Designing for Self-Tracking of Emotion and Experience with Tangible Modality

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ABSTRACT

Self-tracking technologies have been developed to understand the self. Emotions are critical to understanding one's daily life; however, tracking the emotion is challenging due to the implicit form of data. In this paper, we introduce MindTracker, an approach for tracking emotion through a tangible interaction with plasticine clay. We explored the benefits and challenges of MindTracker via a two-week data collection study with 16 college students as well as via interviews with three clinical mental health experts. MindTracker is designed for users to craft a form that represents emotion using clay and to describe the experience that evokes the emotion using a diary. We found that the tangible modality of MindTracker motivated the participants to express various aspects of emotions. In addition, MindTracker's data collection and reflection process could have therapeutic properties, such as expressive therapy, self-soothing, and emotional self-regulation. We conclude this paper by discussing the design features of emotion-tracking tools and opportunities to use MindTracker to promote mental health.

Author Keywords

Self-tracking, emotion, mental health, MindTracker

ACM Classification Keywords

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

INTRODUCTION

Self-tracking tools ranging from diaries to wearable trackers have impacted the process of collecting and reflecting on personal information. The purpose of self-tracking is to gain self-knowledge through the reflection of gathered information [15]. The advent of self-tracking tools has allowed people to both automatically or manually log various aspects of their daily lives to improve their health and well-

being [10]. Self-tracking tools produces a variety of personal health information, ranging from automated recorded fitness activities collected through embedded sensors (e.g., a pedometer, an accelerometer, or a GPS) to user-generated food and medication logs.

Previous personal health informatics research has predominantly focused on physical activities that are often represented as explicit forms of data (e.g., steps counted, running distance, or calories burned). While there has been significant investment in self-tracking of physical activities, little is known about the methods for tracking one's emotional states (e.g., mood, stress, or depression), which are ambiguous but critical to understanding mental health. In this regard, we seek a deeper understanding of what an "emotion tracker" might be like. Research in this area is still new, with current technologies primarily targeted at assessing a person's mental health state using physiological parameters such as voice [16], or self-reported mood scale [17]. However, these deterministic and diagnostic tracking trends, in turn, reduce individuals' engagement with the data collection as well as self-reflection [21]. In this paper, we seek to design new ways of self-tracking technology that can engage users in the process of emotional data collection and reflection to better support mental well-being. To this end, we proposed to embed tangible modality—a mode that allows users to track their emotion through tangibly crafting an artifact—into the process of emotion tracking.

We begin by providing background on self-tracking practices for emotions. Also, we discuss the relation between form and emotion as well as the potential of tangible modality to express one's emotions. We then propose MindTracker, an approach to expressing invisible emotions by crafting a tangible clay form that represents one's state of mind. Focusing on college students' mental well-being, we examined the benefits and challenges of emotion data collection and reflection via MindTracker with 16 students and three mental health professionals. Our findings indicate that the novel data-creation method with tangible interaction engaged our participants in the activity of data collection and reflection, Meanwhile, our tracking approach provided therapeutic interventions such as expressive therapy and emotional self-regulation. Building upon these findings, we identify design properties of new types of emotion data tracking techniques as well as further design opportunities to

employ the emotion tracking technique in a broad context—mental healthcare.

The contributions of this work include:

- The development of a novel emotion-tracking approach that adds a tangible modality to the data-collection process.
- An empirical study to validate the concept of MindTracker from the perspectives of students and experts.
- The identification of design features of emotion-tracking tools in general and opportunities for the use of MindTracker to promote mental health in a clinical setting.

RELATED WORK

Self-Tracking and Mental Well-Being

Self-tracking including sensing and tracking technologies has been widely developed with a desire of understanding oneself [7]. Many studies have been done in the fields of personal informatics and quantified self, to identify effective data-collection methods. Health-related self-tracking methods range from automated recording of physiological conditions to semi-automated or manual tracking [3]. Previous research in this area has predominantly focused on tracking physical activities. Understanding one's affective state, however, is as critical as understanding one's physical state for achieving in-depth understanding of oneself. Recent tendencies in health research represent the significance of mental well-being, especially dealing with depression, anxiety, and stress as the main topics [24]. For instance, Health Mashups [3] was built to integrate various sources of health and well-being data, including weight, sleep, step count, calendar data, location, weather, pain, food intake, and mood. The field study on Health Mashups revealed that contextual information supports data collection and reflection. The aforementioned mental health studies imply the importance of continuous monitoring of emotional states coupled with an individual's daily experience.

Approaches to Tracking Emotion

Recent efforts in HCI have emphasized tools to automatically monitor and assess a person's mental health state using physiological parameters (e.g., heartrate [18] voice [16], and face logging [25]). However, Rooksby et al [21] reported that such "diagnostic" data tend to be isolated from the lives that people lead. The tracking approach, in turn, reduces opportunities for proactive data collection and self-reflection. To address the remaining limitations in the traditional personal informatics model, researchers conceptualized personal tracking as "lived informatics" by highlighting the exploratory nature of data coupled with everyday life [9,10,21]. The playfulness of data creation is also considered a novel form of tracking. In this regard, our aim is to develop an approach that motivates people to engage with data creation and gain an understanding of data that are relevant to their emotional states.

