*]. In the future, we will 1) investigate the impact of such gaming behaviors on the reflection process; 2) monitor the writing process in more dimensions and provide more diverse feedback to reduce boredom; 3) explore gaming behavior detection and correction methods to guide users to the right path.

Discussion and Future Work
We present mirrorU, a mobile system that supports *scaffolded* emotional writing by providing in-situ assessment and interactive feedback based on the current draft. In a 24-subject pilot deployment, we found that such scaffolding and feedback could help participants compose longer reflections with more positive emotion words and more insight and causal words. Although the preliminary results are promising, several important questions remain unaddressed: 1) whether such in-situ scaffolding impacts users' intrinsic motivation for emotional reflection; 2) whether and to what extent such *scaffolded emotional writing* can improve well-being as assessed by psychological metrics.

References
1. Fan, X., et al. Scaling Reflection Prompts in Large Classrooms via Mobile Interfaces and Natural Language Processing. In Proceedings of IUI2017.
2. Isaacs, E., et al. Echoes From the Past: How Technology Mediated Reflection Improves Well-Being. In Proceedings of CHI2013.
3. Lepore, S. J., et al. "It's not that bad: Social challenges to emotional disclosure enhance adjustment to stress." Anxiety Stress & Coping 17.4(2004):341-361.
4. Mcduff, D., et al. "AffectAura:an intelligent system for emotional memory." In Proceedings of CHI2012.
5. Peesapati, S. T., et al. "Pensieve: supporting everyday reminiscence." In Proceedings of CHI2010.
6. Pennebaker, J. W., et al. "Linguistic predictors of adaptive bereavement." Journal of Personality & Social Psychology 72.4(1997):863.
7. Pennebaker J. W., et al. Linguistic Inquiry and Word Count 2001[J]. Lawrence Erlbaum Associates Mahwah Nj, 2001.
8. Pennebaker, J. W., & Chung, C. K. (2011). Expressive writing: Connections to physical and mental health. In H. S. Friedman (Eds.), Oxford handbook of health psychology (pp. 417-437). Oxford, England: Oxford University Press.
9. Seligman, M. E. P., & Csikszentmihalyi, M. (2000). Positive psychology: an introduction. American Psychologist, 55(1), 5.
10. Sloan, D. M., et al. (2005). Further examination of the exposure model underlying the efficacy of written emotional disclosure. Journal of Consulting and Clinical Psychology, 73(3), 549-554.
11. Zhang, X., et al. Examining Unlock Journaling with Diaries and Reminders for In Situ Self-Report in Health and Wellness. In Proceedings of CHI2016.