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Positive Emodiversity in Everyday Human-Technology Interactions and Users' Subjective Well-Being

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ABSTRACT

This paper investigates the effects of experiencing diverse positive emotions in technology use on users' well-being, referred to as positive emodiversity. We examined technology's role in facilitating positive emodiversity and well-being through a questionnaire study ($N = 116$; 580 example cases), in which three sources of emotions were considered: technology as an object, instrument, or enabler. Further, we evaluated how technology-supported hedonic and eudaimonic pursuits are associated with well-being. A regression analysis showed that increased positive emodiversity leads to increased well-being ($p < .001$). The effect was predicted by the three sources and both hedonic and eudaimonic pursuits. When engaged in positive activities enabled by technology, users experienced more diverse positive emotions, increasing their well-being. The study offers new understandings of the relationships between technologies, emodiversity, and well-being, and provides evidence that designing for a wide diversity of positive emotions, as opposed to generalized pleasure-displeasure distinction, can enrich users' experiences, enhancing their well-being.

1. Introduction

Over the last decade, several initiatives to design for subjective well-being have gained increased attention and momentum in design research and HCI. These initiatives put emphasis on the possibility of contributing to users' long-term well-being that goes beyond mitigating negative experiences. Examples of such initiatives are Positive Computing (Calvo & Peters, 2014), Positive Technology (Diefenbach, 2018), Positive Design (Desmet & Pohlmeyer, 2013), and Experience Design (Hassenzahl, 2010). While different in their names, at the broadest level, they are aligned with the vision of positive psychology—supporting people to flourish (Lyubomirsky et al., 2005b; Seligman, 2011). The initiatives above claim that design and technology can play a critical role in fostering well-being by deliberately making the vision of good life tangible and actionable, shaping people's experiences to enhance their well-being. As many of our experiences are profoundly shaped by the opportunities and limitations imposed by the technology (e.g., consumer electronics and interactive systems) (Dourish, 2001), technology bears the possibility to create positive experiences. Therefore, in design for well-being, those experiences and their impact on well-being become explicit objectives of design (Fokkinga et al., 2020).

In this paper, in line with Pohlmeyer and Desmet (2017), we see design for well-being as the attempt to support people to function well psychologically and to live well (i.e., subjective well-being). While there is no universally accepted single definition of well-being, it is generally agreed that well-being includes the presence of more positive than negative affect (e.g., emotions and moods) and satisfaction with life, fulfillment of positive functioning (Diener, 2000; Ryff & Keyes, 1995). Here, in simple terms, we refer to "well-being" and "happiness" as the states of "the experience of pleasure and a sense that one's life is good, meaningful, and worthwhile" based on the definitions of Lyubomirsky (2008) and Dolan (2014). In human-technology interactions, well-being can be facilitated by technologies that enable us to arrange our daily activities to be meaningful and enjoyable (Hassenzahl et al., 2013). The resultant design challenge is, therefore, to create opportunities for people to have pleasurable as well as meaningful experiences supported by technology (Stevens et al., 2019).

With the aim to support the practice of design for well-being, various theoretical frameworks have been proposed to support designers to be aware of and address key design ingredients in their creative processes. The framework of Positive Design (Desmet & Pohlmeyer, 2013), for example, includes pleasure, virtue, and personal significance, while Experience Design (Hassenzahl et al., 2013) includes a set of fundamental psychological needs. Although these frameworks have different theoretical backgrounds, they share the idea that positive emotions are critical to increasing well-being. A considerable amount of psychology literature has proven that positive emotions are associated with well-being (e.g., Kirby et al., 2014; Seligman, 2011). In particular, there

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is a wealth of evidence that less intense but more frequent positive emotions are more strongly associated with well-being than more intense but less frequent positive emotions (Diener et al., 1985; Lyubomirsky et al., 2005a). This suggests that the frequent evocation of pleasant experiences by a technology would lead to users' increased well-being. However, it has been proposed that if the focus of the design is on eliciting a small set of positive emotions and increasing their frequency, users' appreciation of the technology may soon fade with time (Pohlmeyer & Desmet, 2017; Yoon et al., 2020b). The underlying idea of the proposition was based on the phenomenon of hedonic adaptation (Lyubomirsky, 2011); when users quickly become accustomed to the pleasure elicited by a technology, they eventually find it mundane.

