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Master's Thesis
Academic Year 2021

Influencing Emotional Acuity and Expression through Acoustic Mood Self-Tracking

Keio University
Graduate School of Media Design

Darlene Hannah Jane Rasco Nolasco

A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

Darlene Hannah Jane Rasco Nolasco

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Abstract of Master's Thesis of Academic Year 2021

Influencing Emotional Acuity and Expression through Acoustic Mood Self-Tracking

Category: Design / Ubiquitous Computing / Empirical Research

Summary

Mood-tracking technologies face numerous challenges in the motivation and engagement of persons with affective disorders. Although useful as mechanisms for self-reflection and for facilitating treatment provided by caregivers, existing mood-tracking applications fall short in providing users with a reason to track their emotions; subsequently, they fail to supply them with the means to strengthen their emotional acuity. A majority of applications impose normative ideas of "good" and "bad," leading users to feel pressured to meet externally-derived standards unrepresentative of the uniqueness of their experience. There is a need for more engaging methods of tracking mood that empowers users to confront their emotions on their own terms. In response, this thesis explores a more interventional approach through "TENOR," an acoustic mood-tracking application designed to increase user involvement through music creation and emotional recall.

To validate the effectiveness of a creative-based emotion self-tracking platform, an experiment was conducted to measure the recall quality of users when interacting with two test modes: An experimental music creation interface with an accompanying 12-item emotional word bank, and an untreated version with only the emotional word bank available. The results of the experiment revealed a heightened interest in habitual mood-tracking when in regards to using the music interface; users also demonstrated consistent recall quality across valence and arousal states when reappraising emotions classified through music. A dampening effect on negative emotional states was noted, likely due to the delight factor presented by the music creation feature. Despite this, the outcome of the experiment builds upon the benefits of an untapped genre of mood-tracking, one that is worthy of exploration given its warm reception from users.

Keywords:

Human-computer Interaction, Ubiquitous Computing, Self-Tracking Technology, Mood-Tracking, Emotions, Mental Health, Emotional Acuity, Emotional Regulation, Emotion Reappraisal, Emotion Repression

Keio University Graduate School of Media Design

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To Panini, for turning me into a morning person by whining from the kitchen at eight o'clock in the morning, every single day, without fail—I don't miss when you used to do it at six. It was a questionable decision on my part to get a puppy while neck-deep in the process of completing a graduate thesis, but at the end it was to my advantage: You're very cute. As much as it put a strain on me, caring for you kept me sane.

To the version of me from fifteen years ago, who could scarcely put into words why the weight of her emotions far exceeded what others deemed acceptable—your feelings escaped you just as fervently as they broke loose from your chest like an avalanche dislodged by an errant step. Wasn't it tiring? As if you yourself were on the mountain as the snow spilled over. It took you forever to forgive yourself. Through no fault of your own, you spent years learning to survive the ache through incessant introspection—the process whittled you down to a sprig. It didn't make it hurt any less, did it? You just got better at holding it in your hands without flinching. This is for you and for others like you: I want this pain to end with us.

This work is dedicated to those who suffer for their inability to confront their emotions with the grace and aplomb that society expects of them. You are not faulty; you are underserved. For many of the enduring gaps in mental health research, it is my greatest wish to see this be the *beginning* of the end.

Chapter 1
Introduction

1.1. Background

As far as the subjectivity of the human experience goes, emotions may be one of its most elusive aspects. Although often categorized and many times plotted out and delineated, emotions are ultimately felt in unique ways distinct from person to person; just as the vividness of a certain color and the texture of a square of cloth may translate differently to someone outside of ourselves, feelings such as anger, joy, sadness, and frustration may also manifest through means that only we can fully comprehend and discern. In the realm of Philosophy, this is known as Qualia [1]. Emotion theorists have already studied this subjectivity and have even identified its ties to sociocultural dynamics [2].

The acts of measuring, tracing, and quantifying emotions are all fundamental to mental health research [3–5]. They've served as a vehicle for investigations into healthcare solutions for people with autism spectrum disorder and bipolar disorder [6–10] among other psychiatric illnesses, and have shown to be subjects of interest to even neurotypical individuals who see it as a method of improving their wellbeing [11]. Several studies in human-computer interaction have sought to integrate the study of emotion with novel technology: If we were to gaze into the present climate of HCI for mental health, we would find that a wealth of experimentation has largely gone into the self-tracking of affective states [12].

1.2. Motivation

The majority of these self-tracking tools focus on determining shifts in emotions as a way of identifying trends, mainly for the purpose of self-reflection and to support ongoing treatments administered by caregivers. However, two ventures remain un-

examined: First, the enduring problem of deteriorating mental health conditions in users upon seeing the results of their evaluation and finding that the data is not representative of the efforts taken to perform [11]; self-tracking imposes an ideal standard of "emotional stability" externally-derived from social mores [13], which present technologies have yet to address. Second is the unexplored territory of implementing built-in features for encouraging more emotional reappraisal and less emotional repression, which are both the usual methods of emotion regulation [14–16]. Reappraisal is not a process included in most mood-tracking tools, while repression is neither a factor of consideration. As both are deeply embedded in the practice of regulating and assessing emotions and has roots in the social functioning of individuals [14], it stands to reason that mood-tracking can benefit from probing into these behaviors.

1.3. Contribution

This thesis introduces an alternative approach to emotion self-tracking that does away with explicit binary classifications of "positive" and "negative" moods. To achieve this, it encourages users to express their feelings through music creation instead of using simply words or colors. Rather than foist an idea of "emotional stability" on users, the application's objective is to foster and influence their "emotional acuity," which is defined as the ability to accurately absorb and identify one's emotions. By these means, individuals are empowered to build their capacity to express and reappraise their affective states on their own terms, through an approach that is less invasive and less beholden to extrinsic pressures. In order to explore whether a creativity-based interface assists in mitigating repression and supporting reappraisal of emotions, the tool has a recall test system that measures the user's memory retention. In order to prevent the user from feeling a pressure to perform, results of their recall tests are not divulged—in this manner, confidence levels in their ability to remember past inputs are also examined by the experiment as a way to gauge whether the interface influences this aspect of the experience.

Chapter 2
Related Works

2.1. HCI for Mental Health

There is a rapidly growing body of literature surrounding HCI technology and interventions for mental health conditions. A foundational review [12] of the corpus of HCI for mental health research presented at SIGCHI conference proceedings in the decade following 2009 revealed 139 relevant papers out of 2775 texts; of these, 72 were published in the latter-most half from 2018 to 2019. A bulk of the studies were found to focus on technology for automated diagnosis and self-tracking of emotional states (e.g., depression scale), mental states (e.g., productivity, sleep hygiene), and physical states (e.g., fitness activity), while the rest referred to developments in biofeedback training, computerized cognitive behavioral therapy, and online social support systems.

Although efforts are being taken to introduce novel contributions that probe into the unique demands of individual affective disorders, there still remain a number of enduring flaws in the field that are in urgent need of intervention. Self-tracking technologies, in particular, carry numerous unaddressed concerns despite being the second most commonly examined field of focus.

2.1.1 The Fractured Landscape of Emotion Self-Tracking Technology

A surprising majority of existing self-tracking systems and system proposals target multiple stakeholders beyond the party afflicted by an affective disorder. While the objective of these platforms is to aid the user in self-reflection, the data collected is often shared with caregivers, family, and clinical staff either as a way to bolster the user's adherence to a course of treatment or to strengthen their social network

in order to provide them with more support [12].

In spite of the web of beneficiaries these technologies cover, a number of negative consequences have been shown to affect its users. One paper [11] that delved into the experiences of undergraduate and graduate student populations in the US reported that 36% of respondents who were made to use self-tracking applications for conditions such as physical exercise, bedtime and sleep quantity, class attendance, academic workload, and mood reported a profoundly negative reaction to their results as they believed it reflected poorly on their person: Users described a feeling of disconnect between their experiences and the representation of the data, as it often depicted results indicating poor or lukewarm performance despite them having given their best effort.

Similar outcomes emerged in a different analysis [17] examining women's interactions with weight loss tracking applications. Participants were found to have a disordered use of the platforms: Many reported obsessive logging of every food intake, a self-imposed pressure to be exact about their calories and macronutrients, a fixation on calorie control through the numbers reflected on the application, and restrictive eating. Users often manipulated the application by skipping or falsifying logs in order to avoid feelings of dissatisfaction and guilt, or would find themselves compensating for missed goals through excessive exercise or even vomiting. These behaviors mirrored that of individuals with an eating disorder (ED), despite the fact that these women were not diagnosed with an ED or were in a state of recovery from one for a significant period of time . As soon as the users realized their behaviors were unhealthy, they chose to switch to a different app or to stop using them entirely.

Another study [18] introduced an activity monitoring and sharing application for senior adults as a means of facilitating an active and sociable process of aging. Participants could share personal information (e.g. location, mood, health) to peers and caregivers indicated in a sociogram that they created themselves. The results of the experiment found that most participants were hesitant to disclose their mood data due to fears that peers may feel obligated to respond, but with unhelpful advice, or that medical professionals may consider the information as evidence of a deeper issue. Most significantly, participants believed that sharing negative moods will create a negative self-presentation that may change the

perception their peers have of them .

It could be said that many of these self-tracking platforms suffer from what is known as "data fetishism." The advent of self-tracking was jumpstarted by the Quantified Self (QS) movement that first began in 2007, when ubiquitous usage of wearable technology as a means of automatically obtaining data on one's everyday activities was said to guarantee an optimization of self-improvement and the maintenance of good habits [19]. There is a widespread belief that data is neutral and objective [20], thereby possessing an authority in illuminating certain details about ourselves that we may otherwise overlook without any technological intervention; however, quantification of the self is inherently reductionist, given that it fails to account for the fluid nonlinearity of natural human conditions such as mood, health, and productivity, and assumes normative ideals for what it means to maximize these states [21]. This phenomenon can be traced back to as early as 1993, when a case study on data-driven evaluation of infant daycare showed that neglecting to use qualitative methods in the analysis of human behavior leads to restricted findings out of touch with the complexities of reality—as it stands, it is impossible to codify the effects of non-maternal care without the presence of any theoretical and empirical investigation [22].

In spite of these glaring complications, self-tracking technologies have still shown some promise in the realm of mental health self-management, particularly for those with Autism Spectrum Disorder (ASD) and Bipolar Disorder (BD). Pervasive usage of a smartwatch that utilizes "implicit interaction" through automated sensing of inward and outward states revealed improved emotion regulation in individuals with ASD, as the data allowed them to access highly customizable therapy resources on their phones that were adapted to their needs, which would have otherwise only been accessible from their caregivers on physical paper [9]. In addition to this, self-tracking has shown to assist users with BD in identifying personal patterns and triggers faced in their daily lives, which furnishes them with the insights to refine their recovery strategies and gain the courage to overcome struggles with self-acceptance [7].