A growing number of studies have highlighted that understanding the state of affect is necessary for mental well-being [2,3,16,24]. Affect is a broad range of feelings that people often experience in a form of emotions or moods. As defined by Santos et al [22], *emotions* are short-lived feelings that comes from contextual stimuli and can be mapped into diverse dimensions, while *moods* are longer lasting either positive or negative affect caused by unclear factors and that are comprised of multiple specific emotions. Self-reporting is a commonly used method of assessing the degree of affective state. One study monitored collective moods in workplaces to enhance managers' emotional intelligence through an interface for self-reporting [17]. Another study has investigated the self-assessment technique which is accessible via smart watch [11]. However, sustaining users' motivation to collect data is difficult with self-reporting, and it does not support users in expressing emotions that are ephemeral, subtle and subjective. There have been efforts to complement self-reporting by adopting technologies that automatically collect continuous emotional data [5,6,16] Although we can measure affective state and use the data for diagnostic approaches using these technologies, these technology-driven tracking approaches might reduce the chance of "exploration," which is a critical part of understanding oneself [21]. Enabling people to explore their emotions in a form of self-recognition and self-expression would significantly enhance their level of understanding about themselves. Thus, we propose that emotion tracking offers an invaluable opportunity to realize a more sophisticated form of self-understanding.

Emotion, Form, and Tangibility

In the domain of design research, a variety of work has linked visual dimensions of form to invisible properties such as emotion. To provide deeper understanding of the correlation between emotion and form, Isbister et al. created a set of biomorphic objects in clay (e.g., a bubbly form) that represent certain feelings such as happiness [12]. The participants of that study were asked to use the objects to express their emotions in the context of assessment and communication. Melcer et al. examined the embodiment of emotion in form and provided a taxonomy of affective dimensions of shape [20]. For example, sharp and spiky shapes convey frustration, while rounded shapes represent contentment. In this study, clay played a key for creative expression because it maintains fine-grained details of shape while it does not require highly skilled manipulation or tool use. This study reveals that expressing feelings with the objects increased engagement because doing so allowed for flexibility and tangibility—the sense of touch. Recent research has investigated the tangible modality as a tool for detecting stress via mindless gestural inputs such as squeezing, rocking, and rolling [1]. Tangible objects are also used to cope with stress [14] and increase mindfulness [23].

A conceptual breakthrough for MindTracker came during the ideation session, when we discovered the close relationship between emotion and form with tangibility described above.

To support the sophisticated form of self-understanding, we applied the properties of tangible modality to collect data about emotion. Existing self-tracking of one's mentality has largely depended on the self-reporting method, which has several limitations in producing a satisfactory outcome, as mentioned earlier. There have been subsequent attempts to track people's emotions in more indirect manners, but they do not seem to put much weight on physiological and behavioral sensing, which might isolate data from their context. Thus, we investigated ways of tracking and contextualizing emotions to improve mental health.

METHODS

In this section, we describe the process involved in the MindTracker study. We specify the design of the MindTracker Kit and the participation process. Then, we discuss the analysis process.

The Design of the MindTracker Kit

Our research goal was to design novel approaches for tracking emotion data. We began to imagine possible designs to make emotions visible. Specifically, we wanted to convert intangible forms of emotion into a tangible medium. Through our literature review, we realized that form creation with a flexible material such as clay would facilitate the realization of emotion. This initial insight led us to explore the opportunities of using tangible mobility to elicit and visualize emotion.

We propose the concept of a tool that allows people to log their emotions and experiences on a daily basis. Dubbed the MindTracker, this initial approach was intended to track emotions by having users keep reporting short-lasting feelings and emotion-provoking stimuli for a certain period. We designed a MindTracker study kit to investigate whether this approach is appropriate for documenting emotions, as presented in Figure 1. The MindTracker study consisted of three parts: (1) constructing a form of emotion with plasticine clay, (2) writing a detailed explanation about the form of emotion and the reason why the participant created it, and (3) charting the trend of emotion.

The MindTracker kit is simply composed of a box and a workbook. The box contained instructions informing the participant how to collect data, a chunk of plasticine clay, and a card for charting changes in the participant's mood over a two-week period. The workbook was designed for noting detailed descriptions of emotion to relate the actual meaning of the emotion to the clay forms. Specifically, the workbook provided a template for structured reporting. The template included a space for (a) placing a created clay form to take a picture, (b) naming a constructed form of emotion, (c) scoring the emotion on two scales (five-level) for positivity and negativity, respectively, and (d) describing the reasons or experiences that evoked the emotion. Using MindTracker in an empirical study, we sought to learn what emotions people decided to track, how they tracked the emotions, and how they perceived the logged data.
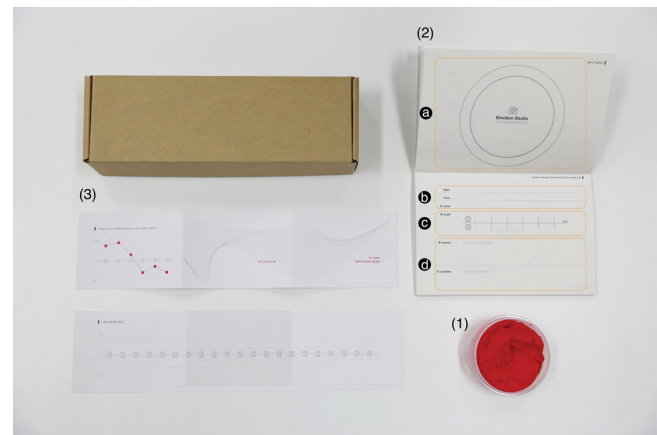

