



Mitigating Negative Emotions in Anxious Attachment through an Interactive Device

Heimin Kang¹, JungKyun Yoon², and Chajoong Kim^{1,*}

¹Department of Design, UNIST, Ulsan, South Korea

²Department of Human Centered Design, Cornell University, Ithaca, NY, USA

This paper investigates how negative emotions arising from anxious attachment can be effectively mitigated through the design of interactions and how design-supported attachment stabilization can contribute to well-being. Anxious attachment is a type of attachment that is prominent in individuals who are highly dependent on others and have lower self-esteem in interpersonal relationships (e.g., *I need constant reassurance from my partner to feel secure.*). To illustrate how interactions can be systematically designed to alleviate anxious attachment, the paper presents the development of a self-administered interactive device that supports users in the contexts of underachievement, self-depreciation, and future worries. The development process was informed by a diary study with individuals with anxious attachment that explored daily coping strategies, and a design workshop with design professionals that generated a set of design strategies. A ten-day field evaluation study showed the device's effectiveness in alleviating negative emotions associated with anxious attachment through three aspects: facilitating explicit emotion awareness, encouraging positive self-perception, and introspecting the problems at hand. These positive effects were more pronounced when experiencing moderate and low intense negative emotions. This paper discusses implications for design practice with future research directions.

Keywords – Attachment, Attachment Stabilization, Positive Intervention, Emotion Regulation, Design for Well-being, Behavior Intervention Technology, Interpersonal Relationship.

Relevance to Design Practice – This research expands the current practice of design for well-being by integrating a psychological understanding of interpersonal attachment, focusing specifically on anxious attachment. The conceptualization process and resulting design strategies can inform the creation of future products tailored for users with anxious attachment, improving their interpersonal relationships and well-being.

Citation: Kang, H., Yoon., J., & Kim, C. (2024). Mitigating negative emotions in anxious attachment through an interacting device. *International Journal of Design*, 18(2), 17-35. <https://doi.org/10.57698/v18i2.02>

Introduction

Social interaction is crucial for all humans, as maintaining healthy interpersonal relationships benefits both physical and psychological well-being. Especially for young adults, nurturing close relationships is a key developmental goal (Erikson, 1994); supportive social connection has been found to be an effective strategy to support well-being (Aljohani, 2016; Senter, 2024). However, the wide spread of social media and smartphone use has made it more challenging to foster positive interpersonal relationships (Misra et al., 2016; Przybylski & Weinstein, 2013). Among the detrimental effects on interpersonal relationships increasingly reported are diminished empathy, weakened closeness with peers, lowered self-worth due to social comparisons, and an unhealthy reliance on the approval of others (Przybylski & Weinstein, 2013). Further, the prolonged COVID-19 pandemic further decreased opportunities for meaningful interpersonal interactions, leading to more heightened anxiety and depression among young adults, relative to older populations (Kaiser Family Foundation, 2023; Barankevich & Loebach, 2022).

Given these circumstances, it is imperative to critically examine the complex dynamics of interpersonal relationships and associated challenges (e.g., forming, maintaining, and adjusting

relationships). One promising approach is Attachment Theory, originally developed by Bowlby (1982). This theory emphasizes the importance of a secure base for individuals to explore their surroundings and a safe haven to return in times of distress. Secure attachment is positively correlated with well-being and happiness (Öztürk & Mutlu, 2010). The theory provides a framework to explore these dynamics. It suggests that individuals form tendencies known as attachment type. These include: (1) secure attachment, (2) anxious attachment, (3) avoidant attachment, and (4) anxious-avoidant attachment. These are generally determined by whether people see themselves and others positively or negatively (see Figure 1). These attachment types significantly influence interpersonal relationships and are closely linked to mental health (Cozzarelli et al., 2003; Meng et al., 2015).

Received November 21, 2022; **Accepted** April 05, 2024; **Published** August 31, 2024.

Copyright: © 2024 Kang, Yoon, & Kim. Copyright for this article is retained by the authors, with first publication rights granted to the *International Journal of Design*. All journal content is open-accessed and allowed to be shared and adapted in accordance with the *Creative Commons Attribution 4.0 International (CC BY 4.0)* License.

*Corresponding Author: cjkim@unist.ac.kr

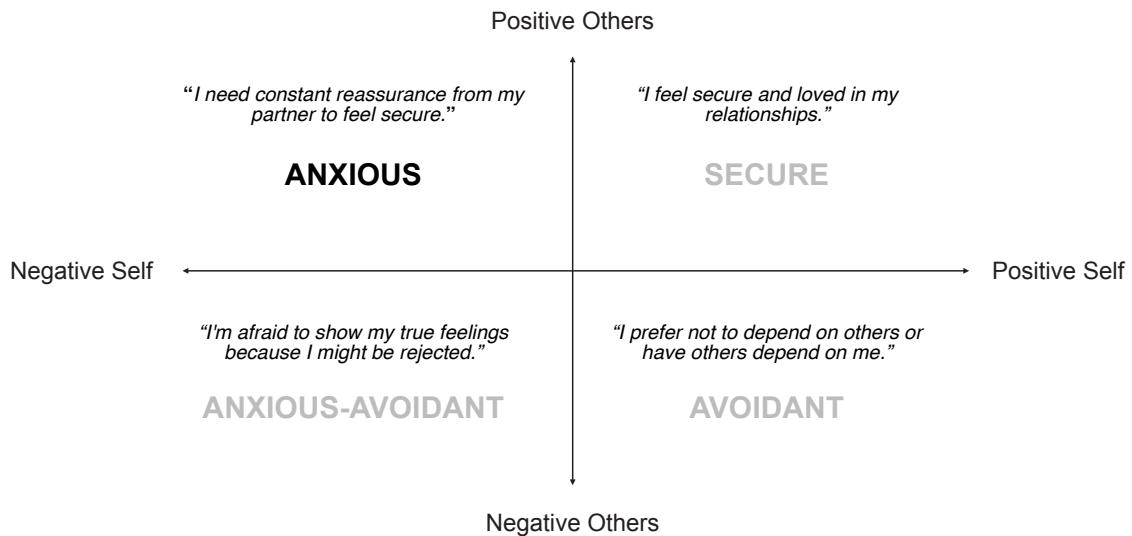


Figure 1. Classification of attachment based on Bartholomew & Horowitz (1991), with the focus of current research highlighted in black.

For example, individuals with secure attachment feel comfortable with both intimacy and autonomy, resulting in less emotional distress and depression. On the other hand, those with anxious attachment often focus on excessively on relationships, depend on others, and have lower self-worth (Konrath et al., 2014). Especially, anxious attachment has a stronger negative correlation with well-being than avoidant attachment (Burge et al., 1997; Hammen et al., 1995; Kafetsios & Sideridis, 2006; Mikulincer & Florian, 2003.)

While secure attachment is important for well-being, not everyone has this attachment type. A study by Gleeson and Fitzgerald (2014) found that among the Irish population, approximately 30.4% have a secure attachment, around 18.1% exhibit anxious attachment, 16.3% display avoidant attachment, and 35.2% show anxious-avoidant attachment. Anxious attachment is particularly salient because it has been linked to a range of psychological challenges, including anxiety disorders, depression, and difficulties in interpersonal relationships. Given its significant prevalence and the profound impact it can have on individuals' well-being, this paper specifically focuses on anxious attachment as a critical area to design for.

Heimin Kang is a graduate student at the Faculty of Industrial Design Engineering (IDE) at Delft University of Technology (TU Delft). She holds a master's degree in Creative Design Engineering from UNIST. Her research focuses on design for well-being, psychological intervention, and the integration of design and technology.

JungKyoon Yoon is an assistant professor in the Department of Human-Centered Design at Cornell University, where he leads Meta Design & Technology Lab. His research focuses on experience design with an emphasis on affective experience, subjective well-being, and design-mediated sustainable behavior.

Chajoong Kim is a full professor in the Department of Design and the founder of Emotion Lab at UNIST. He earned an MSc and PhD at the Faculty of Industrial Design Engineering, Delft University of Technology. His main research interests range from user experience design, design for well-being, and cultural influence in human-product interaction. With these research topics, he has published in, among others, *Design Studies*, *The Design Journal*, *Journal of Design Research*, and *International Journal of Design*.

Anxious attachment is characterized by two traits in interpersonal relationships: a negative self-perception and a positive perception of others. For instance, when these people perceive someone as less committed than they are, they often think they are unworthy (Murray et al., 2006; Murray & Holmes, 2009). This mindset heightens their vulnerability and self-deprecating thoughts. In addition, those with anxious attachment are more susceptible to stress than those with secure attachment (Cassidy & Shaver, 1999) and experience negative emotions more frequently in their daily lives (Pietromonaco & Barrett, 1997; Tidwell et al., 1996), which can detriment their well-being (Schönenfeld et al., 2016). Research has shown that individuals with anxious attachment lack the skills to handle daily emotional experiences (Mikulincer et al., 2009; Mikulincer & Florian, 1998). They typically regulate emotions poorly, resorting to expressing fears, exaggerating distress (Cassidy & Shaver, 1999), overreacting emotionally towards those they are attached to, e.g., romantic partners and close friends (Marmarosh & Tasca, 2013), and obsessively worrying about their unavailability.

Fraley (2019) notes that attachment types can change over time through positive interactions, and several studies have shown that it is possible to stabilize an attachment (Arriaga et al., 2018; Green et al., 2011; Johnson, 2009; Taylor et al., 2015). According to Arriaga and her colleagues (2018), individuals with anxious attachment can benefit from changing their perception of themselves to be more positive through fostering a secure model of self. This process involves engaging in positive activities tied to personally significant goals. These goals offer purpose, stimulate vitality, and structure daily life, thus boosting independence and self-efficacy. Effective emotion regulation is vital, as anxious individuals often experience more negativity in stress situations (Mikulincer & Florian, 1998). Continuous supportive interactions are also key for attachment stabilization, offering a secure base for individuals to feel supported (Cassidy & Shaver, 1999).

However, few studies have systematically explored the factors that facilitate a transition from insecure to secure attachment, partly due to the fact that such a transition tends to manifest over a substantial time, necessitating long-term observations (McConnell & Moss, 2011). Considering such constraints, related studies have examined short-term predictors and their long-term effects on attachment transitions. For example, Mikulincer and Shaver (2008) found that reduced negative emotions mediate secure attachment. Similarly, McConnell and Moss (2011) showed that a decrease in negative emotions corresponds to an increase in attachment security. Emotion regulation in a positive direction has been shown to stabilize anxious attachment into secure attachment, improving self-efficacy (Arriaga et al., 2018). Thus, we postulate that, as illustrated in Figure 2, mitigating negative emotions could help stabilize anxious attachment in the long run.

Therefore, this paper explores how design can alleviate the negative emotions of individuals with anxious attachment as a means of enhancing interpersonal relationships and well-being. In a nutshell, the research questions this paper addresses are:

1. What are the effective strategies for helping individuals mitigate their anxious attachment?
2. How can design integrate these strategies to mitigate their anxious attachment?

We expect that the resulting insights will help designers understand and address the dynamics of interpersonal attachment in a systemic way. The paper begins by reporting a diary study that explored daily coping strategies of individuals with anxious attachment. The following section, inspired by the diary study's findings, describes a set of design strategies developed with design professionals in a design workshop. These two studies (i.e., diary study and design workshop) informed the development of an interactive prototype tailored for individuals with anxious attachment. We then report on a ten-day field study evaluating the prototype's effectiveness in alleviating negative emotions associated with anxious attachment. Finally, the paper reflects on the lessons learned from the prototype's conceptualization and testing, and it suggests implications for design practice with future research directions.