While well-meaning and advantageous in some regards, particularly in facilitating conversation with caregivers and improving self-discernment [7], it is evident that self-tracking applications lose serviceability when it makes the mistake of ex-

cessively quantifying and standardizing subjective experiences. These platforms also fail to account for the mental load involved in the self-tracking process, as well as the importance of managing users' self-perception and their perceived reputation among peers and caregivers.

2.1.2 Digital Music Therapy for Neurological Conditions: A Holistic Alternative

Music therapy has been a longstanding form of rehabilitation for a number of affective disorders and has even shown to have a learning effect on users. Several studies have remarked on its profound effects on emotional and psychological health: One usability study on mild to moderately severe Alzheimer's disease patients in Paris showed that the use of MINWii, a song improvisation game that utilizes a virtual keyboard, fostered powerful reminiscence in users and promoted positive interactions with their caregivers; users also manifested clear signs of learning as well as a mastery of the game in spite of physical or cognitive impairment [23]. In another study with children with autism, a tool called BendableSound, a multi sensory surface that can be manipulated to generate music, promoted tactile learning, motor development, and improved attentiveness in its users [24].

Technologies already exist that utilize music generation and listening for tracking mental health. Cove, a mobile application by Humane Engineering Ltd. that encourages users to create and label songs to express complex emotions, is one such application that assists in processing difficult feelings such as grief and bereavement [25]. Users select a general "mood" and then arrange notes and chords to design a short composition emblematic of what they feel at a particular point in time. Instruments and effects can be incorporated to find the precise sound that matches their disposition. These songs are then tagged and stored in a private journal. The application is an ongoing project in collaboration with National Health Service (NHS) England. Another identical application is Humm.ly, a platform containing music and guided meditations curated by both music therapists and music producers that was designed to assist users in mental and emotional healing depending on their needs [26]. The application monitors your heart rate

to gauge the effects of the audio on your disposition. At the time of writing, neither of these technologies have completed any scientific investigation in order to measure their impact.

2.2. Studying Emotions with HCI

Emotions play a huge role in our interaction with technology and have been taking on an increasing significance in the design of user experiences [27]. Even affective cues as simple as apologetic on-screen messages can inspire lower levels of frustration in users [28]. Given the wide scale influence that emotions have on the usability of technology, it stands to reason that developing a better understanding of emotions lends itself to the process of creating more human-centered tools in line with supporting well-being. This much is evident in the study of Parkinson's Disease (PD) patients and their ability to perceive emotions through facial expressions; patients exhibited a lower accuracy rate as compared to a healthy control group [29]. This lends credence to the notion that individuals with PD are known to suffer from alexithymia, a subclinical phenomenon that manifests as a struggle to identify one's emotions [30]. Although believed to be a core feature of Autism Spectrum Disorder (ASD), evidence suggests that alexithymia is a discrete condition in itself simply comorbid with other mental illnesses [31], and it can also manifest and be tested in neurotypical individuals to some degree [31,32]. This raises the importance of exploring not only emotional variation and recognition in HCI, but also emotional restriction, as it poses an additional challenge for researchers to approach in the balancing act of maximizing inclusivity.

Chapter 3
Concept

The previous chapter made plain the pervasive issues in self-tracking technologies on mental health: It sets stringent, unrealistic precedents for positive affective states such as happiness or healthiness [21]; it discourages open and liberal sharing of information, particularly regarding fitness progress and mood, out of shame and fear of inviting undesirable advice or clinical diagnoses and skewing how peers or caregivers perceive them [17, 18]; lastly, it worsens the condition of users upon discovering that their performance evaluations do not reflect the amount of effort put into their self-improvement [11].

The danger of self-tracking is rooted in what it implies. The assumption that something could and should be made better invites the untoward belief that we are innately lacking and must always move towards an ideal version of the self [13]. Conversely, self-tracking could impose adverse effects that disqualify any benefits it would ordinarily predicate, going as far as to enable economic discrimination and marginalization in the workplace due to additional cognitive labor and a fostering of untoward competitive tension [33].

Evidently there is a need to dismantle the elements of "competition" and "one-upmanship" in the process of self-improvement, which at its crux is a social endeavor [34]. From adolescence to adulthood, we find ourselves molded not only by the influence of those around us but by their evaluation of our progress. Rather than use social mores and expectations as a measuring stick for one's excellence, the ideal reference point should begin and end in oneself; as En and Pöll rightly put it, "why be afraid of 'mediocrity' when there are no hierarchies to contend with, thereby ridding the term of its threatening quality?" [13]

These insights preface the core values embedded into this thesis paper's primary contribution: TENOR, a visual and acoustic emotion self-tracking tool, is

designed to improve emotional acuity in users while doing away with the use of externally-imposed performance standards. Digital mood-tracking techniques can range from wearable technology and behavioral monitoring to electronic self-reporting systems [35]. While the first two offer compelling insights with a high possibility for non-invasive longitudinal monitoring, they are limited in their accessibility to users with respect to everyday tracking—for this reason, TENOR is designed to suit the general population and operate through self-reporting via personal computer or cellphone.

Mobile mood-tracking applications for general use are rampant in smartphone app stores and cover four stages: **Preparation**, **Collection**, **Reflection**, and **Action**—Preparation refers to instructions on how one should track their mood, Collection pertains to the act of inputting mood data, Reflection features visualizations such as graphs and charts outlining mood trends, and Action prescribes recommendations on how to improve one's mood based on the data presented [36]. In a feature analysis surveying the characteristics of 32 mobile mood-tracking applications, several insights and trends were found: Only a few applications offered instructions or motivations for mood-tracking; tracking interfaces in the Collection stage were diverse, but primarily focused on the usage of words, colors, pictures, and recorded audio clips; and only 7 out of 32 applications offered actionable points to help improve mood [36]. Several reviews from users reveal strong desires for additional features, such as personalized mood options, categorizations for logged data (e.g. location, time), additional privacy settings, and a greater variety of mood choices. Users with affective disorders (e.g. depression, bipolar disorder, anxiety) commonly requested for features that catered to their specific conditions; many of them prefer applications catering to the general population as its design allows them to track several issues at the same time.

Absent from this conversation are several behaviors intrinsic to the emotional experience: The **Fading Affect Bias (FAB)**, which pertains to the faster decaying of intensity in negative emotions as compared to positive emotions [37], and the practice of emotion reappraisal and suppression for emotional regulation [14]. Both FAB and emotion suppression serve as self-preservation responses to protect individuals from reliving traumatic events [16, 38–40], however, habitual use of suppression can pose detrimental effects to relationship satisfaction and come

with a social cost [14]. None of these have yet to be explored through the lens of self-tracking technology, and doing so may poise us to uncover revelations in the treatment and intervention of affective disorders.

Given this information, this thesis postulates the following research questions:

1. Is music a viable, less intimidating, and more flexible alternative to defining and labeling moods in comparison to simply words?

2. Is a creativity-based self-tracking interface capable of influencing the fading effect bias and emotional reappraisal and repression?

3.1. Design Paradigm

Many of these existing mood-tracking applications fall into the trap of assuming binary classifications for emotions (e.g. happy is positive, sad is negative), when truly neutral feelings can exist, and feelings of happiness to a particular degree could indicate a manic episode in individuals with bipolar disorder [36, 41]. Moreover, the idea that one should track their emotions in order to achieve a sense of *emotional stability* can be detrimental, as it assumes there is a universally-expected social standard for such a state of being. This thesis asserts that mood-tracking should instead encourage and focus on the improvement of *emotional acuity*, or one's capacity to process, absorb, and approach complex emotions. Through this method of self-reflection, users should feel no pressure to conform to externally-imposed ideals of what it means to be psychologically stable; they can ascribe their own benchmarks and definitions for moods and emotional dispositions unique to their person.

With this in mind, TENOR utilizes music creation as a means of classifying and logging emotions. Rather than make use of words, colors, and pictures, which may put forward explicit meanings as well as notions of "good" and "bad," users have the freedom to create short songs open to more subjective interpretation. In the place of trend lines referring to the days in which their mood rose or fell, users instead see patterns of music notes, making the process of reexamining emotions less invasive and intimidating for those who have a difficult time facing and approaching difficult feelings. Named after a homonym with different definitions,

"tenor" can refer to an instrument or singing voice, or the general meaning or content of something. This reflects the tool's dual features of music creation and emotion self-tracking.

3.2. Design Process

3.2.1 Focus-Conducive Interface

Reducing the amount of attentional resources demanded by an interface allows users to properly digest its design [42]. This is best achieved by balance and symmetry, as users are comforted by familiar components, which also create a perception of usability [43]. Additionally, users with affective disorders can often struggle with technology due to their illness; the effects of their symptoms could lead to reduced technology use [44] and a dislike for reading long material [8], and individuals with depression may have trouble keeping to a regular logging schedule [6]. Building off of this information, TENOR's interface design minimizes the amount of details, features, action points, and text that users are confronted with; after logging into the system, they are directed immediately to a simple music grid with a short prompt asking them to express their mood through music in however way they see fit. Users can then label their finished song using an emotional word bank, which was incorporated as a way to examine the influence of the music interface on their memory retention of past emotions (Fig. 3.1).

3.2.2 Neutral, Equitable Aesthetics

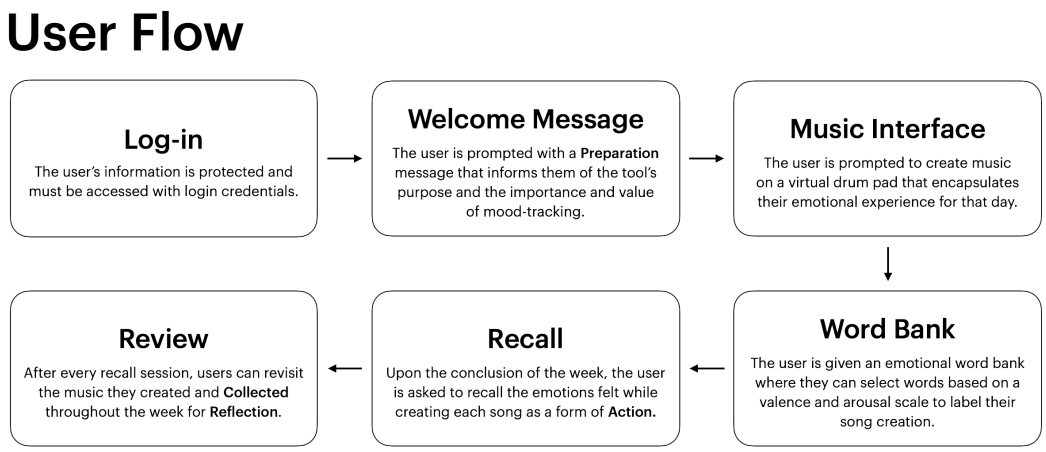
Light or dark gray colors are ideal for achieving a user-friendly contrast and can assist in focusing the user's attention on the content of the interface [45]. Certain colors invite notions of emotion and sensation (i.e. soft and hard, warm and cool) [46–49]. Red, orange, and yellow are often attributed with forms of arousal or exuberance while shades of blue can indicate placidity and quietude [46,50]. Conversely, green has shown to aid in memory retention of positive information [51] and invokes a sense of calm and trustworthiness [52]. To diminish any associations that could be made from the interface design while maximizing user attentiveness, green was used as the dominant color and light gray as the background.