To minimize the chance of hedonic adaptation occurring, experiencing a diversity of positive emotions has been suggested (i.e., positive emodiversity; Yoon et al., 2020b). Several empirical studies have demonstrated that eliciting various positive emotions can help forestall the diminution of positivity and enhance people's well-being (e.g., Sheldon et al., 2013). Other research has similarly established an association between greater differentiation in positive emotions and adaptive coping and adjustment (e.g., Tugade et al., 2004). Recently, it has also been found that experiencing an array of positive emotions has a positive impact on improving the physical condition of the body, e.g., decreasing inflammation (Ong et al., 2018). Similarly, studies on Positive Psychology Intervention (PPI) show that the use of diverse happiness interventions contributes to greater increases in happiness than when using one happiness intervention at a time (e.g., Parks et al., 2012).

Given these benefits, we postulate that by experiencing a wide array of positive emotions in human-technology interactions, as opposed to a small set of positive emotions, the experiences of using technologies may become more dynamic and richer, enhancing users' well-being. To date, yet little is known about if and how the diversity of positive emotions during unfolding usage of technologies influence users' well-being; the ongoing discussions on the impact of diverse positive emotions have remained speculative. While theoretically acceptable, to our knowledge, there has been no empirical study that investigated the impact of experiencing a variety of positive emotions in human-technology interactions on users' well-being. Therefore, this paper investigates the association between technology-mediated positive emodiversity and well-being (we detail the concept of emodiversity in the following section). In particular, we aim to develop an understanding of (1) how the breadth of positive emotions that users experience in day-to-day technology use is related to users' well-being, and (2) the roles a technology plays in eliciting diverse positive emotions and increasing well-being. Here, we are not interested in investigating technologies whose main purpose is to support well-being such as an app that helps users to practice happiness-enhancing activities (e.g., Live Happy app developed based on Lyubomirsky (2008); Panoply app developed by Morris and Picard (2014); Gratitude messaging app for medical students (Naqshbandi et al., 2020)). Instead, we aim to understand how "*everyday*" technologies, e.g., consumer electronics and software, incorporate certain aspects that facilitate positive emotional experiences. One example of such aspect is the option in smart speakers that allows users to anticipate a positive event based on their calendar, e.g., "What's the first thing you want to do when you get there?" in relation to an upcoming trip (for an overview of the process of technology adoption in everyday life, see Nimrod & Edan, 2022).

Thus, the research question addressed in the paper is: *How is positive emodiversity in human-technology interactions related to users' well-being?* We expect that the study will disentangle the link between positive emotional experiences in technology use and user well-being. Besides, it is expected that generated insights will serve as a reference in developing design methods and tools that enable the development of a technology that is not only pleasurable, but also deliberately contributes to users' well-being. The paper begins by providing a general introduction to the concept of emodiversity, placing it in the bigger context of emotional complexity literature, and discussing the implications for the current study. In the following, we detail the approach of the study and how it was operationalized. Then, we report the study in which individuals reported positive emotions experienced in the interactions with everyday technologies and their impact on well-being. The paper concludes with a discussion of the implications of the study and suggestions for future research.

2. Theoretical background: Emotional complexity and subjective well-being

The phenomenon of emodiversity refers to the diversity and abundance of emotions (both positive and negative) that people experience (Quoidbach et al., 2014). The concept of emodiversity stems from the body of emotion research investigating the added value of having a sophisticated and complex emotional life (Barrett, 2013; Lindquist & Barrett, 2008). This section reviews the broad concept of emotional complexity and describes the paper's specific investigation.