Preliminary Study: Exploring Daily Coping Strategies

A two-week diary study was conducted to deepen our understanding of negative experiences tied to anxious attachment in interpersonal relationships, as well as the coping strategies used. Throughout the study, participants kept notes of their lived experiences resulting from anxious attachment.

Method

Participants

Fifteen participants (8 males and 7 females, aged 20 to 31 years old) exhibiting anxious attachment were randomly recruited through UNIST's recruitment system. To identify individuals with anxious attachment, the recruitment announcement included a link to an online version of the Experiences in Close Relationships (ECR; Brennan et al., 1998) that measures attachment types. The ECR comprises 36 questionnaire items on a 5-point scale that assess attachment types based on two dimensions: anxiety and avoidance. Questions include 18 items related to anxiety (e.g., "I worry a lot about my relationships.") and 18 items related to avoidance (e.g., "I don't feel comfortable opening up to romantic partners."). Based on the scores of the two dimensions, the test identifies attachment types corresponding to Bartholomew's four types (see Figure 1). Individuals with high anxiety scores, who frequently worry about and are dissatisfied with the attention they receive from others, along with low avoidance scores, meaning they readily open up to others and share their feelings, fall under the category of anxious attachment. Participants with test results indicating an anxious attachment type contacted and shared the results with the researcher (the first author) to participate in the study.

Procedure

Following the procedure in the prior literature on attachment and social interactions (Tidwell et al., 1996), the diary consisted of three parts, as illustrated in Figure 3: (1) a report of emotional experience throughout a day, (2) a record of negative situations and coping behaviors, and (3) desired experiences. Emotional experiences, negative situations, and coping behaviors were reported daily. The part of desired experiences was completed once a week, for a total of two times. To make the diary easier to fill out, we included instructions with examples and a list of emotions based on Positive Affect and Negative Affect Schedule (PANAS; Watson et al., 1988), consisting of ten positive (e.g., excited, inspired) and ten negative items (e.g., upset, afraid).

The study was conducted in three stages: an introduction, diary writing, and an interview. Participants were instructed to write in their diaries daily for two weeks, starting from the day of the introductory interview. To ensure they did not write all entries at once, we asked them to submit photos of their entries each night. After the diary writing period, a one-hour one-on-one interview was conducted corresponding to each individual diary to ensure clarity and avoid misinterpretation of participants' content and intentions.



Figure 2. The process of attachment stabilization for anxious attachment.

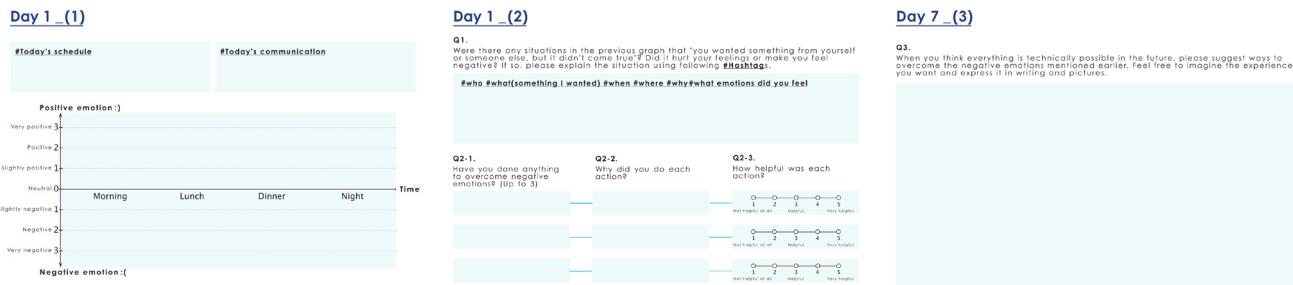


Figure 3. The three parts of the diary used in the diary study.

Data Analysis

A total of 15 diaries, each spanning two weeks, were collected, and all interviews were transcribed. Subsequently, a spreadsheet was created for systematic data analysis, compiling the diary results of all participants. The analysis incorporated five key factors: stimulator (self, others, or situation), motivation (reasoning), coping strategy, example activities, and a scale indicating the efficacy of the coping activity, drawing references from mood regulation strategies (Desmet, 2015).

Results

The diary study generated three main findings: (1) situations when participants experienced negative emotions due to anxious attachment, (2) coping strategies they employed to overcome these emotions, and (3) the types of experiences they sought to alleviate these emotions. For each of the three main findings, subcategories were generated by two design researchers specializing in human-centered and experience-driven design.

Situations

Data analysis revealed nine situations where participants with anxious attachment experienced negative emotions, which are outlined in Table 1.

Underachievement refers to the negative experiences that arise when individuals fail to reach their personal goals, such as failing to mend a strained friendship. *Self-depreciation* is the dissatisfaction one feels towards themselves due to their shortcomings, like feeling unworthy after an argument with a partner. *Unmet expectations* refer to the disappointment experienced when others do not live up to one's expectations, such as a friend not showing up to a planned meeting. *Interpersonal conflicts* cause negative emotions due to

disputes in relationships, like a disagreement with a co-worker over a shared task. *Future worries* relate to the fear caused by uncertainty about what lies ahead, like fretting over a potential breakup. *Negative empathy* involves experiencing negative emotions because of absorbing others' emotional distress, like feeling upset when a friend is heartbroken. *Uncontrolled external factors* pertain to factors beyond one's control in relationships that occur, for instance, a friend moving away unexpectedly. *Breach of morality* depicts situations where one violates ethical standards within relationships, such as someone breaking a promise to a friend, causing feelings of disappointment and anger. *Regret for wrongdoings* pertains to the negative experiences that arise when one acknowledges mistakes or harmful behaviors within relationships, such as feeling remorse after having spread a rumor about a friend, causing damage to their reputation.

Coping Strategies

Participants rated their coping behaviors for negative emotions tied to anxious attachment on a scale of 1 (not helpful at all) to 5 (very helpful). For further analysis, only coping behaviors scoring four or five were included and categorized (see Table 2). The categorization was inspired by the strategies for mood regulation proposed by Desmet (2015).

The results showed that the participants managed their negative emotions by engaging in positive behaviors such as sharing their feelings with others, rewarding themselves, and committing to enjoyable activities. They also took a rest or redirected their attention to other matters to forget their negative feelings. From a cognitive perspective, they adopted a positive mindset or considered others' viewpoints. Social interactions, like giving or receiving support, were also utilized. In situations perceived as uncontrollable, participants used strategies like mediation and temporal suppression.

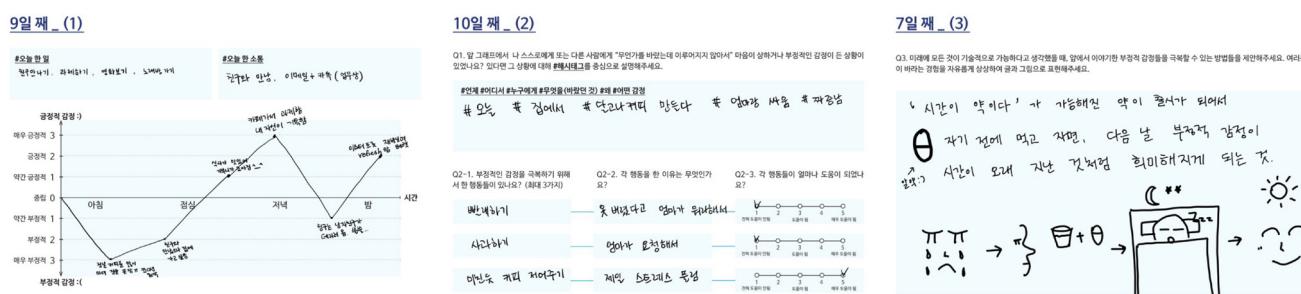


Figure 4. An example image of the diary made by a participant.

Table 1. Nine situations where negative emotions were experienced.

Category	Definition	Example
Underachievement	Failure to achieve a self-assessed goal	"I'm upset because I didn't study and talked too much with my friends." (P16, day 2) "I'm worried because my grade is low compared to others." (P4, day5)
Self-depreciation	A situation where one feels inadequate and is dissatisfied with oneself	"I'm sad because love and study are not perfect." (P7, day 10) "I'm disappointed in myself because there's a lot I don't know." (P5, day 12)
Unmet expectations	A situation where expectations towards others are not fulfilled	"I am annoyed because my friend did not reply quickly." (P12, day 4) "I'm sad that my boyfriend didn't keep his promise." (P7, day 7)
Interpersonal conflicts	A situation where (in)direct conflict arises between oneself and others	"I am so angry at my mom." (P7, day 3) "I'm frustrated because I don't agree with my team members." (P12, day 3)
Future worries	Concerns about an uncertain future	"I'm worried about my research." (P11, day 9) "I'm worried that I won't do well on the test." (P13, day 8)
Negative empathy	A situation where one experiences negative feelings due to empathy with others' feelings	"I'm depressed because my friend broke up." (P4, day 14) "I feel sad and sorry that my friend was rejected from the job." (P4, day7)
Uncontrolled external factors	An external, uncontrollable situation that is not desired	"I'm anxious that my plan to study in COVID-19 has been disrupted." (P9, day 2) "I'm in a bad mood because I had a bad dream." (P9, day 3)
Breach of morality	A situation where morality has been violated	"I get angry because of the person who leaked the test questions." (P5, day 9) "I'm angry about the bully." (P3, day 12)
Regret for wrongdoings	A situation where one feels regret for having wronged others.	"I'm sorry I didn't keep my promise." (P14, day 2) "I'm sorry that my girlfriend misunderstood my intentions." (P6, day3)

Note: Participants were coded as P# in the diary study.

Table 2. Coping strategies reported by the participants.

Category	Definition	Example
Vent	Expressing feelings, often through communication	Discussing feelings with a friend
Self-reward	Engaging in pleasurable activities	Enjoying one's favorite meal
Refreshment	Changing current feelings through different activities	Listening to uplifting music
Rest	Taking a break to rejuvenate energy	Going to bed early
Distraction	Focusing on other things to avoid dwelling on negative emotions	Immersing in work
Positive thinking	Adopting optimistic perspectives and recalling positive aspects of life	Remembering the kind help of a friend
Thinking from the other's perspective	Considering another's viewpoint for perspective	Considering a partner's viewpoint during a disagreement
Detach	Creating mental distance from current feelings	Meditating with calming music
Giving up/leaving	Removing oneself from a negative situation	Leaving a stressful workplace early
Temporal repress	Temporarily suppressing feelings, such as avoiding an argument	Avoiding a political argument with a parent
Problem-solving	Deliberately addressing the problem causing negative emotions	Creating a plan to solve an issue
Analyse	Examining feelings in detail, often through writing	Keeping a diary
Social support	Seeking help from others	Sharing concerns and soliciting advice from others
Providing social support	Offering support to others	Listening attentively to a friend in need

Desired Experiences

Participants expressed their desired experiences in writing and drawing once a week to overcome negative emotions. This process resulted in a total of 30 ideas, which were clustered into seven groups, as shown in Table 3.