3.2.3 Straightforward Interaction

The initial design of TENOR made use of a two-octave piano (Fig. 3.2). This was changed in favor of a uniformed music grid (Fig. 3.5), which maximizes the design's symmetry and allows users unfamiliar with musical instruments to approach the interface with less hesitation.

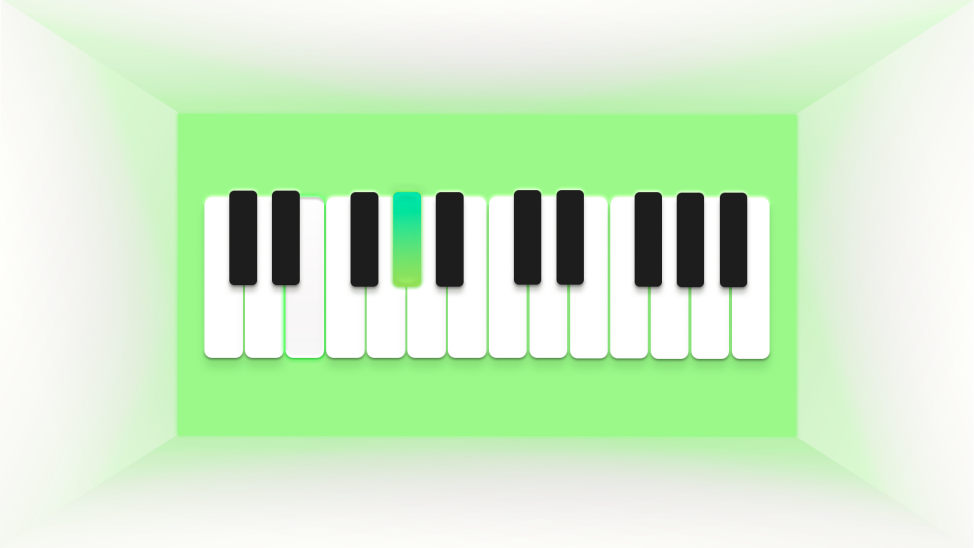
3.2.4 Music Creation Feature

The music grid makes use of a pentatonic C minor scale. "Bb2", "C3", "Eb3", "F3", "G3", "Bb3", "C4", "Eb4", "F4", "G4", "Bb4", "C5", "Eb5", "F5", "G5", and "Bb5" were the final notes selected from lowest to highest order and are represented by the vertical axis of the grid. The horizontal axis represents time (Fig. 3.5). The pentatonic musical scale fits 5 notes per octave, which allows us to fit more octaves into the grid and provide the user with a broader variety of high and low notes. A minor scale was favored over major as it affords the user with a wider range of emotional expression, since major scales possess more bright sounds and not enough somber tones.



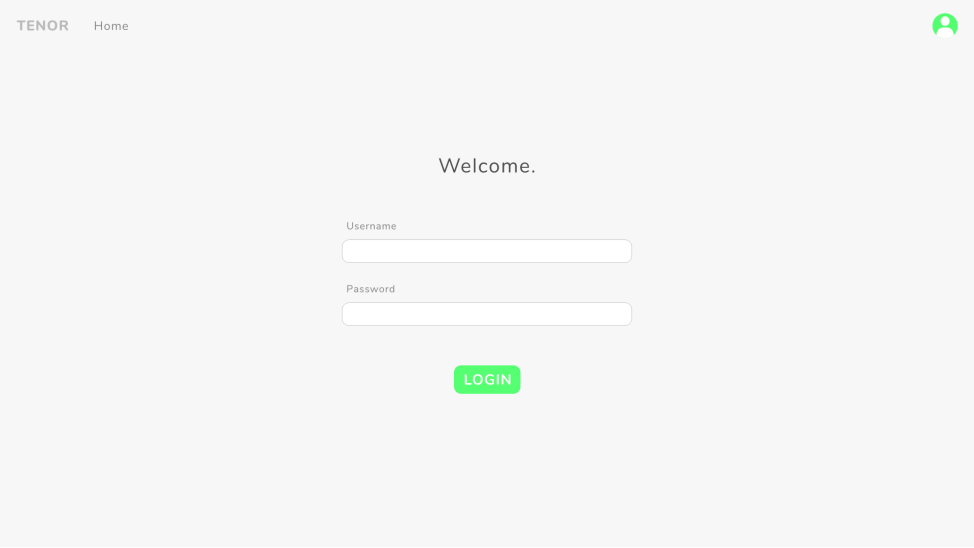
This diagram illustrates the user's journey when interacting with the platform from beginning to end.

Figure 3.1 Tenor Application User Flow



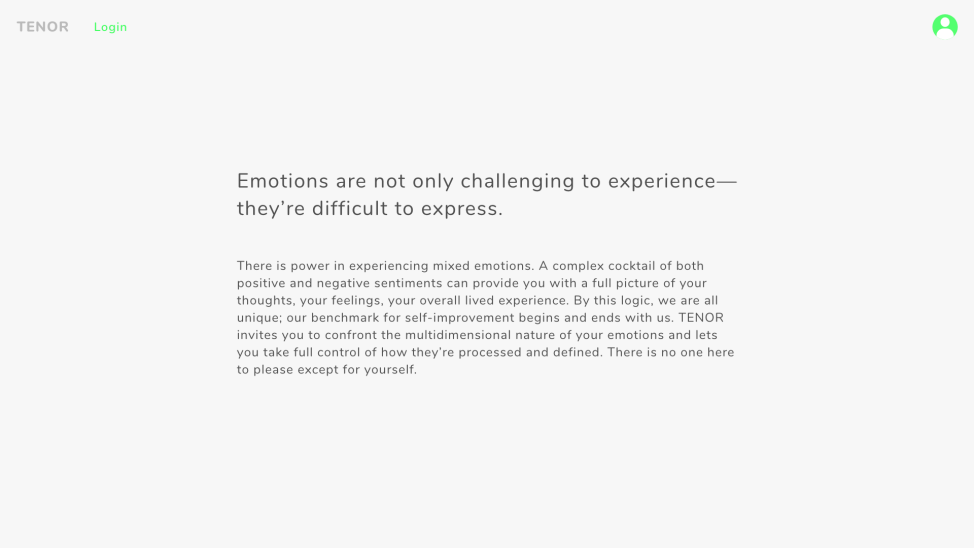
A virtual piano was originally used for the music creation feature until it was converted into a grid.

Figure 3.2 Tenor Initial Design



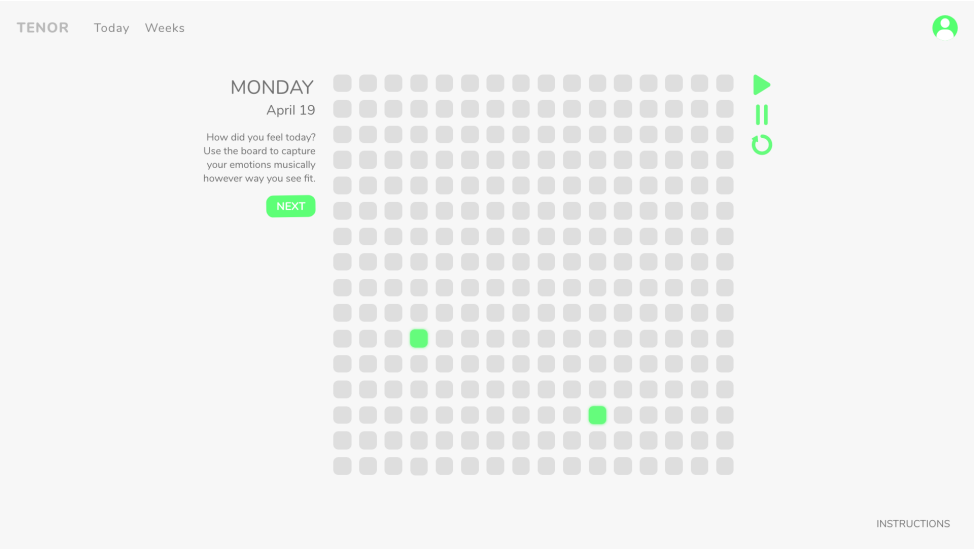
Users first encounter a login page upon opening TENOR, where they can enter the credentials emailed to them.

Figure 3.3 Tenor Login Page



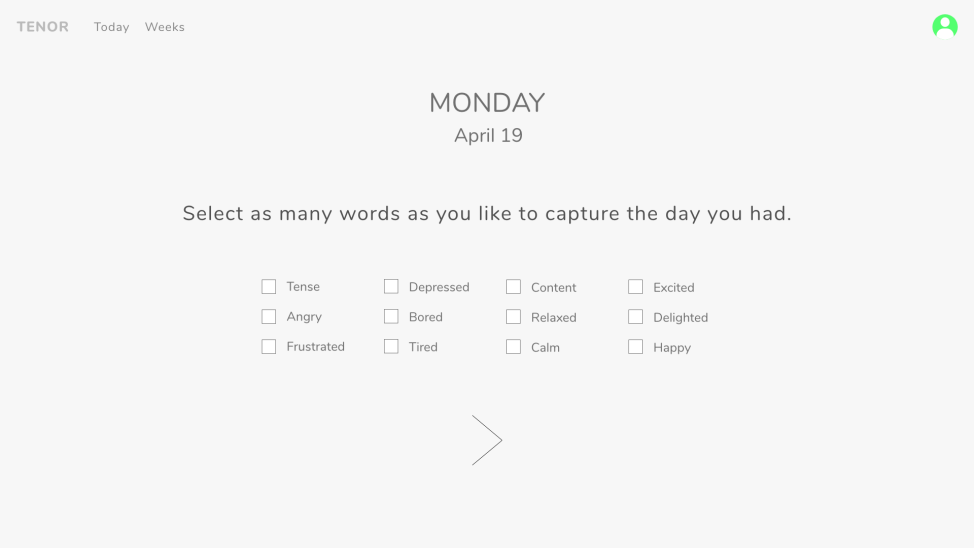
Upon logging in, users are led to a screen with motivating text written to encourage mood-tracking.

Figure 3.4 Tenor Homepage



By proceeding to the mood-tracking portion of the platform, users can then interact with the music creator.