Figure 1. MindTracker Study Kit

The MindTracker Study

We conducted a two-week data collection study with 16 university students to understand their lived experience with MindTracker. At the end of the study, we conducted follow-up interviews with each participant to elicit feedback about MindTracker. To gain expert opinions about the validity of MindTracker, we organized a special focus group interview session with a psychiatrist, a clinical psychologist, and a counselor employed by a university healthcare center.

Recruitment

We wanted to explore the potential of MindTracker with people who have a need for tracking their emotions in their daily lives. Previous studies reported on the increasing mental health issues among young adults who are at risk for stress and academic pressure [19,26]. Thus, we decided to start with younger participants, such as college students, whose everyday lives are in some ways structured but also dynamic between studying and socializing.

The participants were recruited at a large university through flyers, word-of-mouth, and internal social media sites. While 22 students volunteered for the study at the initial screening phase, 16 (eight females and eight males, with a mean age of 23.1) finally confirmed their participation. Eight participants were undergraduate students, and the other eight students were graduate students. The participants had a variety of study majors, including Business, Chemistry, Design, Industrial Engineering, Material Science, and Physics. We launched a two-week study that included a week of final exams to introduce common variables that could incur emotion changes from students' day-to-day lives. For participating in the study, the participants were paid $50 for data collection with MindTracker during the two weeks and an additional $10 for participating in a follow-up interview.

Study Procedure

We held several informal meet-up sessions with participants just before starting the study to instruct them on how to collect data, what data to collect, and when to collect data. We then provided each participant with a MindTracker kit. To provide a prompt response to participants' questions

about the study, we created a study account with the most popular smartphone instant messaging service among university students.

Over the course of two weeks, the participants were encouraged to record their emotions at least three times per day. We sent reminders through the mobile messaging service to remind the participants about the MindTracker study and to motivate them to record their emotions. The messenger sent a reminder at a somewhat random time to avoid similar emotions from being evoked by routinized experience. Upon receiving a reminder, the participants were expected to (1) make a 3D piece with clay to express the emotion they felt at that time, (2) score the emotion on five-point scales of positiveness and/or negativeness, (3) write a description of the clay piece in the notebook, and finally, (4) take a photo of the 3D clay piece and immediately send it to the study messenger account.

After the second week, each participant took part in a follow-up interview. The purpose of the follow-up interviews was to encourage the participants to reflect on their participation in the MindTracker study, expand on the context of specific clay pieces, and work through experiences pulled from the workbook. We asked them about their overall experience with MindTracker, the benefits of MindTracker for recording emotions, the practical and technical challenges of the study, and the effects of tracking their emotions for two weeks. The materials used during the follow-up interview included the pictures they sent and their workbooks. In this session, the participants also created a mood graph based upon the positive and negative scores they gave to each emotion.

Analysis

As a result of the MindTracker study, we collected a dataset of 616 forms of emotion with accompanying descriptions that contextualize each emotion. On average, each participant created 38.5 sets of emotion data over the two weeks (2.8 emotions per day), perhaps providing some evidence of their level of engagement in the MindTracker study. We discuss this theme in more detail in the next section. To ensure anonymity of the data, we eliminated any identifiable information from the raw data. We created a set of cards by translating handwritten scores and descriptions, which became our units of analysis. Each card contained a photo of a clay form, the affective score of the emotion, the description of the emotion, and further comments from the interview transcriptions.

We conducted a thematic analysis of our data [4] through a data workshop with eight students majoring in design. Our primary interests were in what kinds of emotion people chose to express using MindTracker, why they expressed the emotion with a particular clay form, and how they perceived the emotion. We proceeded by categorizing and coding the data based upon the primary interests. By doing this, we generated a taxonomy of the shape of the emotions across different participants. We finally presented the general trend of data to the three clinical experts, who provide mental

Figure 2. Affinity analysis of the 3D clay pieces and descriptions.

healthcare services for students at the university where we conducted this study, to validate the quality of the data and to explore potential opportunities for designing emotion-tracking tools to serve clinical needs.

FINDINGS

With MindTracker, we wanted to uncover whether the approach we used motivates people to collect emotion data, what types of emotions people want to capture, how they embody emotion in forms, and how they interpret the logged data. In the following sections, we present examples and descriptions that best capture the core themes that emerged in analysis. We begin by describing the various motivations guiding participants' emotion data collection through the MindTracker study. We then highlight how the participants generated data, especially the mapping of emotion into a 3D form along with three approaches. Then, we present the taxonomy of forms representing emotions. We also discuss the value of MindTracker perceived by participants.