2.1. Concept of emotional complexity

Our everyday life, including using technologies is constituted of a wide range of emotional states. Some people experience emotions in a highly complex manner, while others do so in a general manner. Characterizing differences in the complexity of emotional life, Wessman and Ricks (1966) first introduced the term "affective complexity." In contemporary research, emotional complexity refers to experiencing positive and negative affect at the same time, and experiencing a variety of emotions (Kashdan et al., 2015). From functionalist perspectives on emotions (Shiota et al., 2014), emotional complexity has been considered an integral part of human experience linking to well-being (Ryan & Deci, 2001). Theoretically, individuals with highly complex emotions may have more highly discrete awareness of their emotions

(e.g., relief, fascination, resentment, and annoyance) than those with general emotional experiences (e.g., feeling good or bad). Emotion awareness includes the cause of an emotional experience (e.g., being fascinated by something novel and sad about something irreversible), the expected sensations, its display rules (i.e., what a person believes they should do with their facial and bodily expressions), and actions to take to adapt to the situation (Barrett et al., 2001). In sum, the highly discrete awareness of complex emotions helps people with their adaptive responses to the perceived demands and opportunities imposed by the situation at hand (Kashdan et al., 2015; Kirby et al., 2014).

2.2. Types of emotional complexity

While emotional complexity has been differently conceptualized across studies, emerging literature suggests that emotional complexity can be broadly grouped into two categories according to the degree of (1) the co-occurrence of positive and negative emotions, and (2) emotion differentiation (Hay & Diehl, 2011; Lindquist & Barrett, 2008).

2.2.1. Co-occurrence of positive and negative emotions

Research on mixed emotions has shown that people can experience positive and negative emotions together, based on the notion that people can see the good and the bad in all experiences (Larsen & McGraw, 2014). Some of the most enjoyable and memorable things in life (e.g., awe-inspiring experiences in response to art and the thrill of riding a rollercoaster) are not simply positive or negative; they elicit a whole spectrum of positive and negative experiences, and these mixed emotional experiences are often actively sought out (Tan, 2008). The terms "co-occurrence of emotions" and "emotional covariation" refer to individual differences in the extent of the co-occurrence of positive and negative emotions (Grossmann et al., 2016). Greater emotional covariation is found to be associated with greater resilience and lower stress (Ong & Bergeman, 2004); People who report a greater covariation of positive and negative emotions tend to move out of a highly negative emotional status more rapidly than those with a lower covariation (Hay & Diehl, 2011).

2.2.2. Emotion differentiation

Individuals differ in the degree to which they characterize their emotional experiences with specificity (Barrett et al., 2001; Boden et al., 2013). Emotion differentiation, also referred to as emotional granularity (Lindquist & Barrett, 2008), means individual differences in their tendency to categorize and label emotional experiences in distinct terms. Some people experience emotions in a highly differentiated fashion, distinguishing among a range of subtly different emotions (e.g., "I feel satisfied with the new laptop and fascinated by its novel features."). On the other hand, others experience emotions in an undifferentiated manner (e.g., "I feel good about it."). According to recent studies, people with the ability to highly differentiate emotions are less likely to be overwhelmed in stressful situations and resort to maladaptive behaviors (e.g., aggression and binge drinking) (Kashdan et al., 2015; Lindquist & Barrett, 2008). These studies suggest that greater emotion differentiation helps people thoroughly consider information related to the emotions (e.g., the causes of the emotions). Other research has similarly shown an association between greater differentiation in positive emotions and adaptive coping and self-regulatory behaviors (Kirby et al., 2014; Tugade et al., 2004).

2.3. Present study

Given the fact that most technologies and their usage situations do not evoke a single emotion, the concept of emotional complexity has been reflected in the development of design tools and methods. For example, self-report tools for emotion measurement such as PrEmo, which includes 14 emotions (Laurans & Desmet, 2017), and EsSense Profile, which includes 39 emotions (King & Meiselman, 2010), help designers reveal a combination of diverse user emotions, transcending the generalized pleasure-displeasure dimension. The implications of emotional complexity for design conceptualization have been investigated by, for example, the contributions of Fokkinga and Desmet (2013) on how to purposefully stimulate mixed emotions to enrich user experiences, and Yoon et al. (2016) on the benefits of differentiating positive emotions in design processes. In general, these studies focused on helping designers systematically consider emotional complexity in their practices. To date, however, little is known about how complex emotional experiences of end-users in their interactions with technologies influence their well-being. In response, the present study seeks to examine the associations between positive emodiversity and users' well-being.

3. Identifying the influence of positive emodiversity on users' well-being

The previous section described the concept of positive emodiversity in relation to the literature on emotional complexity and well-being, along with the present study's focus—investigating the influence of technology-mediated positive emodiversity on well-being. Before reporting the study, we describe how it was operationalized with a focus on the granularity of positive emotions, sources of positive emotions, types of well-being pursuits.