Figure 3.5 Tenor Music Creator

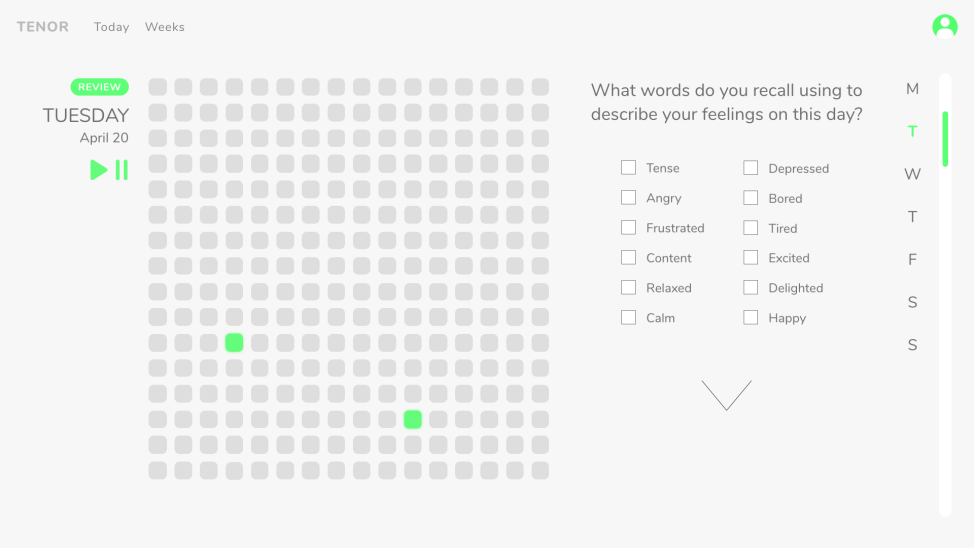


After creating their song, users can classify it further by selecting emotions out of a word bank. The contents of the word bank remain consistent in terms of content and sequencing.

Figure 3.6 Tenor Emotional Word Bank

Users have the option to access a review page that lets them see their weekly song inputs and revisit them.

Figure 3.7 Tenor Music Review Page



At the end of each week, users are asked to remember past emotions logged by performing a recall test. They have unlimited opportunities to listen to their songs, which serve as cues to aid in emotional reappraisal.

Figure 3.8 Tenor Recall Test Page

Chapter 4
Implementation

4.1. Testing

A Minimum Viable Product (MVP) was created and deployed for the purpose of testing the application. It did not have the landing page shown in the concept photos above as it may prime users prior to their interaction with the platform. Priming occurs when participants have their beliefs influenced before testing, which may result in altered behavior due to their expectations being set beforehand [53]. It must be determined whether the users will arrive at the same conclusion as the researcher in regards to the tool's usefulness without any prompting.

The contents of the emotional word bank take from a 12-item two-dimensional valence and arousal matrix, where the y-axis represents a range from excitement to calm while the x-axis represents a range from negative to positive [54]. This leads to four classifications of affective states: **High-Positive**, **High-Negative**, **Low-Positive**, and **Low-Negative** (Fig. 4.2). Many other matrices and diagrams exist that seek to classify emotions in a similar fashion, such as Plutchik's Wheel of Emotions, which accounts for 56 emotions of various intensity levels [55]. However, since users of self-tracking technologies who possess mental health concerns have a tendency to be easily overloaded by a high volume of reading material [8], the 12-item matrix developed by Yu et al. was favored.

Test Setup

Two types of tests were designed for the experiment: **Control**, in which users only logged their emotions using an emotional word bank, and **Experimental**, in which users had to create a song on a keypad interface to express their emotions before selecting choices from the same word bank. Both setups required inputs to

begin at the start of a week, where Monday and Tuesday serve as "practice days" for users to warm up to the interface, while Wednesday served as the official test day. The users were not explicitly informed of this distinction. From Thursday to Saturday, they undergo a period of rest before returning to the application on Sunday to review their responses from Wednesday.

The experiment lasted a duration of two weeks. A total of 19 participants were found through network convenience sampling; of these, 2 participants dropped at the beginning of the experiment. Users were randomly assigned test sequences: 8 testers were made to do Control on the first week and Experimental on the second week, while 9 testers did the opposite sequence.

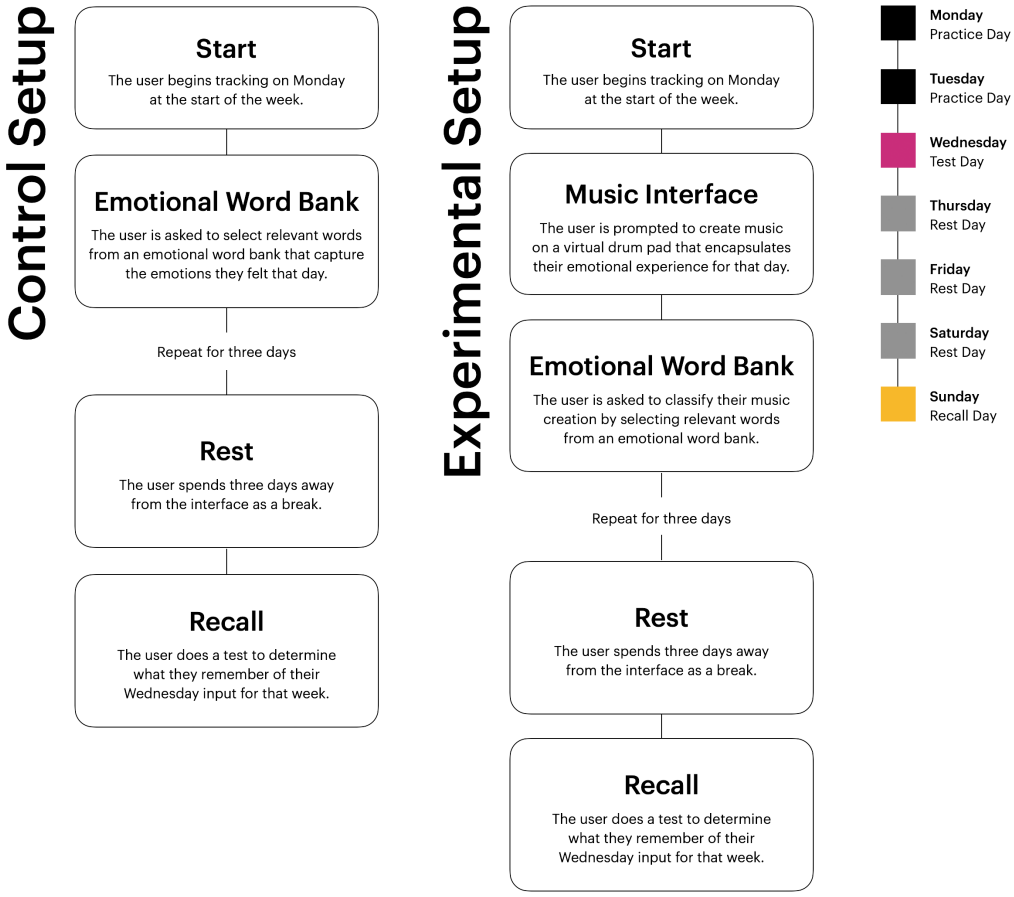
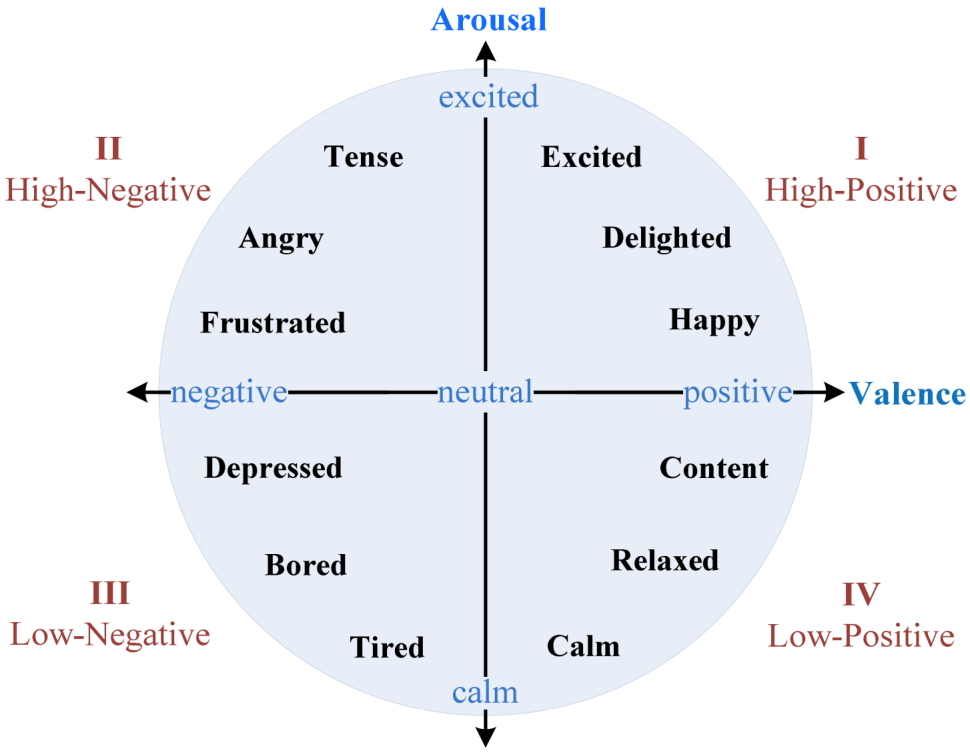


Figure 4.1 Tenor Test Flowchart



(Source: Predicting Valence-Arousal Ratings of Words Using a Weighted Graph Method by Yu et al. [54])

Figure 4.2 Two-dimensional Valence and Arousal Matrix

4.2. Evaluation and Results

Experience Survey

Age	
20	1 (5.9%)
21	1 (5.9%)
22	2 (11.8%)
24	3 (17.6%)
25	3 (17.6%)
26	6 (35.3%)
28	1 (5.9%)

Gender	
Male	10 (58.8%)
Female	6 (35.3%)
Non-Binary	1 (5.9%)

Nationality	
Brazilian	1 (5.9%)
Chinese	1 (5.9%)
Filipino	8 (47.1%)
Filipino-German	1 (5.9%)
French	2 (11.8%)
Indian	3 (17.7%)
Japanese-Malaysian	1 (5.9%)

Figure 4.3 Test Demographics

Participant's ages ranged from 20-28, with 58.8% of users being male, 35.3% of users being female, and 5.9% of users being non-binary. Majority of users were of Asian or mixed-Asian descent, with the exception of 17.7%, who identified as European or South American (Fig. 4.3).

Upon the conclusion of the experiment, participants were given an exit questionnaire to survey their experience with the platform. As users were not given any direction in regards to how they should approach the tool apart from following its onscreen instructions, questions relating to their choice in environment, the consistency of said conditions, and the time frame in which they logged their emotions were asked in order to discern how they shaped their own interactions. Explorations into their impressions of the two test modes were also examined, as well as their experience with the recall process.