Participants mentioned various strategies to manage their negative emotions caused by anxious attachment. They discussed empathy as being comforted by someone, like a family member reacting to their concerns with compassion. They spoke about eliminating negative emotions and feeling a sense of relief from negative feelings, akin to writing down and then physically discarding negative thoughts. An all-around supporter was mentioned, envisioning a supportive entity, similar to a personal virtual assistant that monitors their well-being and suggests coping mechanisms. They talked about dream control, having the liberty to do anything in a dream, resembling a lucid dream offering an escape from reality. Providing a positive experience was a common theme, describing activities that facilitate positive emotional experiences such as indulging in a favorite hobby, walking in a park, or attending a fun social gathering to boost their mood. They also mentioned physical fatigue solutions, methods that alleviate physical exhaustion, like a rejuvenating exercise routine or a restorative drink. Lastly, problem-solving was discussed as finding solutions to complex issues, as if an inner mentor steps in, representing a more confident and competent self, to handle challenging tasks.

Design Considerations

From the various situations and coping strategies identified in the diary study, we narrowed down target situations and strategies as design considerations. These guided the conceptualization of an interactive device that mitigates anxious attachment.

Target Situations

The nine situations identified in the diary study were further analyzed using the attachment type classification model, as illustrated in Figure 5, to identify those aligned with the characteristics of anxious attachment: thinking negatively about oneself and positively about others (Bartholomew & Horowitz, 1991). Situations that fit these criteria, such as *underachievement*, were noted—comparing oneself unfavorably to others. However, a situation like *interpersonal conflict* was excluded because they involved negative perceptions of others, contradicting the positive others aspect of anxious attachment. As such, *self-depreciation*, *future worries*, and *regret for wrongdoings* were identified. Among them, the situation of *regret for wrongdoings* was later excluded because it did not pertain to attachment but applies generally to all attachment types. Hence, *underachievement*, *self-depreciation*, and *future worries* were identified as situations to design for.

Target Strategies

A positioning map was formulated to determine strategies to utilize. The map was based on two axes: emotion regulation strategy (upregulating positive emotions versus downregulating negative emotions) and agent (individual versus collaborative behavior). Figure 6 visualizes the relative positions of existing coping strategies and the desired experience, as categorized from the diary study. For example, venting and empathy were classified under *collaborative behavior–downregulating negative emotion*. This was because participants expressed their emotions to others and empathized, both of which were social interactions intended to decrease negative emotions. Additionally, strategies like positive thinking, thinking from the other's perspective, and eliminating negative emotions fell under *individual behavior–downregulating negative emotion*. These strategies involved individual thought processes that reduced negative emotions with limited social interactions.

Table 3. Desired experiences to mitigate negative emotions reported by the participants.

Category	Definition	Example
Empathy	Being empathized with by someone or something	A product listening and responding to me compassionately
Eliminating negative emotions	Feeling lighter and more at ease from negative feelings	An Emotion trash can—a metaphorical or physical place where I can symbolically dispose of negative feelings
All-around supporter	A helper who assists in various ways	A personal assistant robot informs me of my condition and suggests possible solutions or coping strategies
Dream control	Freedom to do anything within a dream	A lucid dream, offering an escape from reality
Providing a positive experience	Facilitation of positive emotional experiences	Engaging in a hobby, spending time in nature, or participating in enjoyable social events to uplift my mood
Physical fatigue solution	Methods or substances that help alleviate physical tiredness	A restorative supplement that helps maintain energy levels
Problem-solving	The process of finding solutions to difficult or complex issues	An alter ego that manages my challenging task, representing a more confident, competent side of myself

Among the four spaces, the space corresponding to the upregulation of positive emotion and collaborative behavior was selected for conceptualizing the interactive device for the following reasons. First, this space was not addressed by current coping strategies despite being desired by participants. Thus, it was identified as a design opportunity. Second, strategies that upregulate positive emotions have been shown to enhance

happiness, life satisfaction, and self-esteem while holding negative emotions in check (Bryant, 2003; Quoidbach et al., 2010; 2015). Moreover, attachment theory suggests that responsive social interaction is crucial for stabilizing relationships (Arriaga et al., 2018). Therefore, it was expected that interactive devices that respond to users can help establish stable relationships.

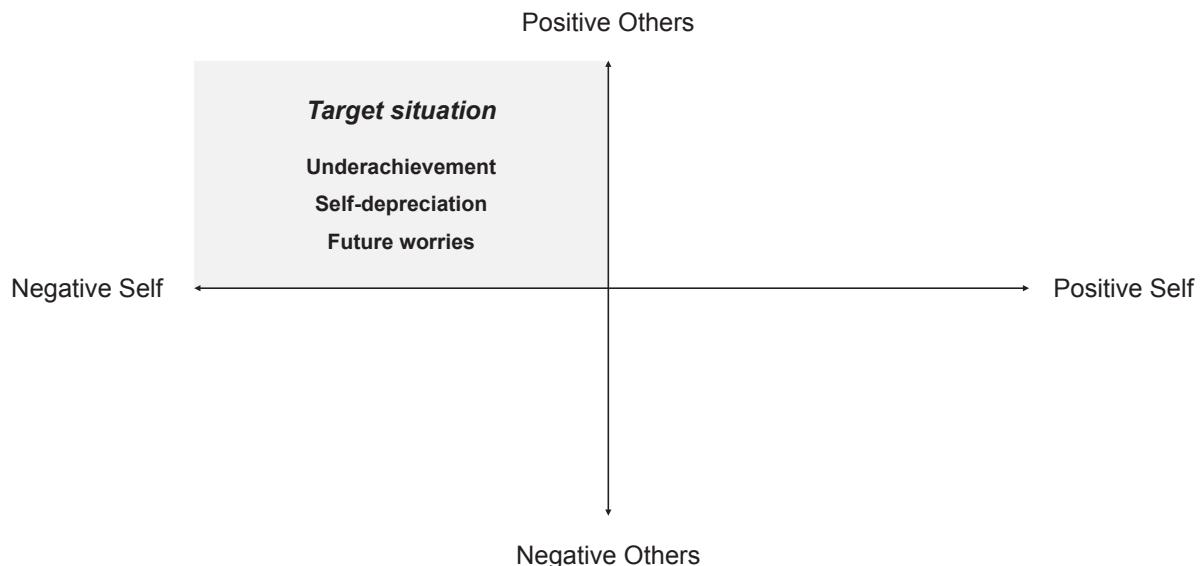


Figure 5. Classification of the target situations to design for.

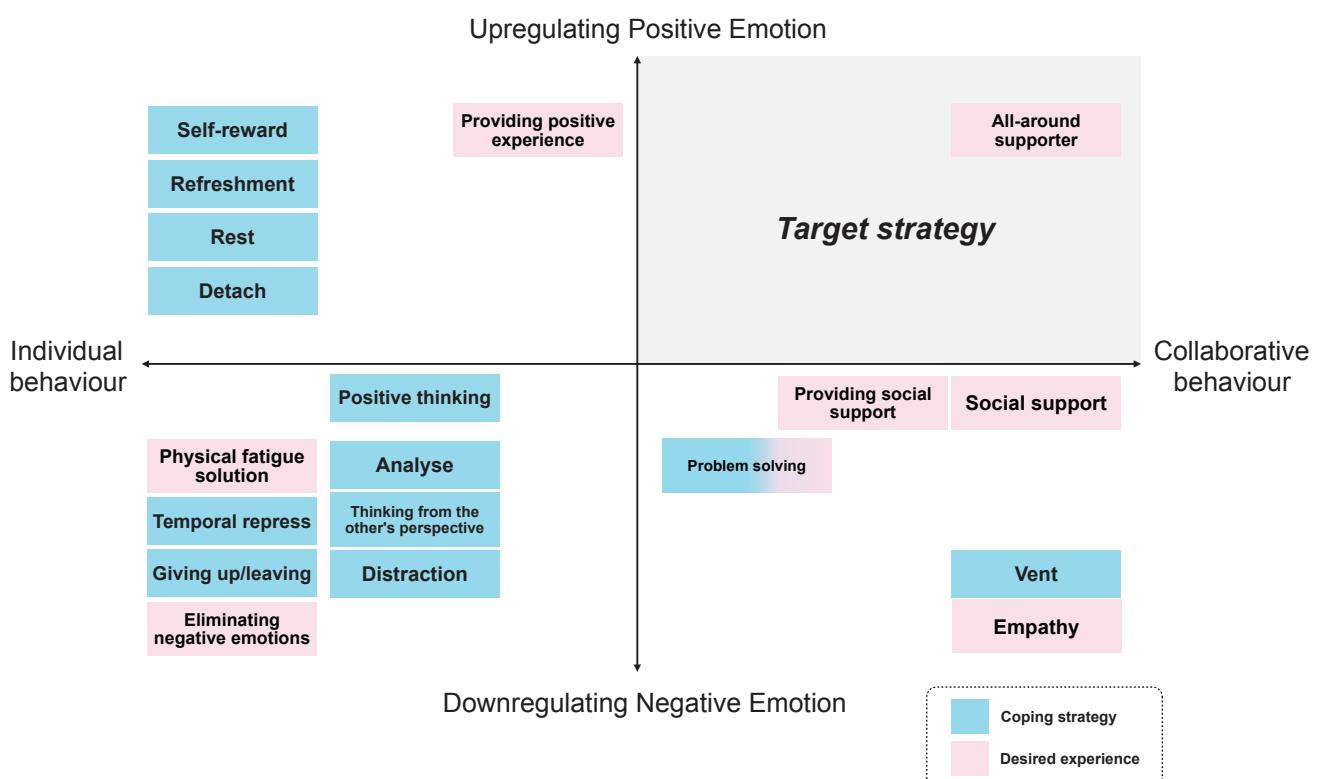


Figure 6. The classification of target coping strategies.

Concept Development

A design workshop was conducted to explore potential user experiences for individuals with anxious attachment. The focus was on three target situations identified in the design considerations: underachievement, self-depreciation, and future worries. Five design professionals participated in the workshop. They are user interface designers, product designers, and user experience designers. Each participant had at least two years of experience in their respective fields. Table 4 provides details on the participants' backgrounds. The goal of including people from various specializations was to gather diverse perspectives.

As determined in the design considerations, participants were guided to envision experiences that upregulate positive emotional experiences (i.e., amplifying and prolonging positive emotions). As a source of inspiration, the participants received a handbook that outlines a set of positive activities applicable to the five strategies for the emotion regulation process (Gross, 1998) in daily life (see Figure 7). The activities were related to (1) choosing situations to enter (or not) based on their preferred emotional outcomes (i.e., situation selection), (2) modifying those situations to be favorable (i.e., situation modification), (3) directing their attention to specific features of the experiences (i.e., attentional deployment), (4) changing their evaluation of the situation (i.e., cognitive change), and (5) altering their experiential, and

behavioral responses (i.e., response modulation). The list was adopted from the emotion-regulating activities compiled by Quoidbach et al. (2015).

The workshop consisted of three phases: introduction, ideation, and discussion. The introduction phase provided research goals, findings from the diary study regarding intended users and situations, and design considerations. In the ideation phase, participants, unrestricted by product types, generated two ideas for each intended scenario, resulting in diverse ideas based on each designer's expertise. This led to a total of 30 ideas (two ideas for each of the three situations from five participants; see Figure 8 for examples of generated ideas). In the discussion phase, designers shared and deliberated on their design strategies with sketches. Table 5 outlines the patterns of resulting design strategies and associated design qualities.

In the situation of underachievement, suggested design strategies included creating achievable goals within a manageable timeframe to avoid feeling overrun, obtaining philosophical guidance to gain broader perspectives, particularly in strained relationships, and compassionate discourse, which comprises expressing feelings without assigning blame during disagreements. They also suggested acknowledging minor accomplishments, such as valuing a successful collaboration with a team member, to enhance self-esteem. Sharing experiences with trusted individuals, like conveying feelings of underachievement

Table 4. Participant information of the design workshop.