General Orientations

We were surprised by our enthusiastic participants who provided 616 emotion forms with scores and descriptions over the course of two weeks. We were concerned that the intensive schedule among the students during a week of final exams might affect the data collection. Most of the participants, however, constantly created data. For some participants, MindTracker itself was a pleasing experience. During the study period, three participants inquired if they could report emotions as many as they want. Two participants proactively reported emotions even before receiving the reminder. P7 reported, *"I was concerned that the [MindTracker] study might be burden on me because the schedule was overlapped with my final exam week. Surprisingly, I really enjoyed the study for two weeks, and it helped me recognize my emotion through crafting and writing."*

Clay as an Instrument for Creative Expression

The novelty of data collection—a combination of form and journal—acted as an engaging factor. Plasticine clay was a material with which most of the participants were familiar. During the instruction session for the MindTracker study, participants showed a positive reaction to the clay, and some immediately opened the box to touch the clay. One participant mentioned that clay reminded her of her childhood. P3 said, *"I made a lot of things with clay when I was young. It reminds me of how I liked this and how I was creative when I was young."*

The participants were able to construct the shape of an emotion without limitations because clay is a highly accessible material for artistic expression and improvisation. As P10 explained, *"I had no confidence in making at the beginning. I had no idea what to make over the first few days, so I decided to just play with clay and make random items around me, like flowers and cups."* He then described several benefits of clay: *"Clay is simple. There's no skill required. It is also flexible, which means I can make anything quickly. I especially love the feeling this clay gives me. It's soft and gentle, which makes me calm."*

Similar to the participant above, six other participants commented on the benefits of clay as a tool for expressing ideas. They commented that using the clay was better than drawing on paper to express their emotions freely. P2 said, *"Making a form using clay is different from drawing. It is reversible. I can destroy it if I don't like it and then make another one. If I were asked to draw my emotions, I couldn't do so."* This accessible nature motivated the participants to make a number of forms and seek sources of ideas. Making three-dimensional forms with clay allowed many of the participants to express what they felt and experienced without barriers.

Motivations: Dynamics of Emotion and Memorable Events
The motivations for recording emotions using MindTracker centered around two general themes: recognizing the dynamics of emotions at a glance and capturing short-lasting feeling with specific experience that stimulate the feeling. P15 explained his motivation for participating in the study: *"I am eager to look at how my emotion changes on these kinds of tough days. That's why I decided to participate in this study. I look forward to seeing the shapes of my emotion, especially when I am taking final exams."* P7 mentioned that final exam week was the most active period for her in recording her emotions: *"That period [finals] was stressful. Through what I made and what I wrote, I tried to know whether I was fine or not during that period."*

Motivated by the MindTracker study, P1 expressed that he would keep collecting his emotions and experiences after the study: *"MindTracker seems to me like mood journaling, and it's a great tool for daily logging. I wouldn't do that if I was doing only the written part of journaling, but making a form associated with my emotion and scoring the emotion made me do it three times a day. I will keep track of my feelings using this strategy."* The participants liked the idea of embodying emotion in a form and naming the form to describe the nuance of that emotion. When they browsed the workbook in the follow-up interview session, they felt proud of what they had created. P5 said, *"I wish I could upload all the pictures of my forms to my Instagram. I want to showcase them. [...] Also, I would like to see how others construct forms about similar emotions."*

Approaches to Constructing Clay Shapes
The vast majority of the data on MindTracker were related to emotions or experiences at the moment of creating the