Quality and Consistency of Environment. Users naturally chose to log their emotions in the same location each evening, typically in their own bedroom or in a hybrid space that integrates both a bedroom and a work station. Some responses emphasized on the amount of personalization that went into designing the spaces they were in, such as mentioning the presence of private belongings

and gifts from loved ones. Users made it a point to log their emotions alone and in silence; interpretations of "the end of the day" varied among individuals, as some saw it as the hours after dinner while others saw it as the minutes before bedtime, which for many may vary between midnight and the early hours of the morning.

Interface Preferences. 94% of users (16 out of 17) reported that the music interface was far more engaging and revealing in comparison to the untreated setup. One user expressed a keen interest in the platform but identified a struggle with connecting their emotions with their musical outputs. Those who had the music creation feature on the second week of the experiment found their experience greatly improved, while those who lost the feature on the second week reported feeling disappointed. Users took their time when creating beats and songs and believed that the music creation feature helped them report their moods with more clarity and consistency. It also served as a huge motivating factor in the act of continuing the emotion self-tracking ritual, as many of them looked forward to the process and felt much more involved. Several users expressed enthusiasm in using the music interface outside of the experiment.

> *"I think my experience changed in the sense that my method for determining how to represent my mood via music notes became more consistent overall."*

> *"I missed the musical segment. I feel it would have been more revealing than simply ticking boxes."*

> *"[T]he second week was more fun. Even though I was tired and stressed, interacting with the music interface was really fun."*

> *"As a musician myself, I liked being asked to compose a melody based on my mood. I liked that it was valid to have any combination of emotions through the day."*

> *"Music is better, kinda makes assessing my own mood easier because I feel it seems clearer to my own self."*

> *"I think my experience changed in the sense that my method for determining how to represent my mood via music notes became more consistent overall."*
>
> *"I enjoyed the mood tracking with music creation feature more. It was somehow a relaxing creative outlet for me to release the moods I was feeling throughout the day. At first, I found the software exciting. Towards the end, I did not enjoy it as much because the music creation feature was gone. It was sort of anti-climatic."*
>
> *"Mood tracking without the music creation feature was very little more functional than a normal mood log on a notepad or any other record-taking software/tool. Mood tracking with the music creation was interesting and it made me curious. I spent more time with the logging, playing and testing over and over, trying to capture how I felt during the day. I don't have much music experience, but I did find it quite pleasant."*

Impressions of the Word Bank Interface. Many users felt that the act of choosing words alone was limiting when it came to identifying their emotions. The selection felt imprecise and lacking in dimension as compared to the ways they were feeling; one user remarked that the choices either failed to capture their disposition or made them feel as if they were overreacting. Some responses noted the absence of "true neutral" choices that were neither positive nor negative, as feelings detached from the two valences were not represented in the choices. Users also felt like their emotions were more forgettable when inputted through the word bank interface.

> *"I felt like judging my mood with words was somewhat frustrating. Even with maybe a dozen options, what I felt could not easily be put into boxes and that maybe with every word choice I was overreacting. Using music had the opposite effect because I felt like I could give my own interpretation to a white canvas."*
>
> *"I would have preferred more neutral answers as well, such as 'okay' or 'fine' maybe even 'meh' because sometimes it doesn't feel like 'calm'*

or 'content' quite fit my mood, but it isn't exactly bad either. Otherwise it was quite nice."

"Having the music feature was more memorable. It was also more fun, but then again it ended up taking more time because I liked playing around with the settings. Using it without the music creation feature was much more straightforward but also forgettable."

Impressions of the Music Interface. Although broadly declared as the more enjoyable interface, the music creation feature was not without its faults. Some users noted that their songs were always *harmonious* and that they had very little room to create discordant sounds that could open up more avenues of self-expression. Users enjoyed the way that the grid allowed them to create a trend-line of emotional fluctuations subject to their unique interpretation; however, it was noted that said impressions could gradually change—what may sound pleasant and positive upon creation may provoke different emotions at a later time.

"I also wish the music composing parts, like sometimes no matter what I did they felt too harmonious which wasn't what I felt."

"The music feature was fun. However, I think my opinion on music can change over time. A sound or song might sound happy to me at one point in time, but might make me feel calm or even sad at another."

"They were fine. I just wish the music tracker didn't sound so harmonious no matter what I did. Both experiences were simple enough, though."

"I think it might be nice if it was a bit easier to manipulate the music creation because for people with low attention spans might find it annoying to do everyday."

"My interpretation for the music notes was that high pitch meant negative feelings and low pitch meant positive ones. I imagined it as a lifeline of my day and usually set the peaks around which points were

> *the hardest to deal with during it or during when I was the most active (meetings, sports etc.). So for example, if I had an interview with a professor at around midday, the middle of the canvas would have a peak followed by a rapid descent. I am not sure if that was the way most people handled it but this is how I rationalized my tracking."*
>
> *"However, the music creation feature showed a trendline of my highs and lows throughout the day, giving a more readable picture, which could be all the more useful when reflecting further back in time. The recalling process was looking back at the key events on a specific day and imputing based on that."*

One user had a contrasting opinion from the rest. Listening to their song on repeat during the process of creating it was frustrating, and they did not feel like their output was anywhere near representative of their emotions. They also could not find a way to connect their choices from the word bank to the song they created.

> *"I would try to make a nice melody and spent much time on it, have to listen to it for several times is annoying, and when I see grids, I also want to make the melody by drawing a pixel picture, but I didn't, because it takes too much time. The pitch of every sound is very high and the rhythm is quick, I don't feel it can reflect my mood/emotion, even when I chose the ones at the bottom. There isn't a correspondence between the words describing my mood and the melody I made, the words are closer, but sometimes I still can't find a suitable word."*

Experiences with Recall. Several users expressed that negative states and experiences were more difficult to remember, both in the input and recall phases of the experiment, due to what they indicate as an unconscious habit of repressing said emotions. Positive states and good days were much easier to recall, and users of the music interface in particular felt more confident about their memory when remembering past experiences.

> *"I think the personal challenges I was going through made me subconsciously forget negative emotions."*

> *"Needed a bit of thinking back on how the day went, though it was easier when I had a good day. I missed the first weeks recall and other stuff because I think it slipped my mind because of overthinking about work."*

One user's experience with the recall process was significant, as they expressed a preference for reports on their overall mental health versus a practice of remembering their moods.

> *"Don't want to recall my mood, but maybe have a quarterly/monthly report of overall mental health level would be better for me."*

Word Correlations

Correlations between emotions chosen by users offers several insights in regards to emotion co-occurrence (Fig. 4.4). High-positives and low-positives are often reported distinctly from one another and are rarely logged together. A small exception to this are **Delighted** and **Content**, which often intersect. In this same vein, high-negatives and low-negatives have their own clusters; **Depressed** often intermingles with high-negatives such as **Tense**, **Angry**, and **Frustrated**, while low-positives such as **Bored** and **Tired** are just as likely to be reported alongside of them as they are with high-positives such as **Content**, **Relaxed**, and **Calm**.

This suggests an association between low-positive and low-negative emotions. Emotional arousal decays over time, and as established in the previous chapter, memories of strong negative experiences fade faster than positive experiences [56]. It is possible that lower arousal states in both valences lead to "stabler" emotions more likely to co-exist and to fluctuate between one another.

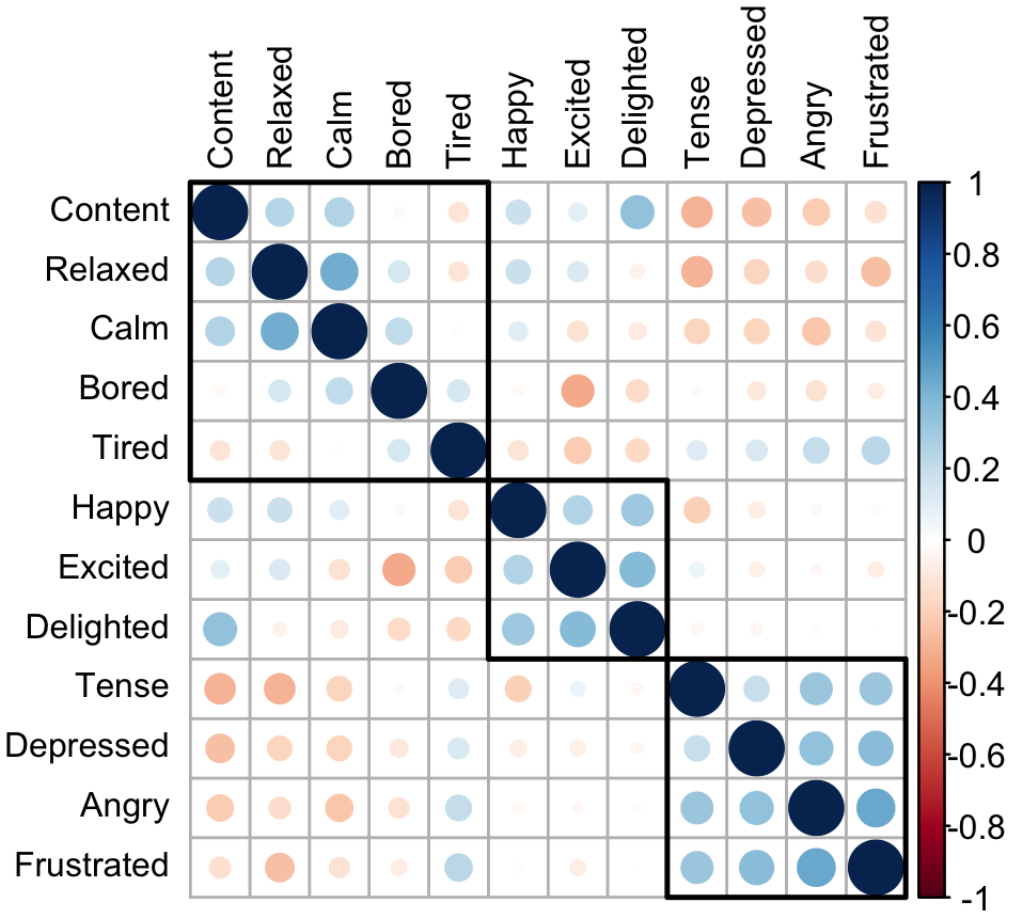


Figure 4.4 Tenor Word Correlations

Recall Testing

In order to investigate the impact of valence quadrant and mode, we constructed a mixed effects model where recall instances were broken up into eight groups: The four valence and arousal quadrants for each testing mode (Table 4.1). We then fit mixed-effects model with correctness (Correct) as binary dependent variable, the eight groups (ModelQuad) as an independent variable, and the participants as a random factor. The choice of optimizer was trivial as available methods showed no difference.

The model was constructed in lme4 [57] as follows:

```
glmer(factor(Correct) ~ factor(ModelQuad) +
(1|User_ID), family = binomial, control =
glmerControl(optimizer ="bobyqa"))
```

The initial model output showed significance with three of the quadrants against the one factor set as a dummy. Pseudo R-squared was calculated with Nakagawa and Schielzeth's formula [58]. The marginal R-squared was 0.13. While this is a relatively low number, it does indicate that valence and mode can have an impact on correctness.