Age	Gender	Occupation	Working experience
30	Female	User experience designer	2 years
29	Male	Product designer, design researcher	2 years
30	Female	Product designer	6 years
26	Female	User experience planner	3 years
32	Female	App user interface designer	3 years

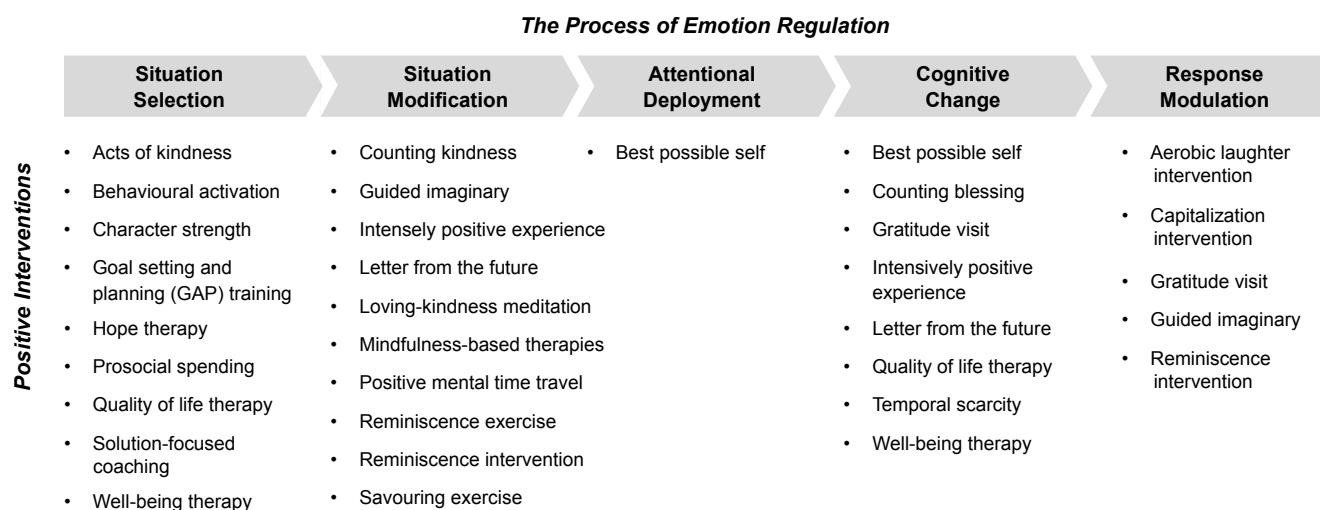


Figure 7. Example approaches for positive intervention (adopted from Quoidbach et al., 2015).

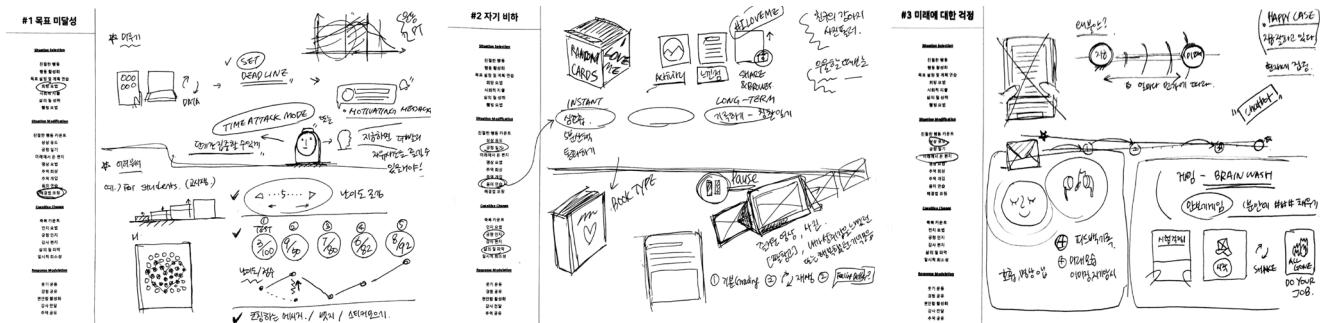


Figure 8. The example results of the design workshop.

Table 5. Suggested design strategies and related design qualities for the three situations.

Situation	Design strategy	Design quality
Underachievement	<ul style="list-style-type: none"> Setting realistic goals and plans (e.g., creating achievable goals within a reasonable timeline) Receiving philosophical advice for perspective (e.g., understanding different viewpoints in a strained relationship) Compassionate communication (e.g., expressing feelings without blaming in an argument) Recognizing small victories (e.g., appreciating a productive conversation with a partner) Sharing experiences with close ones (e.g., discussing feelings of underachievement with trusted friends or family) Engaging in enjoyable activities (e.g., going to a movie with friends to distract from a failed project) 	
Self-depreciation	<ul style="list-style-type: none"> Analyzing situations objectively (e.g., understanding the real reasons behind a setback without self-blame) Identifying steps to improve (e.g., developing better study strategies after a low test score) Recalling past successes (e.g., remembering a time when a project was well-received) Speaking comforting words to oneself (e.g., reminding oneself that everyone makes mistakes) 	<ul style="list-style-type: none"> Conversational—Action-oriented and organized Positive thinking—encouraging and celebratory Familiar and relatable Reflective and motivating Warm and soothing Personal and affirming Purposeful
Future worries	<ul style="list-style-type: none"> Cultivating a positive outlook (e.g., expecting a positive outcome from a job interview) Celebrating small successes regularly (e.g., acknowledging and rejoicing over completing daily tasks) Developing a clear plan of action (e.g., outlining steps to complete a complex work) Visualizing positive future scenarios (e.g., imagining strengthened skills after overcoming a challenge) Practicing positive self-talk (e.g., reassuring oneself that a resolution can be found soon) Setting personally meaningful goals (e.g., learning a new communication skill) 	

with a friend, was recommended as a strategy to receive support and empathy. Additionally, engaging in pleasurable activities, like attending a concert with friends, was suggested as a positive distraction from an unsuccessful endeavour.

For the situation of self-depreciation, designers recommended strategies such as examining situations impartially, which involves comprehending the true causes behind a disappointment without self-criticism, identifying improvement strategies, like devising better communication approaches after a misunderstanding, recalling past victories, such as remembering a well-executed presentation, to enhance self-esteem, and uttering comforting phrases to oneself as a form of self-care and reassurance.

In the situation of future worries, designers recommended fostering a positive mindset, like anticipating a favorable result from a project proposal, acknowledging minor victories

regularly, like recognizing and celebrating the completion of weekly goals, to maintain high spirits. They also proposed formulating a clear action plan, like detailing steps to complete a challenging assignment, envisioning positive future scenarios, for example, imagining acquiring new skills after overcoming a hurdle, practicing positive self-affirmations, reassuring oneself that a solution is within reach, and setting personally significant goals, like mastering a new programming language, to keep motivation elevated.

The design qualities associated with these strategies were proposed to be action-focused, organized and actionable, and associated with clear and concise instructions or steps. They aim to encourage users to take initiative, be reflective, and allow them to consider their progress and emotions while motivating and inspiring them to persist. The design was also suggested to

be encouraging and celebratory to recognize the user's efforts, warm and soothing to offer a comforting environment, personal and affirming to validate the user's feelings and experiences, and purposeful to ensure each component or feature serves a valuable purpose.

From the suggested qualities, we identified three key design qualities to integrate into a design concept: conversational, positive thinking, and familiarity. The *conversational aspect* emerged as a significant component, particularly in the form of smart speakers that offer motivational phrases and concrete action plans. As such, text interaction, which encompasses both reading and writing, was also deemed a viable communication method, providing a quieter, more introspective mode of engagement. *Positive thinking* was identified as important for helping individuals with anxious attachments view themselves in a more positive light. Related, recalling positive memories and envisioning a positive future were proposed as ways to facilitate essential cognitive change through product interactions, encouraging users to reframe their thoughts and perceptions in an optimistic manner. The use of a *familiar product* or a familiar way of using it was emphasized for users with anxious attachments. Given the importance of stability for these individuals, using known products was deemed more reassuring than introducing unfamiliar ones. Hence, integration with an existing product was preferred when developing prototypes to ensure user comfort and security, providing a seamless experience that builds on existing habits and preferences, rather than disrupting them with something entirely new.

A prototype of an interactive device, incorporating three key design qualities, was developed. It consisted of a printer and a mobile application, employing a familiar interaction format similar to writing and reading on paper. Users manually select one of three options on the app's situation button, corresponding to their current negative experience. Once the user presses the print button, the device swings into action, printing written content specifically tailored to the chosen situation (as shown in Figure 9). The content varies based on the selected situation, building on the suggested strategies as outlined in Table 5. For underachievement,

the paper features motivational and comforting phrases (e.g., "It is fine to celebrate success, but it is more important to heed the lessons of failure."). For self-depreciation, it poses questions that remind users of positive self-memories (e.g., "Even if it's small, did you show any consideration for others today? Please compliment yourself."). For future worries, it includes questions that encourage imagination to reduce uncertainty (e.g., "What kind of day do you want tomorrow to be? Please write a future diary imagining an event."). This concept is intended to provide automatic and customized content for users, and to cater to their individual experiences and emotional states.

Main Study: Assessing the Device's Effectiveness

Method

Participants

Six participants, consisting of three men and three women with anxious attachment, were newly recruited through the recruitment system implemented in UNIST. In line with the procedure used in the preliminary study (see Preliminary Study section), participants who self-identified as having anxious attachment contacted the researcher (the first author), with the results of the Experiences in Close Relationships (ECR; Brennan et al., 1998). The average age was 23.5 years, with a range from 20 to 28 years old. Since the app was developed on Android operating system, using an Android phone was a requirement.

Materials

An interactive prototype of the device was developed, as shown in Figure 10. It consists of three parts: a mobile application, a printer module, and a 3D-printed cover. The printed prompts were carefully crafted based on suggested experiences and design qualities formulated during the design workshop. Twenty unique content pieces were prepared for each situation, using a coding mechanism to ensure random selection and prevent duplication

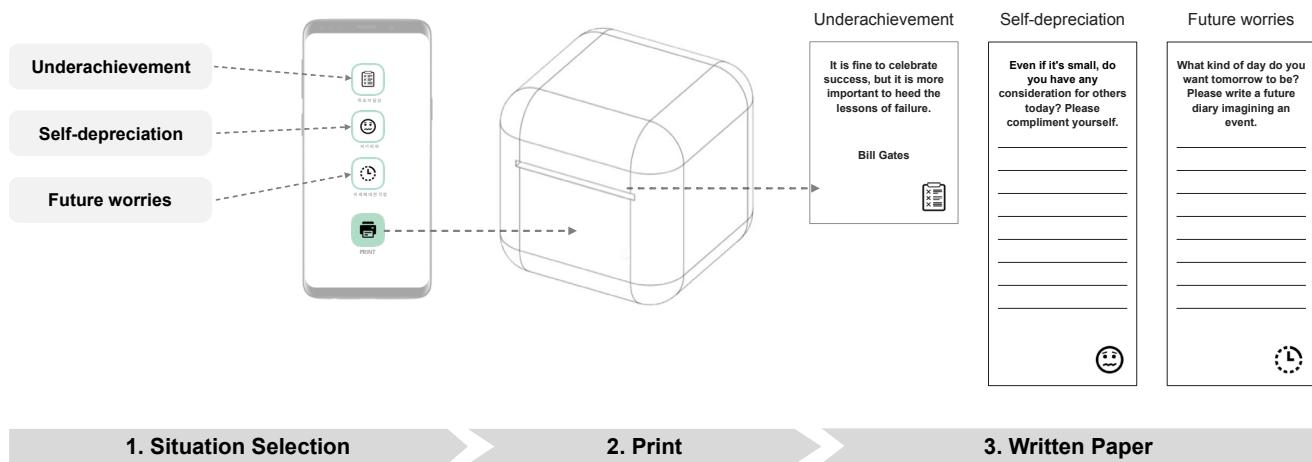


Figure 9. The device operation process.

during printing (totaling 60 content pieces; 20 contents per three situations). Additionally, a user manual explaining how to operate the device was created. Three identical prototypes and manuals were replicated and distributed in two batches, each two weeks apart. Each batch, intended for three participants, contained three prototypes and manuals.