form. Our data workshop allowed us to establish a taxonomy of shapes to represent the intended emotions or experiences. We found that the participants embodied their emotions in forms in three distinctly different ways. First, an **abstract** form represented a nuance of emotion with a shape that was not accurately defined. The forms in the abstract category had a degree of independence from visual references in the world. Second, a **symbolic** form depicted a figure of a specific subject from the participant's surroundings to represent the intended emotion. Forms using metaphors are included in this category. Third, a **scene** form illustrated a specific situation, state, or experience that prompted the emotion. We categorized 610 constructed shapes, not including six situations in which the photo of the shape was not included. Of these 610 shapes constructed by the participants, 198 shapes (32.1%) were created in the abstract form; 309 shapes (50.2%) were created using a symbol; and 103 shapes (16.7%) were created using the scene format.
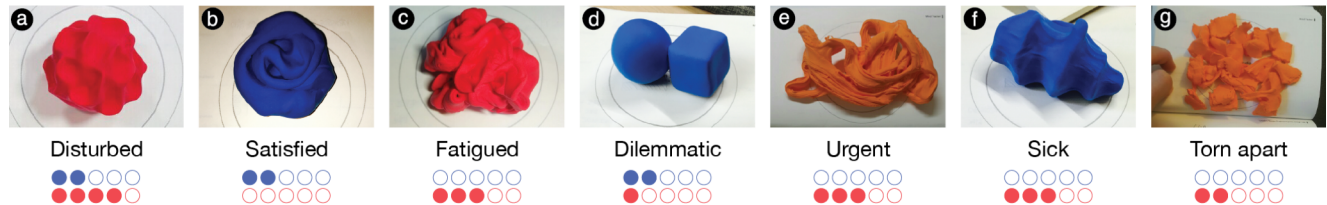
Abstract
We categorized the 198 *abstract* expressions of emotion into three subgroups: untitled or implicit shapes, geometric shapes, and shapes expressed by a gesture or a motion. The participants created 138 shapes using their own language that expressed how they feel and think about a particular emotion (see *Figures 3.a, 3.b, 3.c*). We could not completely understand these figures without supplementary explanation. For example, in *Figure 3.b*, P2 constructed a filled-in shape to express the emotion of satisfaction. The participants also created 24 geometric shapes, including basic 3D or plane models (e.g., a cube, sphere, rectangle, or circle; see *Figure 3.d*). The other 36 shapes employed a gesture (e.g., cutting, extending, grabbing, hitting, tearing, twisting) that participants used to show the emotion itself (see *Figures 3.e, 3.f, 3.g*). For example, in the case shown in *Fig 3.f*, P13 constructed a shape by grabbing, which was intended to express sickness. We focused in particular on the shapes created by gestures because the participants primarily used gestures to express negative feelings in 32 shapes (89%) of total 40 shapes created by gestures.
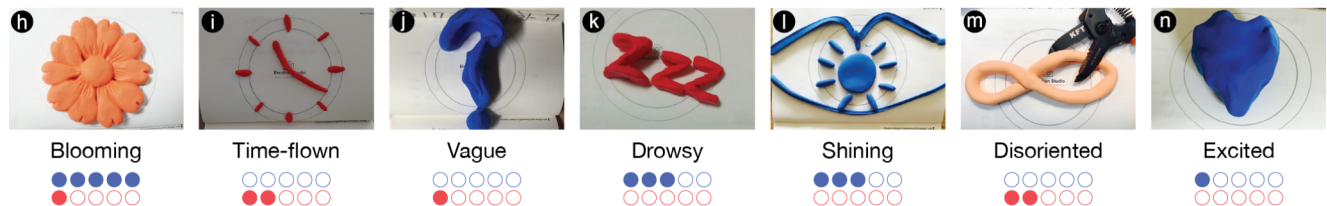
Symbol
For the emotions embodied using symbols, the participants constructed 309 shapes expressing a specific subject that could be discerned from their surroundings. The participants were often inspired by visual references in the real world. They expressed forms with a *symbol* when they wanted to explain the reason for an emotion or a medium that reminded them of other experiences. In comparison, the participants used 274 shapes to describe the exact shape of the subject (see *figures 3.h, 3.i, 3.j, 3.k*). For instance, in the case shown in *Fig 3.i*, P3 created a clock shape to express the feeling of time flying. Thirty-five other shapes were created with a transformed subject using other materials (*figures 3.l, 3.m, 3.n*) to express a more specific emotion (e.g., pouring water into clay, decorating the clay object with a real flower, or cutting off part of the clay). In the case of *Fig 3.m*, P5 added scissors to express a feeling that he or she wanted to cut tasks

ABSTRACT

| a Disturbed | b Satisfied | c Fatigued | d Dilemmatic | e Urgent | f Sick | g Torn apart |

SYMBOL

| h Blooming | i Time-flown | j Vague | k Drowsy | l Shining | m Disoriented | n Excited |

SCENE

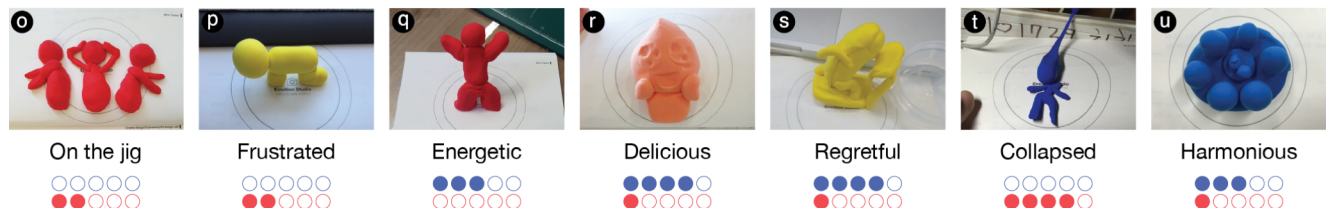| o On the jig | p Frustrated | q Energetic | r Delicious | s Regretful | t Collapsed | u Harmonious |

Figure 3. A taxonomy of three-dimensional shapes of emotions. Seven examples in each category.

that never seemed to end. Additionally, we found that the participants most often used a symbol to embody an emotion when they found it difficult to directly express their emotions. For example, P6 noted, *"I felt a limitation of creativity for constructing new shapes from day 3, so I started to find examples to express my emotion in my surroundings."* P2 said, *"When I had no idea about how to express, I searched for an image from Google with a keyword that was related to my emotion."*

Scene
As for the embodiment of an emotion through a scene, we found that 103 shapes were created to describe an emotional state or action. Fifteen participants explained their emotional state with a self-projected human-like figure. The scene forms were separated into three subgroups depending on how the participants described the self-projected figure. Fifty shapes described the participants themselves as a human figure explicitly *(figures 3.o, 3.p, 3.q),* 27 shapes compared the participants to a symbolic subject that could express their situation more effectively, and 26 shapes simplified or exaggerated the figure. The following examples show differences among the subgroups using a scene to portray an emotion. In *Figure 3.o*, P3 used a human figure to represent himself. In *Figure 3.s,* P5 depicted an éclair exercising on a treadmill to express regret and compared himself to the éclair.