3.1. Approach

The influence of positive emodiversity on well-being was investigated through an online survey in which participants retrospectively self-reported their positive emotions experienced in human-technology interactions and how those experiences contributed to their well-being. A retrospective self-report approach was employed for the following reasons. First, long-term effects of technology usage on well-being may manifest a long time after the interactions with the technology (i.e., months after when a user initially started

Table 1. The 20 positive emotions included in the questionnaire (adapted from Desmet, 2012).

	The feeling when:
Admiration	You look up to someone who has excellent abilities or impressive accomplishment
Anticipation	You expect something desirable will happen to you
Amusement	You encounter something funny, entertaining, or absurd, which makes you smile or laugh
Confidence	You have strong belief in your abilities or qualities in handling a task
Courage	You gain the mental strength to withstand risk and overcome hardship
Desire	You strongly wish for something to happen or to enjoy
Enchantment	You are mesmerized by something that captivates your attention
Energetic	You enjoy a high-spirited state of being lively and vitalized
Fascination	You encounter something new and interesting that you do not immediately understand
Hope	You believe (but are uncertain) that something good may happen in the future
Inspiration	You suddenly have a new idea or insight, or see the world in a different light
Joy	Something good happened to you fulfilling your needs or making progress towards a goal
Kindness	You contribute or be sensitive to the well-being of someone (or something)
Love	You are affectionate to someone (or something)
Pleasant surprise	You realize something good has just happened, which you did not expect
Pride	You possess (or have accomplished) something that exceeds your own expectations or others' standards
Relaxation	You enjoy mental or physical calmness, slowing down and savoring the present moment
Respect	You accept and regard someone or their rights as worthy, good, or valuable
Satisfaction	You enjoy the recent fulfillment of a need, expectation, or desire
Sympathy	You witness the suffering of someone (or something), physically or emotionally

using the technology) (Prochaska et al., 2009). Second, retrospective self-report can be useful for understanding how one's lived emotional experiences (e.g., satisfaction with the technology's aesthetic and instrumental quality) and related emotional residue shape the perception of long-term well-being given their current circumstances (Baumeister et al., 2007). In a similar vein, researchers have looked into the long-term effects of felt experiences following exposure to particular images and social situations (Boden et al., 2013; Suvak et al., 2011). In the following, we point out three key considerations incorporated into the development of the survey.

3.1.1. Granularity of positive emotions

In devising emotion questionnaires, an important consideration is how many emotions to include. Given the study's purpose, we intended to include a high number of positive emotions, ensuring its practicality; the felt experiences should be represented with nuanced positive emotions, but it should be manageable (i.e., not an overwhelming quantity, but enough to have diversity). The initial set was formulated based on the typology of positive emotions that includes 25 positive emotions experienced in technology use (Desmet, 2012). A pilot test with six participants revealed that while highly granular and comprehensive, the 25 emotions for reporting one instance were considered an overload for proper reporting (Park et al., 2022). The participants reported their felt experiences by selecting emotions in the set three times a day for a week. The emotions were subsequently down-selected by the authors on the basis of (1) the literature on the relevance to design (Desmet, 2002) and (2) the emotions least often reported in the pilot test (e.g., lust, euphoria, and relief), resulting in a set of 20 positive emotions (see Table 1).

3.1.2. Sources of positive emotions in human-technology interactions

Most positive emotions evoked by technologies are not always about the technologies themselves (Desmet, 2012). Positive emotions can be either directly elicited by technologies or indirectly elicited by activities and interactions facilitated by the technologies. For example, people can be amused by a smartwatch's playful appearance. They can also be fascinated by the designer's creativity and skills expressed by the smartwatch or what other people can do with it. In other words, technologies themselves can evoke positive emotions, and they can also provide contexts for emotions. Activities, interactions, and associations facilitated by the technologies serve as sources of positive emotions. To further investigate the relationship between positive emodiversity and well-being, the present study looked into the roles that technologies play in eliciting positive emotions and how the different roles would contribute differently to well-being.