To get a general idea of impact of quadrants and testing mode, we ran a pairwise test without adjustment (Table 4.2). The decision to not use Tukey adjustment was intentional in light of the number of comparisons and low sampling power.

No.	Combination	No.	Combination
0	Quadrant 1 + Control	**4**	Quadrant 1 + Experimental
1	Quadrant 2 + Control	**5**	Quadrant 2 + Experimental
2	Quadrant 3 + Control	**6**	Quadrant 3 + Experimental
3	Quadrant 4 + Control	**7**	Quadrant 4 + Experimental

Table 4.1 Quadrant and Mode Combinations

1	Estimate	SE	df	z.ratio	p.value
0-1	**-3.42202**	**1.179**	**Inf**	**-2.902**	**0.0037**
0-2	**-1.56548**	**0.774**	**Inf**	**-2.022**	**0.0432**
0-3	-1.16356	0.689	Inf	-1.689	0.0911
0-4	-1.21063	0.701	Inf	-1.726	0.0844
0-5	-1.57392	0.842	Inf	-1.868	0.0617
0-6	**-1.68209**	**0.773**	**Inf**	**-2.175**	**0.0296**
0-7	-1.12930	0.696	Inf	-1.622	0.1048
1-2	1.85653	1.170	Inf	1.587	0.1125
1-3	**2.25845**	**1.117**	**Inf**	**2.021**	**0.0433**
1-4	**2.21139**	**1.124**	**Inf**	**1.967**	**0.0492**
1-5	1.84810	1.211	Inf	1.526	0.1270
1-6	1.73993	1.166	Inf	1.492	0.1356
1-7	**2.29272**	**1.124**	**Inf**	**2.040**	**0.0414**
2-3	0.40192	0.677	Inf	0.594	0.5526
2-4	0.35485	0.689	Inf	0.515	0.6068
2-5	-0.00843	0.836	Inf	-0.010	0.9919
2-6	-0.11661	0.762	Inf	-0.153	0.8784
2-7	0.43619	0.680	Inf	0.641	0.5213
3-4	-0.04706	0.591	Inf	-0.080	0.9365
3-5	-0.41035	0.756	Inf	-0.543	0.5873
3-6	-0.51853	0.676	Inf	-0.767	0.4430
3-7	0.03427	0.584	Inf	0.059	0.9532
4-5	-0.36329	0.765	Inf	-0.475	0.6348
4-6	-0.47146	0.688	Inf	-0.685	0.4933
4-7	0.08133	0.602	Inf	0.135	0.8926
5-6	-0.10817	0.814	Inf	-0.133	0.8942
5-7	0.44462	0.784	Inf	0.567	0.5704
6-7	0.55279	0.693	Inf	0.798	0.4249

Table 4.2 Pairwise Test Results

The results of the pairwise test revealed six significant pairs: Q1 in Control v. Q2 in Control [0,1], Q1 in Control v. Q3 in Control [0,2], Q2 in Control v. Q4 in Control [1,3], Q1 in Control v. Q3 in Experimental [0,6], Q2 in Control v. Q1 in Experimental [1,4], and Q2 in Control v. Q4 in Experimental [1,7].

Recall of high-negative emotions in the Control setup outperformed recall of both high and low positives in Experimental. This is likely due to the delight attached to using and revisiting the music interface, which may have caused a dampening of negative arousal states. On the other hand, low-negative emotions were recalled significantly better in the Experimental setup in comparison to high-positives in Control; this demonstrates the capacity of the music interface to engender low-arousal negative emotions in users despite its enjoyment factor.

There is a high discrimination in recall quality on the word bank Interface alone. Quadrant-Mode (QM) combinations suffered and competed with one another within the word bank group, propounding high fluctuations in capacity for recall in the Control setup. The absence of significant comparisons between Quadrant-Mode (QM) combinations within the music interface reveals its stability in regards to encouraging recall in users—participants were consistent in their reappraisal of past emotions due to the prompting that their music creations provided them.

The music interface shows greater promise in inducing emotional recall across the board. Although it is more difficult to remember high-arousal negative moods in the Experimental mode, users are still more attuned to emotional reappraisal when using an engaging interface that prioritizes their involvement. The next step to improving the platform would be to determine ways to reduce the emotional dampening caused by the interface's enjoyment factor. That said, there is potential to uncover even more insights through further testing with a larger participant pool, especially given the outcomes in the pairwise test.

Chapter 5
Conclusion

Exploring any facet of the human experience requires discernment beyond the quantitative and computational. Giving data the absolute authority to define our standards for wellbeing is how we run the risk of reducing self-improvement into a zero-sum game. This thesis outlines the ways in which self-tracking technologies for mental health have been pushing normative ideals of positive and negative affective states, thereby pressuring users to conform to externally-imposed standards of achieving their ideal "self." Mood-tracking applications, in particular, are not merely guilty of this practice; they also fall short in providing users with an incentive to monitor their emotions and develop strengths to confront them better.

To address these issues, the author proposes a more interventional approach to mood-tracking that encourages emotional reappraisal while minimizing repression. TENOR, a music-based emotion self-tracking platform, uses a virtual drum pad to encourage users to generate songs emblematic of their day-to-day affective states. Not only does this increase the user's involvement in the tracking process and encourages them to log consistently, it also frees them from the confines of standard beliefs by giving them the license to define and interpret their emotions on their terms.

In a pilot test conducted to determine the effectiveness of TENOR's interface as opposed to an emotional word bank, several insights emerged: Users reported greater self-confidence and engagement when using the music interface and demonstrated greater recall quality and consistency across the board, whereas results from the word bank showed only variable success. This validates the supposition that music is a less intimidating and more adaptable method of defining and labeling moods in comparison to words. Additionally, the greater regularity and accuracy in which users recall past emotions through the music interface reveals

its capacity of increasing emotional reappraisal.

The enjoyment factor attached to the music interface did not diminish reportage of negative emotions. However, recall quality suffered when users were prompted to remember high-negative emotions through this setup. This suggests that the delight involved in using and revisiting the interface dampens the arousal of negative affective states. Future studies should endeavor to seek out ways to reduce this occurrence.

TENOR's warm reception from users illustrates the value of being able to approach one's emotions without feeling the need to appease somebody else, including the application itself. Feelings are complex and arbitrary, and even the most uncomfortable dispositions give rise to richer, more multidimensional perspectives [59]. We should not inhibit them. TENOR does more than encourage users to dive deeper into the emotions they experience; it also persuades them to include and accept negative and mixed emotions as essential parts of the process of bettering themselves. The author believes that this feature of openness should be integrated into more self-tracking technologies within and beyond emotion sensing.

Chapter 6
Future Work

There are several opportunities to expand and improve this study. Future experiments can benefit from a larger participant pool in order to better determine the effects of the music interface on emotional reappraisal and repression. Testing with a single predominant emotion on a day to day basis rather than a range of emotions may also strengthen the statistical significance of recall tests. Future developments in mood detection tracking through music may also be a valid point of exploration for determining trends and patterns in note choices and emotional valences.

6.1. Mood Tracking for Children with Affective Disorders

Majority of studies made into HCI technologies for mental health focus on adult sufferers as main stakeholders (60.4%) [12]. Despite there being compelling reasons to investigate how self-tracking may benefit children sufferers, these individuals qualify as members of a vulnerable population due to their young age; ethical issues such as obtaining fully-informed consent pose as barriers to research. However, given the less-invasive quality of TENOR's approach to emotion regulation and reappraisal, it may be possible to pursue studies with children without compromising their wellbeing.

6.2. Addressing Alexithymia through Interventional Mood-Tracking

Many persons struggling with mental health conditions and affective disorders suffer from a distinct lack of emotional awareness called alexithymia, which manifests as a difficulty in identifying and describing one's feelings [60]. Alexithymia has been identified in people with somatic symptom disorder, panic disorder, obsessive-compulsive disorder, depression and anxiety, eating disorders, and those dealing with substance abuse, revealing that the phenomenon affects a broad and nuanced scope of individuals and occurs across a wide range of different psychological conditions both clinical and subclinical [61–66]. Moreover, alexithymia has been found to be a construct distinct from affective disorders such as depression and anxiety on top of it being an overlapping symptom, suggesting that it impacts even those considered neurologically typical who have not been diagnosed with a mental illness [32]. Based on this information, it is plausible that those utilizing self-tracking technologies for emotions who experience alexithymia to any degree may find it difficult to capture their feelings in an accurate or reliable way. It may also prove challenging for them to connect to any of the revelations their self-tracking activities may end up positing.

Research concentrated on the detection and analysis of alexithymia predominantly make use of eye-tracking software to study emotion recognition. The Stylized Animations for Research on Autism (SARA) project utilized eye-tracking technologies specifically to discern the relationship between ASD and alexithymia [10]. Although no correlation was found between gaze behavior, ASD, and alexithymia in particular, the relationship may still be relevant even on a neurotypical scale, as a study conducted as recently as 2020 suggests that eye-tracking for emotion recognition could aid in machine-driven mapping of human emotions [67]. Diverging from this trend is a 2021 study on the effects of expressive biosignals (i.e. heartbeat sounds) on a user's ability to empathize with what another person is feeling [68]. The results revealed promise in the realm of musical, non-visual emotion perception. Similarly, an experiment employing the use of pulse wave signals and video clips of recorded facial expressions revealed a high recognition rate among its participants, who could identify emotions such as happiness, surprise,

disgust, grief, and anger with rates of success reaching 75.36%, 81.48%, 74.67%, 87.88%, 75.89%, 81.43% respectively [69].

Other than these investigations, there appears to be very little HCI research going into potential treatment methods for alexithymia and its symptoms. It may benefit those suffering from the phenomenon if they were to process their moods through a platform that engages them and influences their emotional regulation.

References

[1] Michael Tye. Qualia. August 1997. Last Modified: 2017-12-18. URL: https://stanford.library.sydney.edu.au/archives/spr2018/entries/qualia/.

[2] Nekane Basabe, Darío Paez, José Valencia, Bernard Rimé, James Pennebaker, Ed Diener, and José L González. Sociocultural factors predicting subjective experience of emotion: a collective level analysis. page 16, 2000.

[3] Tianqiang Hu, Dajun Zhang, Jinliang Wang, Ritesh Mistry, Guangming Ran, and Xinqiang Wang. Relation between Emotion Regulation and Mental Health: A Meta-Analysis Review. *Psychological Reports*, 114(2):341–362, April 2014. Publisher: SAGE Publications Inc. URL: https://doi.org/10.2466/03.20.PR0.114k22w4, doi:10.2466/03.20.PR0.114k22w4.

[4] Paul Gilbert. An Evolutionary Approach to Emotion in Mental Health With a Focus on Affiliative Emotions. *Emotion Review*, 7(3):230–237, July 2015. Publisher: SAGE Publications. URL: https://doi.org/10.1177/1754073915576552, doi:10.1177/1754073915576552.