Finally, in *Figure 3.u*, P8 represented people who ate dinner together, including herself, in the shape of a sphere.

Perceived Benefits of MindTracker
Our participants perceived several benefits while creating forms, observing the collected data, and interpreting data for insights to take action for their mental well-being.

Data Collection as an Expressive Therapy
We found that collecting emotional data had therapeutic properties which could provide an opportunity for interventions such as self-soothing and mindfulness. Several participants mentioned MindTracker as being a self-soothing tool that could enhance mindfulness. Our focus on touching clay to construct the shape of an emotion was helpful for relieving stress and provided comfort. P5 noted, *"I could relieve stress when I touched clay, so sometimes I spent time with the clay regardless of the experiment."*

Writing also can enhance self-awareness [13]. As P7 mentioned, *"The MindTracker was my emotional ventilation tool. I was mad at [my friend] because he canceled our dinner an hour before. I took out my MindTracker set to record my extreme anger, but I realized that I was quite relieved from the stress while making the shape and writing down the situation. I might need a cool-down time, and MindTracker offered me that chance."*

Goal Setting for Mood Management

A fitness tracker helps a user to set a specific goal, such as increasing step counts to maintain or improve health. We found that MindTracker might provide a similar opportunity for setting a specific goal related to emotions and mental health. The participants liked the idea of rating their emotions along the five-level scales of positivity and negativity. Checking the scale for the degree of the emotion and writing a detailed explanation of it could help the subjects recognize their emotional state objectively. P6 mentioned, *"I could recognize my accurate emotional state when I checked the scale and wrote the reason for the emotion."*

Charting their emotions helped the participants set a short-term goal for mood management. When they recognized negative or depressed feelings over a long period of time, they tried to formulate methods to overcome these feelings. P5 noted, *"I intentionally called my mother and friends to relieve stress and feel comfort when I realized I was depressed from the graph and MindTracker workbook."* P12 also said, *"When I recorded my emotions in the morning, I was able to tell today would not be good, so I set today's goal as overcoming my negative feelings until dinner by eating delicious food."* P2 mentioned, *"I had a lot of pressure from my final exams. When I recognized my negative mood, I tried to identify a reason for my stress. However, I realized that I couldn't get rid of the reason, which was final exams. The only way I could do so was concentrating on preparation. So, I came up with self-rewarding activities which I will do after the exams."* Through the participants' interviews, we determined that they tried to manage mood and unstable factors through self-rewarding, communicating with others, and increasing their productivity.

Summative Reflection

A fitness tracker showing analyzed and visualized data is an important motivator that encourages users to improve their lifestyles [7]. Similarly, we found that the participants in this study could reflect feedback from the results of the collected emotion data. The resulting graph played a key role in showing the flow of emotions during the experiment. When we reviewed the graph with the participants in their interview session, they could understand the trend of their emotion changes. Also, they could recognize triggers and contexts that affected this change. P1 noted, *"I could remind myself of the events that affected my emotions from the graph. I think final exams started this day and ended that day because I felt somewhat negative during that time period."*

Our participants were surprised by the unexpected graph results that differed from what they thought during experiment. P2 said, *"I guessed that I was entirely in the negative moods throughout last week, but I am surprised there are many positive feelings in this graph."* This process also allowed the participants to objectify their emotions. P14 answered, *"I could make myself more aware of my emotions through the graph that shows the entire flow of my emotion*

changes. I realized that I am a person with heavy mood swings through the graph, which shows a great change in mood." Revising the data even after the completion of data collection is the foremost part of self-reflection. Therefore, the summarized data supported the participants to reflect on their emotions and encouraged self-awareness, while providing a key factor in the future design of an emotion tracker.

Expert Validation

We conducted semi-structured interviews to complement the study findings with expert perspectives. We interviewed three mental healthcare experts who worked in a university health care center to elicit feedback about the potential use of MindTracker in a clinical setting.

A psychiatrist (E1) stated that the MindTracker study could somewhat serve as an expressive therapy: *"Expressing emotion as itself has a natural effect of relieving stress. This [MindTracker] could allow your participants to understand themselves as they make, describe, and perform the situation stimulating the stress."* E1 also highly valued the use of soft clay to convey emotion. Compared to a drawing activity, constructing a clay form would be more accessible for those who are reluctant to express emotion: *"In our therapy sessions, we attempted to motivate our patients to express their feelings and describe the reason behind the feelings. To do this, we sometimes asked patients to draw something they want to express if they feel it is hard to say. However, they even felt pressure from drawing because they think they are not good at drawing and are afraid of being evaluated. But, the clay would help our patients easily initiate the expression.*

We were told that recognizing the current state of and reason for an emotion is an important factor for dealing with emotion data. As E2, a counselor, explained, *"Understanding the current state of an emotion is the first step to understanding myself. But, it is more important to figure out the reason why that emotion was evoked. I think the activity of writing a reason is necessary. I believe that, in many cases, this activity can provide a 'breathing space' for emotional self-regulation."*

A clinical psychologist (E3) remarked on the importance of continuous charting: *"It is very important to recognize and objectify emotions when we deal with mental health. Showing the entire emotional flow and reminding the subject of events triggering an emotion is a good method for objectifying the emotion."* According to E3, the emotion tracking could be similar to a self-regulation process that is comprised of expressing a short-lasting emotion through clay creation, recognizing the trend of mood through charting emotions, and taking an action.