To operationalize the different roles that technologies serve to evoke positive emotions, we adopted the framework of Desmet and Roeser (2015). The framework identified three ways in which positive emotions are evoked in the interactions with technologies (see Table 2). The first source is perceiving the technology with the senses, such as seeing, touching, and hearing it (e.g., "I love my smartwatch because of its minimal shape and firm texture."). The second source is using, operating, and managing the technology, such as the enjoyment of using its functions or interactive qualities (e.g., "My smartwatch's activity-monitoring function delights me with its easy-to-use interface."). The third source is the self and social implications of using the technology, such as engaging in certain activities, and emphasizing their social identity or relationship with others (e.g., "Through my smartwatch, I got challenged to compete with my friends by sharing my activity information. It fueled my motivation to commute on foot."). Based on these three sources, a technology's roles were determined as (1) Object, (2) Instrument, and (3) Enabler.

3.1.3. Types of well-being pursuits

While pathways to well-being have been operationalized in a variety of ways, they may be grouped into two broad categories: (1) hedonic and (2) eudaimonic pursuits (Deci & Ryan,

Table 2. Definitions and examples of the three sources of positive emotions based on Desmet and Roeser (2015).

Source	Description	Example
The technology as an Object	Perceiving the technology—The emotion is directly evoked by the technology itself. The emotion is attributed to the technology's appearance, qualities, or features, or its meaning.	"I cherish this smartwatch because it echoes my aesthetic taste and represents my passion for sports."
The technology as an Instrument	Using the technology—The emotion is directly evoked by actions and interactions (both mental and physical) with technologies that serve their functions.	"I enjoy the ease of using this car navigation app because of its step-by-step instruction."
The technology as an Enabler	Self and social implications of using the technology—The emotion is indirectly evoked by certain activities and events enabled by using the technology.	"Driving my electric car makes me feel proud because it helps me take good care of the environment."

Table 3. Definitions and examples of the two well-being pursuits based on Ryff (2018).

Type	Description	Example
Hedonic	Pursuing pleasure, desire, and comfort, and avoiding pain and negative affect.	Emotional states that induce comfort, indulgence, consumption, and ownership (e.g., pride, enthusiasm, and desire).
Eudaimonic	Pursuing personal development and meaning in life.	Emotional states that urge to look after, prevent harm to, and care for others as well as see them flourish, form social relationships, and take care of the world we live in (e.g., love, compassion, and kindness).

2008). Both pursuits contribute to well-being in different ways. From a hedonic perspective, well-being is the sum of one's pleasurable moments. The focus is on the "here and now," maximizing pleasure and minimizing negativity such as physical pain and psychological disturbance. Examples are enjoying the high-fidelity room-filling sound of a speaker and relaxing by watching an amusing film after a long day of work. From an evolutionary standpoint, hedonic experiences energize and reward individuals for seeking out food, shelter, and other resources (Deci & Ryan, 2008). From a eudaimonic perspective, well-being is achieved by fulfilling moral values and virtues. The focus is on long-term implications for oneself or society and engaging in personal development and meaningful activities. Examples are taking good care of the environment by consuming technology produced with less environmental harm, participating in donations by using social media, and developing personal talents. These eudaimonic pursuits tend to have a more lasting and meaningful effect on life appreciation (Ryan & Deci, 2001). Note that there is no one-to-one relationship between these two pursuits and emotions. The two types can be attributed to the same emotion and vice versa. For example, a feeling of pride caused by owning a luxurious item may fall into a hedonic pursuit, whereas the same emotion evoked by overcoming setbacks and progressing towards' one's life goals may fall into a eudaimonic pursuit.

We were interested in the relative impact of these two pursuits on well-being. In the literature on emotion-driven design, it has been suggested that a stronger emphasis be placed on evoking positive emotions that facilitate meaningful activities beyond sensory delight. In particular, as was proposed by Desmet and Hassenzahl (2012), experiences need to be more about the 'doing' and 'being' (e.g., social interactions and personal goal achievement) than the 'having.' Many designs are currently adapting to the view that positive emotions evoked by meaningful activities can have a greater impact on well-being compared to stimulation of desire and excitement (Magids et al., 2015). While convincing, how different types of well-being pursuits facilitated by technologies contribute to increasing well-being has yet to be empirically further investigated. Although naturally, both hedonic and eudaimonic pursuits frequently come in combination (Ryff, 2018), the present study separate these two for efficiency of operationalizing the data analysis. Table 3 outlines the characteristics of the two well-being pursuits.