Three online questionnaires and interview questions were prepared. The first questionnaire asked participants about their feelings at the time of using the device, specifically about perceived valence (i.e., positive versus negative; "How did you feel about the situation?"). This was to verify if participants sought the device during negative emotional states, as the evaluation study was centered on the device's effectiveness in alleviating negative emotions within an anxious attachment context. The second questionnaire focused on the perceived effectiveness of the device in positively influencing participants' emotional states, asking "Has using the device helped make you feel better?" The interview and the third questionnaire aimed to understand the motivation for using the device and its potential long-term impact, serving as a post-evaluation. It included questions like, "Have there been any changes in terms of the urge to seek others to talk about your negative experiences?" and "Do you think that using the device has helped manage your feelings by yourself?"

Procedure

The evaluation study was conducted in the order of installation, first questionnaire, second questionnaire, interview, and third questionnaire. The first and second online questionnaires, conducted every five days, assessed the participants' experiences of using the device. After ten days of using the device, an interview was conducted to delve deeper into each participant's survey responses. Throughout the study, participants received a daily reminder to use the device. Finally, a third questionnaire was conducted two weeks after their participation to examine any long-term behavioral changes resulting from device usage.

Results

Manipulation Check and Perceived Effectiveness

The first and second questionnaires included two parts. The results of the first part confirmed that the participants did indeed experience negative emotions when they sought to use the device. Using a 5-point scale where 1 indicates very negative and 5 very positive, 36 responses were collected, with 12 responses for each of the three situations ($M = 1.91$, $SD = 0.41$). Notably, negative responses were tied to self-depreciation ($M = 1.42$, $SD = 0.18$), with most participants indicating very negative or negative feelings. Similarly, responses related to underachievement and future worries were towards negative feelings but were slightly higher ($M = 2.17$, $SD = 0.48$).

The second part explored the extent to which the device helped manage emotions. Utilizing a 5-point scale, where 1 signifies strong disagreement and 5 strong agreement, we collected 36 responses, with 12 responses for each situation. The device was generally perceived as effective across all three scenarios ($M = 3.69$, $SD = 0.75$), with the greatest agreement for future worries with high variability ($M = 4.17$, $SD = 1.21$). For self-depreciation, the participants generally agreed that the device was effective in mitigating negative emotions ($M = 4.08$, $SD = 0.92$). The mean rating for underachievement was 3.08, indicating a slight agreement ($SD = 0.35$). While the sample size was small, the variations in the degree of effectiveness in future worries and self-depreciation implied that its effectiveness was somewhat individual-specific. We delved deeper into the factors contributing to the device's effectiveness for each user in the following section, using qualitative data analysis.

Results of Interviews

All interviews were transcribed and subjected to thematic analysis (Braun & Clarke, 2006; Thomas, 2006). Initially, transcripts were clustered into positive and negative responses. They were

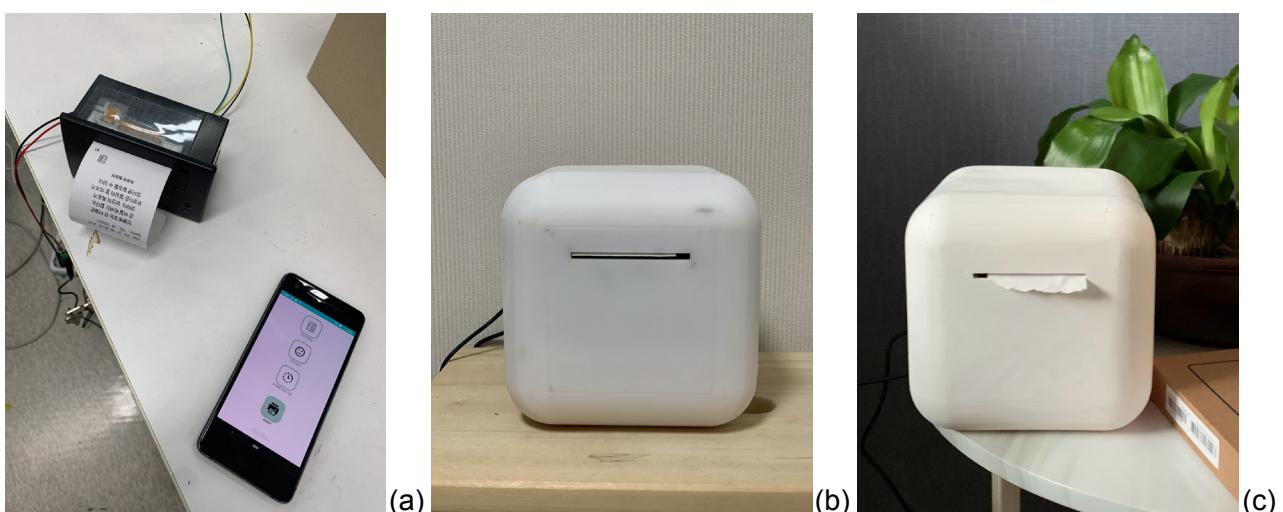


Figure 10. The process of prototyping the device includes: (a) developing the printer module and the mobile app, (b) creating the 3D printed cover, and (c) installing the device at a participant's home.

then further coded to identify factors contributing to the benefits and drawbacks of using the device. In addition to the inductive data coding and interpretation, the design strategies and design qualities derived from the design workshop (e.g., engaging in enjoyable activities, conversational) guided the analysis of the device's key features and participants' responses. To ensure inter-observer reliability, two additional researchers, specializing in human-centered and experience design, independently reviewed de-identified transcripts and coded them. Any differences in interpretations between the researchers were resolved in iterative discussion in which they argued for their analysis with examples until a consensus was reached. The data analysis identified eight types of positive experiences (see Table 6) and four types of negative experiences associated with the device usage. The key findings and corresponding exemplary use cases as well as related design aspects are reported below.

Using the device helped ease negative emotions through three experiences: (1) *explicit emotion awareness*, (2) *positive self-perception*, and (3) *introspecting the problems at hand*. First, the participants mentioned that using the device enabled them to recognize their emotions more explicitly. All participants agreed that choosing a specific situation helped them be aware of their negative emotional experiences in detail, such as worry, frustration, and insecurity. For example, one participant stated, "paying attention to how I felt helped me understand what caused these feelings and how I could respond constructively (Participant 1)." Another remarked, "Choosing one of the three situations already helped me better understand the nature of the negative feelings I was experiencing."

Second, using the device encouraged the participants to adopt a positive mindset. This involved recalling positive experiences and maintaining a positive outlook. For example, Participant 5 shared, "There was a time when I was really happy to recall good memories." Participant 1 stated, "I felt terrible

today, but recalling the good moments made me realize that the day wasn't meaningless. I felt better as I could end on a good note." Even in a short span of time (i.e., ten days), this positive thinking turned into a habit for some participants. Participant 4 explained, "I started focusing on what was best at that time rather than dwelling on what I lost. I spent time answering questions and focusing on my strengths, not my weaknesses."

Third, using the device assisted participants in introspectively managing their emotions. It engaged participants during moments of negative emotions, helping to alleviate these feelings. As noted by Participant 5, the device helped them vent and stop negative thoughts while printing. However, the device's effectiveness appeared to vary depending on the intensity of negative emotions. For example, Participants 1 and 6 found it challenging to focus on their anger, nervousness, or hate while using the device. They noted that during moments of these intense negative emotions, the device hardly managed to get their attention. On the other hand, using the device proved effective in mitigating less intense negative emotions, such as sadness and disappointment.

The device also enabled participants to become more *independent* by helping them manage their emotions without frequently seeking support from others. Participant 6 stated, "As other people might also be struggling, I can't keep talking about my problems. I appreciated being able to handle it by myself." In addition, Participant 5 mentioned, "I liked the fact that I didn't bother others much, and found comfort in resolving my issues to some degree myself."

Interestingly, having a device that can be used during negative emotional states provided an *emotional stability*. Participant 3 stated, "Being far away from home, finding new ways to handle my negative thoughts and feelings was challenging. But, just knowing the fact that I had it was very helpful. The ability to soothe negative feelings by pressing the buttons whenever I wanted gave me a sense of stability."

Table 6. An overview of positive experiences derived from interviews.

Positive experience	Examples
Explicit emotion awareness	<ul style="list-style-type: none"> Choosing situations made me think about my feelings in a clear way.
Positive self-perception	<ul style="list-style-type: none"> It got me thinking on the bright side. Seeing my own growth brought me a sense of satisfaction.
Introspective emotion regulation	<ul style="list-style-type: none"> It provided an outlet for my negative emotions. It nudged me to remember the good times. It just became part of how I manage my feelings.
Increased independency	<ul style="list-style-type: none"> It helped me figure stuff out all on my own. I found myself asking my friends for help less often.
Emotional stability	<ul style="list-style-type: none"> I felt a sense of stability from the device's physical presence.
Human-like interaction	<ul style="list-style-type: none"> It was like having a chat. The waiting process built up my anticipation.
Enjoyable moment	<ul style="list-style-type: none"> The randomness added anticipation and fun.
Memorable reflection	<ul style="list-style-type: none"> Writing down on paper helps it stick better in my memory. Writing down on paper helped me minimize distractions. Seeing those printed papers just grabbed my attention. The printed paper served as a prompt for recording.

The *human-like interaction* and *enjoyable moments* also had positive effects. For example, Participant 5 mentioned, "If I was using the app alone, it would have felt instant. But because it took some time to come out through the printer, it felt like I was waiting to talk to someone else." Participant 1 also noted "I found it easy to organize thoughts because the device gave me questions related to the selected topic." Participant 4 mentioned "It was fun, and I was looking forward to what questions would appear next."

Further, the physicality of the device stimulated *memorable reflection*. As Participant 5 stated, "The app could be ignored, but when it's on paper, I had no choice but to watch it while it was being pulled out." Similarly, Participants 2 and 3 placed the paper on their desks or walls and found themselves glancing at it while daydreaming or waiting for their computer to load. Writing by hand was reported to be more memorable than typing on a cell phone, giving the participants (Participant 3 and 4) the impression of writing a letter. Participant 4 added "One of the device's positive aspects was the increased focus on writing, as there were fewer distractions compared to using my phone." Upon looking at the collected papers, Participants 3, 4, and 5 used the printouts to track their device usage. They noted that the collection of printed papers could serve as a form of memory. Participant 5 mentioned, "The printed papers could become something that I can see when I have a hard time in the future."

Nevertheless, using the device had its drawbacks. As previously noted, when participants confronted intense negative emotions in situations of underachievement such as frustration and anger, some felt overwhelmed. This was because using the device inevitably led them to ruminate on these negative feelings. For example, Participant 1 said, "Filling out the questions was helpful, but it was somewhat difficult as I had to chew over the negative experiences and foreground them." Participant 6 remarked, "It seems to vary depending on the situation. At times, recalling happy memories made me feel worse when comparing them to my current situation."