[5] Matthias Berking and Peggilee Wupperman. Emotion regulation and mental health: recent findings, current challenges, and future directions. *Current Opinion in Psychiatry*, 25(2):128–134, March 2012. doi:10.1097/YCO.0b013e3283503669.

[6] Mark Matthews, Stephen Voida, Saeed Abdullah, Gavin Doherty, Tanzeem Choudhury, Sangha Im, and Geri Gay. In Situ Design for Mental Illness: Considering the Pathology of Bipolar Disorder in mHealth Design. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*, pages 86–97, Copenhagen Denmark, August

2015. ACM. URL: https://dl.acm.org/doi/10.1145/2785830.2785866, doi:10.1145/2785830.2785866.

[7] Elizabeth L. Murnane, Mark Matthews, and Geri Gay. Opportunities for technology in the self-management of mental health. In *Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct*, pages 1093–1096, Florence Italy, September 2016. ACM. URL: https://dl.acm.org/doi/10.1145/2957265.2965008, doi:10.1145/2957265.2965008.

[8] Gavin Doherty, David Coyle, and John Sharry. Engagement with online mental health interventions: an exploratory clinical study of a treatment for depression. In *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems - CHI '12*, page 1421, Austin, Texas, USA, 2012. ACM Press. URL: http://dl.acm.org/citation.cfm?doid=2207676.2208602, doi:10.1145/2207676.2208602.

[9] Juan C. Torrado, Javier Gomez, and Germán Montoro. Emotional Self-Regulation of Individuals with Autism Spectrum Disorders: Smartwatches for Monitoring and Interaction. *Sensors*, 17(6):1359, June 2017. URL: http://www.mdpi.com/1424-8220/17/6/1359, doi:10.3390/s17061359.

[10] Diana Arellano, Reinhold Rauh, Benjamin Krautheim, Marc Spicker, Ulrich Max Schaller, Volker Helzle, and Oliver Deussen. Interactive testbed for research in autism—the SARA project. *Universal Access in the Information Society*, 17(1):21–36, March 2018. URL: http://link.springer.com/10.1007/s10209-016-0521-9, doi:10.1007/s10209-016-0521-9.

[11] Christina Kelley, Bongshin Lee, and Lauren Wilcox. Self-tracking for Mental Wellness: Understanding Expert Perspectives and Student Experiences. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 629–641, Denver Colorado USA, May 2017. ACM. URL: https://dl.acm.org/doi/10.1145/3025453.3025750, doi:10.1145/3025453.3025750.

[12] Pedro Sanches, Axel Janson, Pavel Karpashevich, Camille Nadal, Chengcheng Qu, Claudia Daudén Roquet, Muhammad Umair, Charles

Windlin, Gavin Doherty, Kristina Höök, and Corina Sas. HCI and Affective Health: Taking stock of a decade of studies and charting future research directions. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–17, Glasgow Scotland Uk, May 2019. ACM. URL: https://dl.acm.org/doi/10.1145/3290605.3300475, doi:10.1145/3290605.3300475.

[13] Boka En and Mercedes Pöll. Are you (self-)tracking? Risks, norms and optimisation in self-quantifying practices. *Graduate Journal of Social Science*, 12:37–57, May 2016.

[14] Tammy English and Oliver John. Understanding the social effects of emotion regulation: The mediating role of authenticity for individual differences in suppression. *American Psychological Association*, 13(2):314–329, 2013. doi:10.1037/a0029847.

[15] Thomas Holtgraves and Richard Hall. Repressors: What Do They Repress and How Do They Repress It? *Journal of Research in Personality*, 29(3):306–317, September 1995. URL: https://www.sciencedirect.com/science/article/pii/S0092656685710185, doi:10.1006/jrpe.1995.1018.

[16] Bert Garssen. Repression: Finding Our Way in the Maze of Concepts. *J Behav Med*, (30):471–481, 2007. doi:10.1007/s10865-007-9122-7.

[17] Elizabeth V. Eikey and Madhu C. Reddy. "It's Definitely Been a Journey": A Qualitative Study on How Women with Eating Disorders Use Weight Loss Apps. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 642–654, Denver Colorado USA, May 2017. ACM. URL: https://dl.acm.org/doi/10.1145/3025453.3025591, doi:10.1145/3025453.3025591.

[18] Andrew R. McNeill, Lynne Coventry, Jake Pywell, and Pam Briggs. Privacy Considerations when Designing Social Network Systems to Support Successful Ageing. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 6425–6437, Denver Colorado USA, May 2017. ACM. URL: https://dl.acm.org/doi/10.1145/3025453.3025861, doi:10.1145/3025453.3025861.

[19] Victor R. Lee. The Quantified Self (QS) Movement and Some Emerging Opportunities for the Educational Technology Field. *Educational Technology*, 53(6):39–42, 2013. Publisher: Educational Technology Publications, Inc. URL: http://www.jstor.org/stable/44430216.

[20] Paul Standish. Making Sense of Data: Objectivity and Subjectivity, Fact and Value. *Pedagogika*, 66(6), 2016. Number: 6. URL: https://www.ojs.cuni.cz/pedagogika/article/view/367.

[21] Tamar Sharon and Dorien Zandbergen. From data fetishism to quantifying selves: Self-tracking practices and the other values of data. *New Media & Society*, 19(11):1695–1709, November 2017. URL: http://journals.sagepub.com/doi/10.1177/1461444816636090, doi:10.1177/1461444816636090.

[22] Herbert Zimiles. The adoration of "hard data": A case study of data fetishism in the evaluation of infant day care. *Early Childhood Research Quarterly*, 8(3):369–385, January 1993. URL: https://linkinghub.elsevier.com/retrieve/pii/S0885200605800730, doi:10.1016/S0885-2006(05)80073-0.

[23] Mélodie Boulay, Samuel Benveniste, Sandra Boespflug, Pierre Jouvelot, and Anne-Sophie Rigaud. A pilot usability study of MINWii, a music therapy game for demented patients. *Technology and Health Care*, 19(4):233–246, August 2011. URL: https://www.medra.org/servlet/aliasResolver?alias=iospress&doi=10.3233/THC-2011-0628, doi:10.3233/THC-2011-0628.

[24] Franceli L. Cibrian, Oscar Peña, Deysi Ortega, and Monica Tentori. BendableSound: An elastic multisensory surface using touch-based interactions to assist children with severe autism during music therapy. *International Journal of Human-Computer Studies*, 107:22–37, November 2017. URL: https://linkinghub.elsevier.com/retrieve/pii/S1071581917300757, doi:10.1016/j.ijhcs.2017.05.003.

[25] Cove. URL: http://www.cove-app.com.

[26] Humm.ly Music Wellness App Combining Therapy & Mindfulness. URL: https://www.humm.ly/.

[27] N Tractinsky, A.S Katz, and D Ikar. What is beautiful is usable. *Interacting with Computers*, 13(2):127–145, December 2000. URL: https://academic.oup.com/iwc/article-lookup/doi/10.1016/S0953-5438(00)00031-X, doi:10.1016/S0953-5438(00)00031-X.

[28] S. Joon Park, Craig M. MacDonald, and Michael Khoo. Do you care if a computer says sorry?: user experience design through affective messages. In *Proceedings of the Designing Interactive Systems Conference on - DIS '12*, page 731, Newcastle Upon Tyne, United Kingdom, 2012. ACM Press. URL: http://dl.acm.org/citation.cfm?doid=2317956.2318067, doi:10.1145/2317956.2318067.

[29] Claire Dussard, Anahita Basirat, Nacim Betrouni, Caroline Moreau, David Devos, François Cabestaing, and José Rouillard. Preliminary Study of the Perception of Emotions Expressed by Virtual Agents in the Context of Parkinson's Disease. In *Companion Publication of the 2020 International Conference on Multimodal Interaction*, pages 457–461, Virtual Event Netherlands, October 2020. ACM. URL: https://dl.acm.org/doi/10.1145/3395035.3425219, doi:10.1145/3395035.3425219.

[30] Soizic Argaud, Marc Vérin, Paul Sauleau, and Didier Grandjean. Facial emotion recognition in Parkinson's disease: A review and new hypotheses: Facial Emotions and PD: A Review. *Movement Disorders*, 33(4):554–567, April 2018. URL: http://doi.wiley.com/10.1002/mds.27305, doi:10.1002/mds.27305.

[31] Emma Kinnaird, Catherine Stewart, and Kate Tchanturia. Investigating alexithymia in autism: A systematic review and meta-analysis. *European Psychiatry*, 55:80–89, January 2019. URL: https://www.cambridge.org/core/product/identifier/S0924933800009007/type/journal_article, doi:10.1016/j.eurpsy.2018.09.004.

[32] C Marchesi, E Brusamonti, and C Maggini. Are alexithymia, depression,

and anxiety distinct constructs in affective disorders? *Journal of Psychosomatic Research*, 49(1):43–49, July 2000. URL: https://linkinghub.elsevier.com/retrieve/pii/S0022399900000842, doi:10.1016/S0022-3999(00)00084-2.

[33] Jo Ann Oravec. Digital iatrogenesis and workplace marginalization: some ethical issues involving self-tracking medical technologies. *Information, Communication & Society*, 23(14):2030–2046, December 2020. URL: https://www.tandfonline.com/doi/full/10.1080/1369118X.2020.1718178, doi:10.1080/1369118X.2020.1718178.

[34] Jari-Erik Nurmi. Socialization and Self-Development: Channeling, Selection, Adjustment, and Reflection. In Richard M. Lerner and Laurence Steinberg, editors, *Handbook of Adolescent Psychology*, pages 85–124. John Wiley & Sons, Inc., Hoboken, NJ, USA, July 2013. URL: http://doi.wiley.com/10.1002/9780471726746.ch4, doi:10.1002/9780471726746.ch4.

[35] Gin S Malhi, Amber Hamilton, Grace Morris, Zola Mannie, Pritha Das, and Tim Outhred. The promise of digital mood tracking technologies: are we heading on the right track? *Evidence Based Mental Health*, 20(4):102–107, November 2017. URL: https://ebmh.bmj.com/lookup/doi/10.1136/eb-2017-102757, doi:10.1136/eb-2017-102757.

[36] Clara Caldeira, Yu Chen, Lesley Chan, Vivian Pham, Yunan Chen, and Kai Zheng. Mobile apps for mood tracking: an analysis of features and user reviews. *AMIA Annual Symposium Proceedings*, 2017:495–504, April 2018. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5977660/.

[37] Dr Timothy Ritchie, John J. Skowronski, Jessica Hartnett, Brett Wells, and W. Richard Walker. The fading affect bias in the context of emotion activation level, mood, and personal theories of emotion change. *Memory*, 17(4):428–444, April 2009. Publisher: Routledge _eprint: https://doi.org/10.1080/09658210902791665. URL: https://doi.org/10.1080/09658210902791665, doi:10.1080/09658210902791665.