3.2. Hypotheses

The study investigated the impact of day-to-day technology usage on user well-being by focusing on the role of positive emodiversity, the sources of positive emotions, and types of well-being pursuits (see Figure 1). In terms of the impact of positive emodiversity, we expected that when people experience a wide range of positive emotions in relation to their technologies, the degree to which these technologies contribute to their well-being would be high. In terms of the impact of the sources of positive emotions, we expected that positive emotions attributed to activities and events enabled by using the technologies (i.e., technology as an enabler) would have a higher impact on well-being than those evoked by other sources (i.e., technology as an object or instrument). Finally, regarding the impact of the types of well-being pursuits, we expected that positive emotions related to eudaimonic pursuits would have a higher impact on well-being than those related to hedonic pursuits. These assumptions were operationalized in the following hypotheses:

H1: Greater diversity in positive emotions experienced in technology use predicts increased well-being.

Figure 1. Research scheme: Positive emodiversity facilitated by technology and its influence on well-being.

H2: Positive emotions evoked by activities and events (i.e., enabler) are more closely associated with increased well-being than those evoked by other sources (i.e., object and instrument).

H3: Positive emotions experienced in technology use related to eudaimonic pursuits are more closely associated with increased well-being than those related to hedonic pursuits.

For testing H1, the intended Dependent Variable (DV) was the level of technology-mediated well-being (i.e., happiness). The intended Independent Variables (IVs) were the levels of positive emodiversity associated with three sources of positive emotions (i.e., object, instrument, and enabler) and two well-being pursuits (i.e., hedonic and eudaimonic pursuits). In addition, to get a detailed understanding of positive emodiversity in human-technology interactions (H2 and H3), we explored how the three sources of positive emotions and two well-being pursuits are related to positive emodiversity. In this case, positive emodiversity served as a DV.

4. Materials and methods

All methods described in this section were approved by the Cornell University Institutional Review Board (approval number: 1906008875).

4.1. Measures

4.1.1. Ability to differentiate positive emotions

Participants' sensitivity to distinguish nuances between diverse positive emotions were measured as a baseline test. The purpose was to ensure the validity of the collected data by screening those who would be less aware of the subtle differences between positive emotions. The test enabled us to avoid cases in which a greater diversity of positive emotions is reported by participants who cannot actually distinguish them. We used the Differentiation of Positive Emotion Scale (DOPES) (Kirby et al., 2014), a validated scale that measures an individual's ability to distinguish nuances between positive emotions. DOPES asks participants to imagine themselves in eight different vignettes developed to elicit happiness, pride, gratitude, interest, hope, challenge/determination, awe, and contentment. For example, the vignette representing contentment is:

> *"After working very hard for several weeks, you are finally able to take some time off. Right now, you are relaxing on the beach. There is a nice breeze, you have a drink, and you are relishing the knowledge that there's nothing at all you need to be doing right now."*

Then, they indicate the extent to which they would feel the eight emotions if they were in the situation on a 9-point scale (1: Not at all, 9: Extremely much).

4.1.2. Positive emodiversity level

The level of emodiversity was measured based on the formula of positive emodiversity scores (Quoidbach et al., 2014).

$$\textbf{\textit{Emodiversity}} = \sum_{i=1}^{S} (\boldsymbol{P_i} \times \boldsymbol{lnP_i})$$

In the formula, S refers to the total number of emotions experienced (i.e., 20 positive emotions), and Pi means the proportion of S made up of the ith emotions. There are four steps in computing an emodiversity score: (1) dividing the number of times an individual experienced a certain emotion (e.g., the first emotion in the set) by the total number of times they experienced all emotions in the set, which generates P1, (2) multiplying this proportion by its natural log (P1 X ln P1), (3) repeating steps 1 and 2 for each emotion assessed, and (4) summing all the (Pi X ln Pi) products and multiplying the total by −1. High scores represent more diverse emotions. A person experiencing only one emotion type would have 0 as the score. If the emotions in the set were evenly experienced, the score would be the highest. Note that the score reflects not only the number of emotions an individual experiences (i.e., richness), but also the relative abundance of the different emotions that makes up an individual's emotional experience (i.e., evenness) (for a detailed discussion of the formula's logic, see Quoidbach et al., 2014). The computation of positive emodiversity was operationalized by using the "Emodiversity Calculator" developed by Quoidbach et al. (2014) and the data were converted into a percentage (0: the lowest, 100: the highest).