Furthermore, some participants found it difficult to determine which situations to select. Participant 5 expressed this confusion by saying, "I was a bit confused about which button to press. Sometimes, situations are quite mixed and complex. Self-deprecation, future worries, and underachievement are all intertwined, making it a bit confusing." Similarly, Participant 1 also noted, "Sometimes, I'm not sure if my self-deprecation is due to worries about the future or because I haven't been able to keep up with something."

The printed prompts associated with the situation of underachievement had shortcomings. Some participants found that the content did not directly correspond to their experiences. Participant 5 noted, "The prompts weren't bad, but sometimes the prompts I wanted didn't come up, so that was disappointing. I wished for prompts that were more closely related to solving the concerns in the situation. When unrelated prompts came up, it felt unsatisfying, and I tried to connect them as much as possible."

Additionally, some participants expressed dissatisfaction with the delay caused when they did not have immediate access to the device and printed content. Participant 5 shared, "I've had that

experience a couple of times, like once on the subway and another time when I was probably on a mountain. I was looking forward to printing at home, but it was also somewhat disappointing because I wanted to print and write about my experiences immediately."

Potential Long-Term Benefits of Using the Device

The results of the third questionnaire, which was completed two weeks after using the device, indicated that the post-use experience continued to help alleviate negative emotions associated with anxious attachment, with an average rate of 4.34 out of 5. Five out of six participants reported positive responses, each referring to different reasons. These included: encouraging independent writing and reducing reliance on others (Participant 1); boosting self-esteem and fostering a more positive outlook (Participant 4); aiding in learning to handle negative emotions independently (Participant 6); assisting in understanding one's own emotions and expressing emotions to others (Participant 5), and helping to maintain healthy habits formed through the device usage (Participant 3). For example, participants mentioned that "I could do self-resolution by writing something down and resolving it on my own, even without bothering anyone" (Participant 1), "it seems that my self-esteem has increased during the participation in this research, allowing me to lead a brighter and more positive life" (Participant 4), and "I have been maintaining the improved lifestyle habits that I developed through the device until now" (Participant 3).

Discussion of the Findings

The main study investigated how the use of the device could help individuals with anxious attachment in mitigating negative emotional experiences. The results indicated that the device, developed based on the design strategies from the preliminary study, positively supported participants to manage their negative emotions in a manner that stabilizes their attachment. The findings suggest that interacting with the device could enhance emotion regulation, reducing reliance on others. Yet, they also generated new insights into how its design could be further enhanced by revealing its limitations. In the following section, we discuss (1) how these findings could contribute to mitigating negative emotions resulting from anxious attachment, and (2) how they could be applied in design solutions for anxious attachment and related negative emotional experiences.

Design-Mediated Anxious Attachment and Emotion Regulation

The evaluation study of device usage generated valuable insights into users' emotion-regulating behaviors related to anxious attachment. Notably, self-reflection generated both positive and negative impacts. On the positive side, introspecting and recognizing the source of negative emotions helped participants. As they decided which button to click on the screen, understanding what triggered negative emotions seemed to alleviate these emotions. This aligns with previous studies suggesting that self-

reflection and emotion-introspection could support individuals' adaptive coping because they can guide their thoughts and behaviors in a self-beneficial way, thereby enhancing well-being (e.g., MacIsaac et al., 2023; Herwig et al., 2010). However, some feedback indicated excessive rumination on negative emotions. For example, participants mentioned that using the device sometimes made them focus on negative emotions and related experiences, exacerbating them. This response aligns with studies indicating that rumination can amplify negative emotions by fixating on mood (Lyubomirsky & Nolen-Hoeksema, 1995; Nolen-Hoeksema et al., 2008; Watkins & Roberts, 2020). Considering these two sides, implementing a balanced level of guided self-reflection and diversified strategies for emotion regulation (e.g., distraction and positive reappraisal) should be taken into account in developing a design intervention to minimize unforeseen and undesired effects. The intensity of negative emotions in a situation was an additional factor to consider. When participants experienced intense negative emotions, such as resentment and fear, the device provided limited opportunities for engagement with it due to the overwhelming emotions they faced. This might be comparable to stressful or threatening events such as relationship breakups (Kirkpatrick & Hazan, 1994; Sbarra & Hazan, 2008) or the experience of traumatic experiences (Mikulincer et al., 2011), engendering insecurity (Arriaga et al., 2018; Fraley, 2019). In our study, these insecurity-triggering situations appeared to diminish the device's usefulness. Hence, it is crucial to further explore alternative design strategies that remain effective, even in the presence of strong negative emotions.

In situations of underachievement, the reframing or reappraisal prompts are deemed not particularly useful. According to Troy et al. (2013), the utility of reappraisal in mitigating negative emotions is significantly influenced by the controllability of the stressor encountered. While reappraisal can be beneficial in contexts involving uncontrollable stressors, it can paradoxically increase negative emotions in situations deemed controllable. This dichotomy underscores the device's limited applicability, especially in scenarios where individuals might possess more control over their circumstances. Instead of leveraging reappraisal, these situations might call for direct action or solutions, as the attempt to simply reinterpret the situation without addressing its root causes could inadvertently exacerbate feelings of frustration. The device's lack of utility in these contexts may thus be attributed to its reliance on reappraisal. By adopting a more adaptive and context-sensitive approach to its prompts, the device could improve its effectiveness, particularly in addressing the nuanced challenges associated with underachievement.

Despite the unexpected limitations of the device usage, it is noteworthy that its mere presence often provided a sense of security to the participants. As a tangible artifact, the physical placement of the device within the participants' environments affected their motivation, owing to participants' increased awareness of the device, stimulating them to remember and carry out positive activities during their daily lives (for an overview of the benefits of tangible interactions within the context of self-administered design intervention, see Schueller et al., 2013).

This observation resonates with literature on interpersonal attachment, which posits that individuals often form attachments with easily reachable figures, usually partners, who serve as safe shelters during insecure times (Öztürk & Mutlu, 2010). However, the availability and responsiveness of these attachment figures can vary over time. We postulate that a tangible device offering consistent, supportive, and stable interaction that can be a viable means when help from others is unavailable.

While the positive responses regarding long-term benefits were encouraging, we are aware that they remained hypothetical, illuminating the need for further research into the long-term relationship between design-mediated emotion regulation and attachment stabilization. Potential areas of investigation include the possibility of an intention-behavior gap, an incongruence between what people consider worthwhile and what behaviors they engage in (Carrington et al., 2010) and the novelty of device usage wearing off over time, resulting in lower efficacy in long-term real-life use (Shin et al., 2019).

Design Strategies for Anxious Attachment

The design strategies developed based on real-life coping strategies of individuals with anxious attachment supported the conceptualization process of the device, particularly in determining key features. First, as mentioned earlier, the tangible design proved effective in providing a memorable object for participants. This is consistent with previous studies (e.g., Diefenbach et al., 2016; Desmet & Sääksjävi, 2016) which highlight tangible products can form the material context of our daily lives. Thus, they can be an effective means to influence users' daily behaviors. Whereas traditional screen-based behavioral intervention technologies, such as computers and tablets, may come across as demanding or challenging, a tangible design might help people adopt a more natural, personalized approach to self-guided well-being-enhancing behaviors. This implies that when designing for people with anxious attachment, daily tangible interventions may yield better effects. As some participants noted, they would serve as reminders of their availability, assist in recalling or anticipating positive experiences, or represent attempts to overcome attachment-associated challenges.

Second, the interaction style affected its effectiveness. The design workshop showed that while both reading and writing experiences involved text interactions, writing had a more positive impact on managing negative emotions. During interviews, one participant mentioned that the reading-only scenario was not particularly helpful, as it merely provided a reading prompt. They found writing more effective because it encouraged active participation and was more memorable than just passively reading a prompt. In particular, the act of handwriting on paper facilitated a deeper and more profound reflection than typing on the app or just reading words. This was because writing by hand allowed participants to focus more on the detailed aspects of their emotional experiences (e.g., causes, feelings, and responses) without distractions, helping them better organize their thoughts and behaviors. These observations align with studies suggesting

that paper-based interaction enhances metacognitive abilities more than screen-based interaction, emphasizing its potential to support self-regulation and foster metacognition (e.g., Ackerman & Goldsmith, 2011).

Furthermore, participants mentioned that the subtle delay between clicking the button and receiving the printed paper and being able to write their thoughts at their own pace created a sense of having a reciprocal conversation. This ‘slow interaction’ was perceived as akin to human-human interaction, allowing participants to feel like they were talking with a product, alleviating the burden of conversing with someone (e.g., a friend and a partner). The anticipation fostered by the short waiting experience and the unpredictability due to the randomness of the printed content elicited enjoyment and pleasant surprise, contributing to participants’ increased desire to engage with the device. This *slow design* or *slow technology* quality has been known to be effective in promoting appreciation of the aesthetic quality of experiences at hand and critical reflection, enriching the overall user experience (for an overview of related design cases of slow design and technology, see Odom et al., 2022).

Note that when applying these findings to future designs, it is crucial to consider other factors beyond users’ attachment types. These factors include, but are not limited to, the context in which users interact with the device, such as location (e.g., at home, in the office, or while in transit) or time (e.g., before a user goes to sleep or while waiting for others’ responses), could considerably alter a user’s perception and use of the device. User characteristics like demographics (e.g., age and gender) and traits beyond attachment types (e.g., openness to experience, emotion regulation ability, attitudes towards positive interventions) can also influence the device’s effectiveness. Research suggests that younger generations tend to have a more positive view of product usage than older generations in terms of aesthetics, instrumentality, and identity-association (Yoon et al., 2020), and the effectiveness of an emotion-regulating technology is more pronounced for those with positive attitudes towards such interventions (Yoon et al., 2021). Given that our study primarily involved participants under 30, feedback may vary in other age groups. Thus, a more comprehensive and nuanced understanding of these factors is needed to optimize future design and technology for the diverse range of intended users.

General Discussion and Conclusion

Contributions and Design Implications

Emotional well-being has emerged as a significant societal challenge and as such, the World Health Organization (2013) included it as a key part of the mental health action plan. All products and digital technologies influence users’ day-to-day emotions, strongly affecting their well-being (Calvo & Peters, 2014). With the potential to reach large populations, the domain of emotion-managing products has been recognized as a promising avenue to promote well-being (Coyle et al., 2014). Despite the widespread demand for such products, their development and

adoption have been hindered by a lack of understanding of how they can be systematically integrated into everyday lives. Many of emotion-managing products tended to rely on traditional psychoeducation approaches from existing therapies, often failing to correspond to the interests and situational needs of intended users, including challenges in interpersonal relationships (Slovak et al., 2022).

This paper makes methodological and empirical contributions by making connections between work grounded in design research and psychology, especially linking the phenomena of attachment and emotion regulation across the two disciplines. Based on the theories of attachment in interpersonal relationships and human-centered design approach, we elucidated (1) the conditions that enable users with anxious attachment overcome related negative experiences in daily lives (i.e., coping strategies), (2) how such conditions can be facilitated by human-product interactions with a focus on emotion regulation (i.e., design strategies), and (3) how the design-mediated emotion regulation influence users’ attachment stabilization.