All three experts suggested that the MindTracker kit could be used as a mediating tool for the period between making a reservation and treatment. There is a lag between a patient's first visit to make a reservation and the actual treatment—usually a week to four weeks, due to long waiting lists. E2

mentioned, *"Students should wait for at least one week. I am really concerned about students who need urgent care. I know many students are likely to visit this center when they feel completely devastated."* E2 suggested that the use of MindTracker on a regular basis could provide early intervention effect that might help patients overcome stress. Furthermore, patients who visit the health center are asked to fill out a 20-page self-reporting mental health assessment sheet at their first school's mental health clinic visit. Thus, MindTracker could be used as a field and long-term data-collection tool between clinical visits.

MindTracker was also depicted as a potential prevention method. The visual aspect of the clay forms could help clinicians easily detect disruptive signals at a glance. While reviewing data with the experts, E2 pointed to a photo of a clay form depicting a "hangman" with a five-point negative score and asked, *"Can you refer this participant to us or can you tell her or him to make an appointment with us? I really want to meet because this figure seems to say 'help me'."* Although we did not intend to design Mindtracker for examining or diagnosing an individual's mental health state, the clinical experts suggested further opportunities to recognize risk factors from the scan of clay forms with the aid of automation.

REFLECTIONS ON MINDTRACKER
The analysis of experiences with MindTracker presents the desire to keep track of emotions with personal experiences. Our participants engaged highly in the practice of tracking comprised of collection and reflection of emotion-related data with MindTracker. The process of making forms with soft and flexible material augments the ability of users to express themselves. MindTracker's tangible modality affords users an opportunity to embody their emotions in a variety of forms, including abstract, symbol, and scene forms. MindTracker also served as a self-healing tool by providing a moment of mindfulness and as an expressive therapy that supported the objectification of subjective experiences. Furthermore, visualizing emotions helps users to recognize their exact state of mind and to gain knowledge of themselves. Our participants also highly valued the moment of summarization, which allowed them to observe a trend in mood changes over two weeks. Our mental health expert participants suggested how MindTracker could support their clinical practices. In particular, MindTracker could serve a tool for gathering and tracking contextual data between clinical visits. We will now consider some wider reflections about the essential properties of MindTracker and how we can improve upon and employ the new emotion data-tracking technique in our daily lives as well as in the context of mental health care.

Properties of Emotion Tracker
We found that the properties of our emotion-tracking tool are similar to those of a fitness tracker, which collects user-generated data and shows analyzed visual data to the user. MindTracker allows for the collection of emotion and experience data and reflection on the results through visual data.

In this paper, we propose effective data-collection methods via recording materials with a tangible modality. The tangible modality feature is helpful for expressing emotions through shapes of things. However, it is not a technology for sensing emotions on an automatic level. Rather, MindTracker can motivate users to think about and recognize their emotions accurately by themselves. Motivation provides an important reason for using a tracking tool to record data continuously. Just as we can expect stress relief through touching a tangible modality, the beneficial effects of the compiled data will motivate users to record their emotion data continuously. Also, this method could have high accessibility for a broad range of age groups, as it can be used easily without needing highly skilled manipulation.

On the other hand, tangible modality has another benefit in that it provides sources of inspirations. Our participants reported that it would have been difficult to articulate how they feel if they did not have clay at hands. While playing with clay, they easily came up with ideas and created stories around the form they created. In addition, clay creation allows users to keep consistency of ways to reporting data, which are inherently subjective and varied in individuals. By scaffolding data types with clay, MindTracker could facilitate not only emotion tracking but also analysis of data being collected.

Considering that a workbook is used for providing detailed explanations, a recording tool for capturing the contexts triggering emotions is necessary to support exploring emotions which will lead to emotion regulation [27]. The process of emotion regulation includes: (1) recognizing the current state or event, (2) generating emotions from evaluating the state with the event, and (3) shaping an appropriate experiential, behavioral, and physiological response. The records of contexts by writing details and trends of mood change in graph represented by scoring could support users to objectify events that generate an emotion for managing future situations.

MindTracker to Promote Mental Health
Our study with students and clinical professionals shows that MindTracker can be used as a supporting tool to promote mental health. In this regard, we suggest three opportunities for the use of MindTracker by: (1) supporting data collection between clinical visits; (2) facilitating communication between clinicians and patients; and (3) supporting self-care to prevent disruptive moods from becoming chronic.

First, the MindTracker kit could be further developed as a lived data collection tool for the period between making a reservation and a treatment, which requires at most four weeks for interpreting the self-report survey and due to long waiting lists. The experts expressed a high demand for resources to tackle this issue because students are likely to visit the center when they need immediate services.