[38] Filip Raes, Dirk Hermans, J. Mark G. Williams, Wim Beyers, Els Brunfaut,

and Pau Eelen. Reduced autobiographical memory specificity and rumination in predicting the course of depression. *Journal of Abnormal Psychology*, 115(4):699–704, November 2006. doi:10.1037/0021-843X.115.4.699.

[39] Dorthe Berntsen and David C. Rubin. Flashbulb memories and posttraumatic stress reactions across the life span: Age-related effects of the German occupation of Denmark during World War II. *Psychology and Aging*, 21(1):127–139, 2006. Place: US Publisher: American Psychological Association. doi:10.1037/0882-7974.21.1.127.

[40] Amy Wenzel, Keri Pinna, and David C. Rubin. Autobiographical memories of anxiety-related experiences. *Behaviour Research and Therapy*, 42(3):329–341, 2004. Place: Netherlands Publisher: Elsevier Science. doi:10.1016/S0005-7967(03)00142-6.

[41] Sandra Schönfelder, Johanna Langer, Eva Elisa Schneider, and Michèle Wessa. Mania risk is characterized by an aberrant optimistic update bias for positive life events. *Journal of Affective Disorders*, 218:313–321, August 2017. URL: https://linkinghub.elsevier.com/retrieve/pii/S0165032716313118, doi:10.1016/j.jad.2017.04.073.

[42] Noam Tractinsky and Oded Lowengart. Web-store aesthetics in e-retailing: A conceptual framework and some theoretical implications. *Academy of Marketing Science Review*, 11:1–18, January 2007.

[43] Upasna Bhandari, Tillmann Neben, Klarissa Chang, and Wen Yong Chua. Effects of interface design factors on affective responses and quality evaluations in mobile applications. *Computers in Human Behavior*, 72:525–534, July 2017. URL: https://linkinghub.elsevier.com/retrieve/pii/S0747563217301176, doi:10.1016/j.chb.2017.02.044.

[44] Mark Matthews and Gavin Doherty. In the mood: engaging teenagers in psychotherapy using mobile phones. In *Proceedings of the 2011 annual conference on Human factors in computing systems - CHI '11*, page 2947, Vancouver, BC, Canada, 2011. ACM Press. URL: http://dl.acm.org/citation.cfm?doid=1978942.1979379, doi:10.1145/1978942.1979379.

[45] Zeltīte Barševska and Olga Rakele. Color in UI Design. pages 79–87, Latvia, 2019. Daugavpils University.

[46] Banu Manav. Color-emotion associations and color preferences: A case study for residences. *Color Research & Application*, 32(2):144–150, April 2007. URL: http://doi.wiley.com/10.1002/col.20294, doi:10.1002/col.20294.

[47] Li-Chen Ou, M. Ronnier Luo, Andre Woodcock, and Angela Wright. A study of colour emotion and colour preference. Part I: Colour emotions for single colours. *Color Research & Application*, 29(3):232–240, June 2004. URL: http://doi.wiley.com/10.1002/col.20010, doi:10.1002/col.20010.

[48] Naoki Kawamoto and Toshiichi Soen. Objective evaluation of color design. II. *Color Research & Application*, 18(4):260–266, August 1993. URL: http://doi.wiley.com/10.1002/col.5080180409, doi:10.1002/col.5080180409.

[49] Xiao-Ping Gao, John H. Xin, Tetsuya Sato, Aran Hansuebsai, Marcello Scalzo, Kanji Kajiwara, Shing-Sheng Guan, J. Valldeperas, Manuel José Lis, and Monica Billger. Analysis of cross-cultural color emotion. *Color Research & Application*, 32(3):223–229, June 2007. URL: http://doi.wiley.com/10.1002/col.20321, doi:10.1002/col.20321.

[50] Frank H. Mahnke. *Color, Environment, and Human Response: An Interdisciplinary Understanding of Color and Its Use as a Beneficial Element in the Design of the Architectural Environment.* John Wiley & Sons, April 1996. Google-Books-ID: fAsm_3cXISAC.

[51] Christof Kuhbandner and Reinhard Pekrun. Joint effects of emotion and color on memory. *Emotion*, 13(3):375–379, 2013. URL: http://doi.apa.org/getdoi.cfm?doi=10.1037/a0031821, doi:10.1037/a0031821.

[52] Ümit Demir. Investigation of color-emotion associations of the university students. *Color Research & Application*, 45(5):871–884, October 2020. URL: https://onlinelibrary.wiley.com/doi/10.1002/col.22522, doi:10.1002/col.22522.

[53] Stéphane Doyen, Olivier Klein, Cora-Lise Pichon, and Axel Cleeremans. Behavioral Priming: It's All in the Mind, but Whose Mind? *PLoS ONE*, 7(1):e29081, January 2012. URL: https://dx.plos.org/10.1371/journal.pone.0029081, doi:10.1371/journal.pone.0029081.

[54] Liang-Chih Yu, Jin Wang, K. Robert Lai, and Xue-jie Zhang. Predicting Valence-Arousal Ratings of Words Using a Weighted Graph Method. In *Proceedings of the 53rd Annual Meeting of the Association for Computational Linguistics and the 7th International Joint Conference on Natural Language Processing (Volume 2: Short Papers)*, pages 788–793, Beijing, China, 2015. Association for Computational Linguistics. URL: http://aclweb.org/anthology/P15-2129, doi:10.3115/v1/P15-2129.

[55] Robert Plutchik. Emotions: A General Psychoevolutionary Theory. In *Approaches To Emotion*, pages 197–218. Psychology Press, May 2014. Google-Books-ID: k0mhAwAAQBAJ.

[56] W. Richard Walker and John J. Skowronski. The Fading affect bias: But what the hell is it for? *Applied Cognitive Psychology*, 23(8):1122–1136, 2009. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/acp.1614. URL: https://onlinelibrary.wiley.com/doi/abs/10.1002/acp.1614, doi:10.1002/acp.1614.

[57] Douglas Bates, Martin Mächler, Ben Bolker, and Steve Walker. Fitting Linear Mixed-Effects Models Using **lme4**. *Journal of Statistical Software*, 67(1), 2015. URL: http://www.jstatsoft.org/v67/i01/, doi:10.18637/jss.v067.i01.

[58] Shinichi Nakagawa and Holger Schielzeth. A general and simple method for obtaining R^2 from generalized linear mixed-effects models. *Methods in Ecology and Evolution*, 4(2):133–142, February 2013. URL: http://doi.wiley.com/10.1111/j.2041-210x.2012.00261.x, doi:10.1111/j.2041-210x.2012.00261.x.

[59] Hal E. Hershfield, Susanne Scheibe, Tamara L. Sims, and Laura L. Carstensen. When Feeling Bad Can Be Good: Mixed Emotions Benefit Physical Health Across Adulthood. *Social Psychological and Personality Science*,

4(1):54–61, January 2013. URL: http://journals.sagepub.com/doi/10.1177/1948550612444616, doi:10.1177/1948550612444616.

[60] Tania Singer and Anita Tusche. Understanding Others. In *Neuroeconomics*, pages 513–532. Elsevier, 2014. URL: https://linkinghub.elsevier.com/retrieve/pii/B9780124160088000279, doi:10.1016/B978-0-12-416008-8.00027-9.

[61] Bettina Bankier, Martin Aigner, and Michael Bach. Alexithymia in DSM-IV Disorder: Comparative Evaluation of Somatoform Disorder, Panic Disorder, Obsessive-Compulsive Disorder, and Depression. *Psychosomatics*, 42(3):235–240, May 2001. URL: https://linkinghub.elsevier.com/retrieve/pii/S0033318201705130, doi:10.1176/appi.psy.42.3.235.

[62] Mark G. Haviland, Michael S. Hendryx, Dale G. Shaw, and James P. Henry. Alexithymia in women and men hospitalized for psychoactive substance dependence. *Comprehensive Psychiatry*, 35(2):124–128, March 1994. URL: https://linkinghub.elsevier.com/retrieve/pii/0010440X9490056N, doi:10.1016/0010-440X(94)90056-N.

[63] Kathleen Wheeler, Philip Greiner, and Martha Boulton. Exploring Alexithymia, Depression, and Binge Eating in Self-Reported Eating Disorders in Women. *Perspectives In Psychiatric Care*, 41(3):114–123, July 2005. URL: http://doi.wiley.com/10.1111/j.1744-6163.2005.00022.x, doi:10.1111/j.1744-6163.2005.00022.x.

[64] Mario Speranza, Maurice Corcos, Gwenolé Loas, Philippe Stéphan, Olivier Guilbaud, Fernando Perez-Diaz, Jean-Luc Venisse, Paul Bizouard, Olivier Halfon, Martine Flament, and Philippe Jeammet. Depressive personality dimensions and alexithymia in eating disorders. *Psychiatry Research*, 135(2):153–163, June 2005. URL: https://linkinghub.elsevier.com/retrieve/pii/S0165178105000958, doi:10.1016/j.psychres.2005.04.001.

[65] F. Farges, M. Corcos, M. Speranza, G. Loas, F. Perez-Diaz, J.-L. Venisse, F. Lang, P. Bizouard, O. Halfon, M. Flament, and Ph. Jeammet. Alex-

ithymie et toxicomanie : lien avec la dépression. *L'Encéphale*, 30(3):201–211, June 2004. URL: https://linkinghub.elsevier.com/retrieve/pii/S0013700604954310, doi:10.1016/S0013-7006(04)95431-0.

[66] G Bird and R Cook. Mixed emotions: the contribution of alexithymia to the emotional symptoms of autism. *Translational Psychiatry*, 3(7):e285–e285, July 2013. URL: http://www.nature.com/articles/tp201361, doi:10.1038/tp.2013.61.

[67] Shan Jin, Chunmei Qing, Xiangmin Xu, and Yang Wang. Emotion Recognition Using Eye Gaze Based on Shallow CNN with Identity Mapping. In Jinchang Ren, Amir Hussain, Huimin Zhao, Kaizhu Huang, Jiangbin Zheng, Jun Cai, Rongjun Chen, and Yinyin Xiao, editors, *Advances in Brain Inspired Cognitive Systems*, pages 65–75, Cham, 2020. Springer International Publishing.

[68] R. Michael Winters, Bruce N. Walker, and Grace Leslie. Can You Hear My Heartbeat?: Hearing an Expressive Biosignal Elicits Empathy. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–11, Yokohama Japan, May 2021. ACM. URL: https://dl.acm.org/doi/10.1145/3411764.3445545, doi:10.1145/3411764.3445545.

[69] Huiling Zhang and Guangyuan Liu. Research of emotion recognition based on pulse signal. In *2010 3rd International Conference on Advanced Computer Theory and Engineering(ICACTE)*, pages V3–506–V3–509, Chengdu, China, August 2010. IEEE. URL: http://ieeexplore.ieee.org/document/5579868/, doi:10.1109/ICACTE.2010.5579868.