In particular, this research makes a case for how design can systematically enable users to actively manage their emotions tied to anxious attachment in their routines. Previous studies in psychology provide an understanding of the phenomenon of anxious attachment and associated therapeutic interventions, but they remain abstract and lack sufficient methodological support for creatively conceptualizing and evaluating future designs. A recent literature review indicates that the experiential qualities of most emotion-managing products focus predominantly on bio-feedback or implicit target feedback (e.g., guiding the user towards certain physiological states through breathing exercises with haptic interaction) (Slovak et al., 2022). These observations suggest that the work so far has been confined to technology-specific domains (e.g., biofeedback, reminders) rather than providing designers with a systematic process of creating a positive experiences in-situ. Given the promising results of the evaluation study, the documented design process that builds on the insights shared and checked with the actual users with anxious attachment can be useful for designers who aspire to understand and address the dynamics of interpersonal attachment, enabling empathic and deliberate design decisions.

Further, in addition to the novel interactions enabled by the device, the design strategies developed with design professionals (as outlined in Table 5) can serve as a source of inspiration for designing for people with anxious attachment. The design strategies can be seen as an intermediate level of design knowledge that helps designers bridge the gap between general theories and intentionally designed artifacts, such as design strategies, patterns, and annotated portfolios (Löwgren et al., 2013). Specifically, the design strategies presented in the paper fit into the intermediate space of design knowledge, grounded in real-world coping strategies shared by participants (bottom-up) and theoretical account of interpersonal attachment (top-down). This level of design knowledge is valuable because it is concrete enough to inform design activities yet generic enough to be applicable in different contexts.

While the comprehensiveness of these design strategies has yet to be refined, and they need to be implemented in other design studies beyond the developed device's case, they would offer valuable insights for future applications, such as social robots, AI chatbots, and emotion care services. They could serve as both inspiration and validation for design practitioners, facilitating the generation of design concepts related to anxious attachment and assessing their effectiveness. Specifically, the design strategies can serve as a guiding tool that helps designers pick the respective strategies. The questions designers could address are: What design strategies are appropriate for the situation (e.g., self-depreciation and future worries)? What kinds of existing or new experiences could support the situations appropriately? What are the skills, social supports, and products are needed to motivate and enable the strategies?

Our study indicates that applying positive emotion regulation strategies can be an effective pathway to counterbalance the prevalence of negative emotions. Larsen and Prizmic (2004) and Shiota (2006) that highlight that humour and creating positive sensory events can be used to mitigate negative emotions by increasing positive ones. Supporting this perspective, our testing of the device further elucidated that strategies aimed at regulating positive emotions hold potential not only for mitigating negative emotions but also for enhancing overall well-being. The findings suggest a new opportunity for designers to explore broader emotion regulation strategies. Instead of solely focusing on strategies to downregulate negative emotions, designers could benefit from developing and integrating strategies that actively upregulate positive emotions. Such an expanded repertoire of strategies could contribute to more holistic design approaches, fostering greater individual resilience.

Limitations and Opportunities for Future Research

The evaluation study's strength lies in its qualitative approach, particularly in capturing participants' vivid and rich real-life experiences over ten days. One of the interesting findings is that the effectiveness of using the device differed when participants experienced intense, high-arousal negative emotions. However, it remains unclear what specific types of negative emotions were involved and how they affected participants' experiences in detail. To delve deeper and gain a better understanding, future research needs to take a more nuanced approach that considers a broader range of distinct emotional experiences (both positive and negative) and the patterns of eliciting conditions. Future research would merit employing a systematic typology of emotions such as the Scale of Positive and Negative Experience (SPANE; Diener et al., 2010) and fine-grained probe tools such as the Geneva Appraisal Questionnaire (Scherer, 2001), which would generate complementing insights into what enables and impedes the desired experiences.

It is important to note that the findings should be interpreted with caution, especially regarding the positive impact of the device. The results do not report to what extent the device contributed to resolving negative experiences due to the absence of a control

group. Therefore, future research should involve not only a larger number of participants but also varying study conditions with a baseline metric. For example, following the general practice of experimental studies on positive psychology interventions, three participant cohorts could be considered: a group with the device, a group with a paper version providing the same content, and a control group. These differentiated settings would help delineate the unique contribution of the design. Related, longitudinal, repeated follow-up assessments would be helpful in reliably capturing the effectiveness and usefulness of the device usage. For example, an Ecological Momentary Assessment (Shiffman et al., 2008) would allow intensive, repeated measurements of people's engagement with the device and impact on constructs of attachment and well-being (e.g., psychological needs and life-satisfaction) in real-world settings and observing the patterns in their reports that unfold over time.

Lastly, participants' responses may have been affected due to the Hawthorne effect, also called social desirability bias (McCarney et al., 2007). In the study, the participants may have been inclined to provide positive remarks out of politeness because they were aware that the researchers designed the device. The fact that negative responses to the experience were less frequently reported than positive responses in the study might indicate a need to refine the approach, possibly by employing multiple facilitators on behalf of the researchers.

Conclusion

Anxious attachment, the most prevalent type of insecure attachment, can negatively impact well-being by causing and intensifying negative emotions in interpersonal relationships. Central to the paper is the development of a self-administered interactive device designed to alleviate the negative emotions associated with anxious attachment. We conducted in-depth, comprehensive user studies to identify effective coping strategies with individuals with anxious attachment. These coping strategies were subsequently translated into design strategies by design professionals, resulting in a prototype of an interactive device. By grounding the entire design process in lived experiences, the study underscores the importance of human-centered design deeply rooted in understanding user needs and related psychological underpinnings. Our evaluation study shows that the device, tailored to situations of underachievement, self-depreciation, and future worries, can enhance explicit emotion awareness and foster positive self-perception, thereby serving as an avenue to mitigate anxious attachment. The results support its potential to be integrated into users' daily lives, increasing users' self-esteem and independence. Overall, we conclude that by inspiring users to engage with a wide range of positive activities (both cognitive and behavioral) through situation-relevant but personally interpretable prompts, designers can scaffold opportunities for users to actively look after their own well-being. We hope that our conceptualization and testing of the device will guide further research on developing design and technology that enhance users' interpersonal relationships with their well-being in mind.

Acknowledgments

This research was supported by the Ministry of Education of the Republic of Korea, the National Research Foundation of Korea (NRF-2020S1A5A2A03045893), and the National Science of Foundation (IIS- 2143552).

References

1. Ackerman, R., & Goldsmith, M. (2011). Metacognitive regulation of text learning: On screen versus on paper. *Journal of Experimental Psychology: Applied*, 17(1), 18-32. <https://doi.org/10.1037/a0022086>.
2. Aljohani, O. (2016). A comprehensive review of the major studies and theoretical models of student retention in higher education. *Higher Education Studies*, 6(2), 1-18. <https://doi.org/10.5539/hes.v6n2p1>
3. Arriaga, X. B., Kumashiro, M., Simpson, J. A., & Overall, N. C. (2018). Revising working models across time: Relationship situations that enhance attachment security. *Personality and Social Psychology Review*, 22(1), 71-96. <https://doi.org/10.1177/1088868317705257>
4. Barankevich, R., & Loebach, J. (2022). Self-care and mental health among college students during the COVID-19 pandemic: Social and physical environment features of interactions which impact meaningfulness and mitigate loneliness. *Frontiers in Psychology*, 13, Article No. 879408. <https://doi.org/10.3389/fpsyg.2022.879408>
5. Bartholomew, K., & Horowitz, L. M. (1991). Attachment styles among young adults: A test of a four-category model. *Journal of Personality and Social Psychology*, 61(2), 226-244. <https://doi.org/10.1037/0022-3514.61.2.226>
6. Bowlby, J. (1982). Attachment and loss: Retrospect and prospect. *American Journal of Orthopsychiatry*, 52(4), 664-678. <https://doi.org/10.1111/j.1939-0025.1982.tb01456.x>
7. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp063oa>
8. Brennan, K. A., Clark, C. L., & Shaver, P. R. (1998). Self-report measurement of adult attachment: An integrative overview. In J. A. Simpson & W. S. Rholes (Eds.), *Attachment theory and close relationships* (pp. 46-76). Guilford Press.
9. Bryant, F. (2003). Savoring beliefs inventory (SBI): A scale for measuring beliefs about savouring. *Journal of Mental Health*, 12(2), 175-196. <https://doi.org/10.1080/0963823031000103489>
10. Burge, D., Hammen, C., Davila, J., Daley, S. E., Paley, B., Lindberg, N., Herzberg, D., & Rudolph, K. D. (1997). The relationship between attachment cognitions and psychological adjustment in late adolescent women. *Development and Psychopathology*, 9(1), 151-167. <https://doi.org/10.1017/s0954579497001119>
11. Calvo, R. A., & Peters, D. (2014). *Positive computing*. MIT Press.
12. Carrington, M. J., Neville, B. A., & Whitwell, G. J. (2010). Why ethical consumers don't walk their talk: Towards a framework for understanding the gap between the ethical purchase intentions and actual buying behavior of ethically minded consumers. *Journal of Business Ethics*, 97, 139-158. <https://doi.org/10.1007/s10551-010-0501-6>
13. Cassidy, J., & Shaver, P. R. (Eds.). (1999). *Handbook of attachment: Theory, research, and clinical applications*. Guilford Press.
14. Coyle, D., Thieme, A., Linehan, C., Balaam, M., Wallace, J., & Lindley, S. (2014). Emotional wellbeing. *International Journal of Human-Computer Studies*, 72(8-9), 627-628. <https://doi.org/10.1016/j.ijhcs.2014.05.008>
15. Cozzarelli, C., Karafa, J. A., Collins, N. L., & Tagler, M. J. (2003). Stability and change in adult attachment styles: Associations with personal vulnerabilities, life events, and global construals of self and others. *Journal of Social and Clinical Psychology*, 22(3), 315-346. <https://doi.org/10.1521/jscp.22.3.315.22888>
16. Desmet, P. M. (2015). Design for mood: Twenty activity-based opportunities to design for mood regulation. *International Journal of Design*, 9(2), 1-19.
17. Desmet, P. M. A., & Sääksjärvi, M. C. (2016). Form matters: Design creativity in positive psychological interventions. *Psychology of Well-Being*, 6(1), Article No. 7. <https://doi.org/10.1186/s13612-016-0043-5>
18. Diefenbach, S., Hassenzahl, M., Eckoldt, K., Hartung, L., Lenz, E., & laschke, M. (2016). Designing for well-being: A case study of keeping small secrets. *The Journal of Positive Psychology*, 12(2), 151-158.
19. Diener, E., Wirtz, D., Tov, W., Kim-Prieto, C., Choi, D.-W., Oishi, S., & Biswas-Diener, R. (2010). New well-being measures: Short scales to assess flourishing and positive and negative feelings. *Social Indicators Research*, 97(2), 143-156. <https://doi.org/10.1007/s11205-009-9493-y>
20. Erikson, E. H. (1994). *Identity and the life cycle*. W. W. Norton & Company.
21. Fraley, R. C. (2019). Attachment in adulthood: Recent developments, emerging debates, and future directions. *Annual Review of Psychology*, 70, 401-422. <https://doi.org/10.1146/annurev-psych-010418-102813>
22. Gleeson, G., & Fitzgerald, A. (2014). Exploring the association between adult attachment styles in romantic relationships, perceptions of parents from childhood and relationship satisfaction. *Health*, 6(13). <https://doi.org/10.4236/health.2014.613196>
23. Green, B. L., Furrer, C. J., & McAllister, C. L. (2011). Does attachment style influence social support or the other way around? A longitudinal study of early head start mothers. *Attachment & Human Development*, 13(1), 27-47. <https://doi.org/10.1080/14616734.2010.488121>
24. Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, 2(3), 271-299. <https://doi.org/10.1037/1089-2680.2.3.27>
25. Hammen, C. L., Burge, D., Daley, S. E., Davila, J., Paley, B., & Rudolph, K. D. (1995). Interpersonal attachment cognitions and prediction of symptomatic responses to interpersonal stress. *Journal of Abnormal Psychology*, 104(3), 436-443. <https://doi.org/10.1037/0021-843X.104.3.436>