MindTracker could supplement the healthcare center's resources in various ways. First, by virtue of its self-tracking and awareness capabilities, MindTracker might empower an individual to be able to become her own counselor. Second, it could provide qualitatively improved data by overcoming the limitations of many self-report surveys that are not best for identifying latent problems among patients. In addition, the tangible interaction with a soft clay could be a type of emotional regulation activity that reduces nervousness, stress, or anxiety. Besides being used to collect data between clinical visits, MindTracker could also provide a chance for the preparation of the visit. Users could analyze the states of emotions and contributing experiences by themselves prior to the visit.

Second, the collected data could facilitate communication in treatment. A clinician and a patient suffering from mental health problems primarily communicate by talking. However, using only verbal communication prolongs the time needed to obtain a completed diagnosis of the patient, and the clinician may not be able to draw out sensitive issues. To overcome these limitations, clinicians often use expressive therapies (e.g., art therapy, sandplay therapy, music therapy, role-playing therapy) to open a patient's mind for detecting inner problems. Therefore, our participating experts suggested that the MindTracker study, which includes expressive therapy factors, can be an initiating tool for communication during diagnosis. The experts also imagined that the data from the patient's own experience including triggers and contexts would affect the likelihood of accepting the diagnosis. More importantly, MindTracker could be utilized to prevent stress from becoming chronic. As presented in our findings, an expert wanted to see the participating student who created a hangman figure and scored the emotion as five points negative. MindTracker provides an opportunity to monitor danger signals at a glance because it is visually represented. Previous studies on the relationship between form and emotion have suggested technologies for analyzing 3D shapes of form to understand emotion [20]. One can imagine an interactive system that automatically determines the emotion state by analyzing the shape of the emotion with visual recognition techniques. The system would be able to automatically classify data based upon a pre-defined model relating forms and emotions [20] or a machine learning algorithm that detects patterns of a vast amount of visual data being collected. In turn, it can notify users to visit a mental health care center when the expressed form signifies an extreme situation.

Finally, MindTracker could support self-care beyond clinical treatment. We found that the participants realized their emotional state by scoring the intensity of their emotions with scale and checking a graph that represents their overall changes. Then, they tried to set a goal to overcome their emotional state when they had negative feelings for a long time or in extreme negative feelings. They tried to refresh their situation through their own methods, like self-rewarding, communicating with others, and increasing productivity to evoke positive emotions. According to dialectical behavior therapy (DBT) [8], one strategy for regulating emotional vulnerability is accumulating positive emotions. Our experts also remarked that they had asked patients to keep thinking of positive experiences because emotions easily go away when they are no longer reinforced by positive consequences in action. Regarding the opportunity for interactive technology design, we could automatically obtain personal patterns of mood changes and keywords that trigger emotions using natural language processing (NLP) by digitizing the descriptions of experiences and scaled data. When depressive emotions or extreme mood changes are detected from a user, a system could provide a personalized reward to overcome the negative emotion by reminding them of experiences that evoke positive emotion.

POTENTIAL LIMITATIONS AND FUTURE WORK
Our study demonstrated some limitations and challenges. First, we recognized a variety of external factors that might affect the level of engagement with MindTracker and the validity of data participants reported. For instance, the reminding message we sent could be one of the contributing factors of participants' engagement throughout the study. Reporting emotions, however, was completely voluntary and had no additional incentives. As demonstrated in findings section, the total number of reported emotions indicated their willingness regardless a week of final exams, perhaps the busiest time of a semester. Also, participants reported they were highly motivated to track emotions because they wanted to understand how their emotions were affected by the stressful stimuli such as final exams.

Second, although participants were asked to report emotions they exactly felt at the moment of form creation, it is possible that the reported emotions might be affected by the practice of clay creations. Self-soothing effect is very encouraging, but quite unexpected because our primary focus was not on how the MindTracker can work as intervention, rather we were more interested in how participants express their emotions using the new type of emotion tracking tool. Nonetheless, we are excited to explore the effect of tangibility and expressiveness on emotional regulations in further studies.

We also recognized some practical challenges of the proposed emotion tracking approach. During the study period, participants were strongly encouraged to carry with clay and workbook and handwrite contextual information which might cause inconvenience. While our participants and clinical experts appreciated the value of manual input, we expect to reduce participants' physical burden by digitalizing input methods except clay construction when we develop interactive application built on the findings of this study.

CONCLUSION
We have explored the potential of technology to track one's emotions and experiences, which might be critical to mental

health. We proposed MindTracker, an approach that asks users to express their emotions using clay and describe their experiences in the workbook. We confirmed that the participants were highly engaged in this study. We found that representing their emotional image with clay was a chance for them to express their reactions in creative ways by creating abstract, symbolic, and contextual forms. The tangible interaction during the data creation allows for self-soothing and emotional self-regulation. As mental health issues caused by emotional stresses are becoming severe in the contemporary world, emotion tracking would work as a great tool for approaching this problem. Just as self-tracking in the fitness area contributed to increased physical soundness among people, emotion tracking will do the same to the remaining half: mental soundness. We hope this study will guide others in designing interactive technologies that improve mental wellness.

ACKNOWLEDGEMENT

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