4.1.3. Well-being fostered by technologies

Following prior research on technology-mediated well-being (Yoon et al., 2022), we assessed a technology's impact on a user's subjective well-being by using a questionnaire adopted from Van Boven and Gilovich (2003)'s study on the effects of purchasing experiences on well-being. The questionnaire

Figure 2. Examples of the questionnaire pages: (A) Helping participants understand the meaning of the 20 positive emotions and (B) providing examples of everyday technology (both tangible and digital).

consisted of two questions with anchors from 1 (not happy) to 5 (moderately happy) to 9 (extremely happy).

- When you think about this technology, how happy does it make you?
- When you think about this technology, how much does it contribute to your happiness in life?

Participants were provided with the meaning of well-being and happiness based on Lyubomirsky (2008) and Dolan (2014)—"By the term '*happiness*,' we refer to the experience of pleasure and a sense that one's life is good, meaningful, and worthwhile."

4.2. Participants

Participants were recruited through Amazon Mechanical Turk. Collecting data through this online platform has been found reliable and efficient while reducing threats to internal validity, relative to other recruitment methods (Paolacci et al., 2010). Criteria for participant selection included being a native-English speaker living in the United States, having a 98% minimum task approval rating, at least 500 completed tasks, and Amazon Masters whose previous records have consistently high approval ratings. 116 participants were recruited in total (60 male and 56 female). Age ranged between 24 and 70 ($M = 41.17$, $SD = 10.41$), and the nationalities consisted of the United States (82.76%), India (14.66%), and Unknown (2.58%). Participants were paid $10 for their participation.

4.3. Questionnaire and procedure

The questionnaire inquired about positive emotions evoked by everyday technologies and their impact on well-being, which consisted of four parts: (1) introducing the study, (2) assessing the ability to differentiate positive emotions, (3) reporting emotional responses, and (4) reporting well-being. The first part described the general aim of the study and obtained consent for participation by informing the research topic, their tasks, risks/discomforts, compensation, and deidentification of the data to be collected. The second part assessed individual differences in the ability to differentiate positive emotions by incorporating the DOPES (Kirby et al., 2014). Following the guideline of DOPES, participants were asked to imagine themselves in eight different vignettes, each eliciting a distinct positive emotion. For each vignette, participants were asked to rate their imagined emotional responses on a 9-point scale, from "not at all" to "extremely much." The third part began by helping participants understand the meaning of the 20 positive emotions in the set. Besides the emotion descriptions (based on Table 1), visuals of behavioral manifestations were provided (see Figure 2A). The visuals were validated ones used in Positive Emotional Granularity Cards (Yoon, Desmet & Pohlmeyer, 2013). Participants were guided to go through and compare the meanings to understand the nuances between the emotions. Providing this information ensured that all participants understood the distinct and unique qualities of the emotions. The textual and visual descriptions of the 20 positive emotions were made available to refer to throughout the questionnaire.

Before participants reported their emotional experiences, it was explained that the term "technology" used in the questions referred to any kinds of technology artifacts (both digital and tangible) used in everyday contexts. A collage of 36 technology images was shown that represented a wide range of technologies (e.g., smartphones, eBooks, TV streaming services, ATMs, and robot vacuum cleaners) to give an idea of the possibilities that the participants could consider (see Figure 2B). Then, participants shared their experiences by selecting five technologies that pleased them in the last month. Next, for each technology, they were prompted to describe the situation in which they used the technology and why they found the experience pleasurable as detailed as possible. Guiding questions were given following the procedure of Desmet (2012): What happened and what were you doing? How would you express your feelings? What was on your mind? After that, they selected relevant emotions (as many as they wanted) and indicated how strong the emotions were on a 5-point scale, from "Not at all" to "Strongly."