26. Herwig, U., Kaffenberger, T., Jäncke, L., & Brühl, A. B. (2010). Self-related awareness and emotion regulation. *NeuroImage*, 50(2), 734-741. <https://doi.org/10.1016/j.neuroimage.2009.12.089>
27. Johnson, S. M. (2009). Attachment theory and emotionally focused therapy for individuals and couples. In J. H. Obegi & E. Berant (Eds.), *Attachment theory and research in clinical work with adults* (pp. 410-433). Guilford Press.
28. Kafetsios, K., & Sideridis, G. D. (2006). Attachment, social support and well-being in young and older adults. *Journal of Health Psychology*, 11(6), 863-875. <https://doi.org/10.1177/1359105306069084>
29. Kaiser Family Foundation (2023, March 20). *Mental health and substance use state fact sheets*. Retrieved from <https://bit.ly/3BtafUp>
30. Kirkpatrick, L. A., & Hazan, C. (1994). Attachment styles and close relationships: A four-year prospective study. *Personal relationships*, 1(2), 123-142.
31. Konrath, S. H., Chopik, W. J., Hsing, C. K., & O'Brien, E. (2014). Changes in adult attachment styles in American college students over time: A meta-analysis. *Personality and Social Psychology Review*, 18(4), 326-348. <https://doi.org/10.1177/1088868314530516>
32. Larsen, R. J., & Prizmic, Z. (2004). Affect regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 40-61). Guilford Press.
33. Löwgren, J. (2013). Annotated portfolios and other forms of intermediate-level knowledge. *Interactions*, 20(1), 30-34. <https://doi.org/10.1145/2405716.2405725>
34. Löwgren, J., Larsen, H. S., & Hobye, M. (2013). Towards programmatic design research. *Designs for Learning*, 6(1-2), 80-100. <http://dspace.mah.se/handle/2043/16915>
35. Lyubomirsky, S., & Nolen-Hoeksema, S. (1995). Effects of self-focused rumination on negative thinking and interpersonal problem solving. *Journal of personality and social psychology*, 69(1), 176.
36. MacIsaac, A., Mushquash, A. R., & Wekerle, C. (2023). Writing yourself well: dispositional self-reflection moderates the effect of a smartphone app-based journaling intervention on psychological wellbeing across time. *Behaviour Change*, 40(4), 297-313.
37. Marmarosh, C. L., & Tasca, G. A. (2013). Adult attachment anxiety: Using group therapy to promote change. *Journal of Clinical Psychology*, 69(11), 1172-1182. <https://doi.org/10.1002/jclp.22044>
38. McCarney, R., Warner, J., Iliffe, S., Van Haselen, R., Griffin, M., & Fisher, P. (2007). The Hawthorne effect: A randomised, controlled trial. *BMC Medical Research Methodology*, 7(1), Article No. 30. <https://doi.org/10.1186/1471-2288-7-30>
39. McConnell, M., & Moss, E. (2011). Attachment across the life span: Factors that contribute to stability and change. *Australian Journal of Educational & Developmental Psychology*, 11, 60-77.
40. Meng, X., D'Arcy, C., & Adams, G. C. (2015). Associations between adult attachment style and mental health care utilization: Findings from a large-scale national survey. *Psychiatry Research*, 229(1), 454-461. <https://doi.org/10.1016/j.psychres.2015.05.092>
41. Mikulincer, M., & Florian, V. (1998). The relationship between adult attachment styles and emotional and cognitive reactions to stressful events. In J. A. Simpson & W. S. Rholes (Eds.), *Attachment theory close relationships* (pp. 143-165). Guilford Press.
42. Mikulincer, M., & Florian, V. (2003). Attachment style and affect regulation: Implications for coping with stress and mental health. In G. J. O. Fletcher & M. S. Clark (Eds.), *Blackwell handbook of social psychology: Interpersonal processes* (pp. 535-557). Wiley. <https://doi.org/10.1002/9780470998557.ch21>
43. Mikulincer, M., & Shaver, P. R. (2008). Adult attachment and affect regulation. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (pp. 503-531). Guilford Press.
44. Mikulincer, M., Shaver, P. R., Sapir-Lavid, Y., & Avihou-Kanza, N. (2009). What's inside the minds of securely and insecurely attached people? The secure-base script and its associations with attachment-style dimensions. *Journal of Personality and Social Psychology*, 97(4), 615-633. <https://doi.org/10.1037/a0015649>
45. Mikulincer, M., Shaver, P. R., & Rom, E. (2011). The effects of implicit and explicit security priming on creative problem solving. *Cognition and Emotion*, 25(3), 519-531. <https://doi.org/10.1080/02699931.2010.540110>
46. Misra, S., Cheng, L., Genevie, J., & Yuan, M. (2016). The iPhone effect: The quality of in-person social interactions in the presence of mobile devices. *Environment and Behavior*, 48(2), 275-298. <https://doi.org/10.1177/0013916514539755>
47. Murray, S. L., & Holmes, J. G. (2009). The architecture of interdependent minds: A motivation-management theory of mutual responsiveness. *Psychological Review*, 116(4), 908-928. <https://doi.org/10.1037/a0017015>
48. Murray, S. L., Holmes, J. G., & Collins, N. L. (2006). Optimizing assurance: The risk regulation system in relationships. *Psychological Bulletin*, 132(5), 641-666. <https://doi.org/10.1037/0033-2909.132.5.641>
49. Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on psychological science*, 3(5), 400-424.
50. Odom, W., Stolterman, E., & Chen, A. Y. S. (2022). Extending a theory of slow technology for design through artifact analysis. *Human-Computer Interaction*, 37(2), 150-179. <https://doi.org/10.1080/07370024.2021.1913416>
51. Öztürk, A., & Mutlu, T. (2010). The relationship between attachment style, subjective well-being, happiness and social anxiety among university students. *Procedia-Social and Behavioral Sciences*, 9, 1772-1776. <https://doi.org/10.1016/j.sbspro.2010.12.398>

52. Pietromonaco, P. R., & Barrett, L. F. (1997). Working models of attachment and daily social interactions. *Journal of Personality and Social Psychology*, 73(6), 1409-1423. <https://doi.org/10.1037/0022-3514.73.6.1409>
53. Przybylski, A. K., & Weinstein, N. (2013). Can you connect with me now? How the presence of mobile communication technology influences face-to-face conversation quality. *Journal of Social and Personal Relationships*, 30(3), 237-246. <https://doi.org/10.1177/0265407512453827>
54. Quoidbach, J., Berry, E. V., Hansenne, M., & Mikolajczak, M. (2010). Positive emotion regulation and well-being: Comparing the impact of eight savoring and dampening strategies. *Personality and Individual Differences*, 49(5), 368-373. <https://doi.org/10.1016/j.paid.2010.03.048>
55. Quoidbach, J., Mikolajczak, M., & Gross, J. J. (2015). Positive interventions: An emotion regulation perspective. *Psychological Bulletin*, 141(3), 655-693. <https://doi.org/10.1037/a0038648>
56. Sbarra, D. A., & Hazan, C. (2008). Coregulation, dysregulation, self-regulation: An integrative analysis and empirical agenda for understanding adult attachment, separation, loss, and recovery. *Personality and Social Psychology Review*, 12(2), 141-167.
57. Scherer, K. R. (2001). Appraisal considered as a process of multi-level sequential checking. In K. R. Scherer, A. Schorr, & T. Johnstone (Eds.), *Appraisal processes in emotion: Theory, methods, research* (pp. 92-120). Oxford University Press.
58. Schönfeld, P., Brailovskaya, J., Bieda, A., Zhang, X. C., & Margraf, J. (2016). The effects of daily stress on positive and negative mental health: Mediation through self-efficacy. *International Journal of Clinical and Health Psychology*, 16(1), 1-10. <https://doi.org/10.1016/j.ijchp.2015.08.005>
59. Schueller, S. M., Muñoz, R. F., & Mohr, D. C. (2013). Realizing the potential of behavioral intervention technologies. *Current Directions in Psychological Science*, 22(6), 478-483. <https://doi.org/10.1177/0963721413495872>
60. Senter, M. S. (2024). The impact of social relationships on college student learning during the pandemic: Implications for sociologists. *Teaching Sociology*, 52(1), 39-54. <https://doi.org/10.1177/0092055X23117850>
61. Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, 4, 1-32. <https://doi.org/10.1146/annurev.clinpsy.3.022806.091415>
62. Shin, G., Feng, Y., Jarrahi, M. H., & Gafinowitz, N. (2019). Beyond novelty effect: A mixed-methods exploration into the motivation for long-term activity tracker use. *JAMIA Open*, 2(1), 62-72. <https://doi.org/10.1093/jamiaopen/ooy048>
63. Shiota, M. N. (2006). Silver linings and candles in the dark: Differences among positive coping strategies in predicting subjective well-being. *Emotion*, 6(2), 335-339. <https://doi.org/10.1037/1528-3542.6.2.335>
64. Slovak, P., Antle, A. N., Theofanopoulou, N., Roquet, C. D., Gross, J. J., & Isbister, K. (2022). Designing for emotion regulation interventions: An agenda for HCI theory and research. *ACM Transactions on Computer-Human Interaction*, 30(1), Article No. 13. <https://doi.org/10.1145/3569898>
65. Taylor, P., Rietzschel, J., Danquah, A., & Berry, K. (2015). Changes in attachment representations during psychological therapy. *Psychotherapy Research*, 25(2), 222-238. <https://doi.org/10.1080/10503307.2014.886791>
66. Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation*, 27(2), 237-246. <https://doi.org/10.1177/1098214005283748>
67. Tidwell, M.-C. O., Reis, H. T., & Shaver, P. R. (1996). Attachment, attractiveness, and social interaction: A diary study. *Journal of Personality and Social Psychology*, 71(4), 729-745. <https://doi.org/10.1037/0022-3514.71.4.729>
68. Troy, A. S., Shallcross, A. J., & Mauss, I. B. (2013). A person-by-situation approach to emotion regulation cognitive reappraisal can either help or hurt, depending on the context. *Psychological Science*, 24(12), 2505-2514. <https://doi.org/10.1177/0956797613496434>
69. Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063-1070. <https://doi.org/10.1037/0022-3514.54.6.1063>
70. Watkins, E. R., & Roberts, H. (2020). Reflecting on rumination: Consequences, causes, mechanisms and treatment of rumination. *Behavior Research and Therapy*, 127, 103573. <https://doi.org/10.1016/j.brat.2020.103573>
71. World Health Organization. (2013). *Mental health action plan 2013-2020*. World Health Organization.
72. Yoon, J., Kim, C., & Kang, R. (2020). Positive user experience over product usage life cycle and the influence of demographic factors. *International Journal of Design*, 14(2), 85-102.
73. Yoon, J., Li, S., & Yu, H. (2021). Design-mediated positive emotion regulation: The development of an interactive device that supports daily practice of positive mental time traveling. *International Journal of Human-Computer Interaction*, 38(5), 432-446. <https://doi.org/10.1080/10447318.2021.1948685>