In the fourth part, participants indicated the contribution of the technology to their happiness by using the 1-9 scale (from "Not happy" to "Extremely happy") based on the procedure of Van Boven and Gilovich (2003). Participants were presented with the meaning of "happiness" based on Lyubomirsky (2008) and Dolan (2014). Participants repeated the third and fourth parts until they went through all five chosen technologies. The procedure was conducted individually and took approximately 50 minutes to complete.

4.4. Data analysis

4.4.1. Data inclusion for analysis

In total, 580 cases were collected (116 participants × 5 technologies). Attrition was prevalent; 28 participants were dropped from data analysis because of incomplete data, leaving 88 participants. Among the remaining participants, individuals with a lower ability to differentiate positive emotions were excluded based on the DOPES questionnaire results (Kirby et al., 2014). Following the questionnaire's instruction, each participant's degree of emotion differentiation was quantified by intercorrelating the ratings for each emotion scale across the eight vignettes. Then, the mean Cronbach's alpha, based on the intercorrelations among the eight vignettes, was computed. Higher mean intercorrelation reflects lower levels of differentiation because they indicate that the emotion ratings covary strongly across the vignettes. Since each vignette portrays a distinct emotion, higher ratings for other emotions imply that the participant could not distinguish the intended emotion from others. 28 participants' intercorrelation values were above the criterion of 0.70 (according to Nunnally, 1975), indicating their low ability to distinguish nuances between positive emotions. Thus, these participants' data were removed, leaving 60 participants (average α=.40) with 300 cases. Finally, five cases were removed that were unclear regarding what aspects of the technologies the participant was referring to. This process resulted in 295 cases for data analysis.

4.4.2. Coding the three sources of positive emotions and the two types of well-being pursuits

The two authors and four external researchers independently read the entire data and deductively classified them into the three sources of positive emotions (i.e., object, instrument, and enabler), and two well-being pursuits (i.e., hedonic and eudaimonic pursuits) following the general thematic analysis process (Braun & Clarke, 2006). Four researchers who have expertise in design for emotion and well-being were invited to improve consistency of the data analysis. The classifications were compared, and in case of disagreement, the six researchers discussed how they interpreted the data. Some cases included multiple sources of positive emotions (e.g., a smartphone as an object and an enabler of activity). In those cases, the most salient source of positive emotions described in the report was finally chosen. The process was iterative and completed when no more changes were made.

An example from "enabler" (i.e., positive emotions evoked by activities and events enabled by a technology) and "eudaimonic" (i.e., personal development and meaning in life supported by a technology) was:

> "*My smart phone has been my lifeline to my family during quarantine. Yesterday I spoke with my sisters* [activity enabled by a technology; **code: enabler**], *as seeing them in-person was not an option. I felt grateful that I could easily keep in touch with people and support them I care about* [activity enabled by a technology/meaning in life; **code: enabler and eudaimonic**]. *I appreciated that I could call, text, or video chat. It made me feel connected* [meaning in life; **code: eudaimonic**] (Participant 87)."

5. Results

5.1. Experience reports and technology types

A total of 295 technologies were mentioned, four or five per participant. They were categorized into 31 technology types based on their similarities in terms of their overall purposes. For example, online movie-streaming services such as Netflix, Hulu, and Disney + were classified as "over-the-top services." Wireless speakers, headphones, and MP3 players were classified as "audio devices." A wide array of technologies and activities were mentioned, including personal computers, smartphones, audio devices, gaming consoles, TVs, over-the-top services, tablet PCs, smartwatches, home appliances, smart speakers, cameras, self-checkouts, ATMs, etc. The majority of the reported experiences (86.82%) referred to one of these technologies, either directly or indirectly, by describing a particular quality (e.g., "versatility of a smart speaker") and activity (e.g., "discovering a new music album to share with friends"). More unusual examples were a vending machine, a smart security system, a credit card reader, or a home network device (13.18%). A multitude of usage contexts were mentioned, ranging from homes, cars, public transportation, and supermarkets to offices.

The sources of positive emotions and types of well-being pursuits were independent of technology types. As shown in Desmet (2012), many reported experiences showed that a specific technology type could play diverse roles in eliciting positive emotions. For instance, a smart speaker served

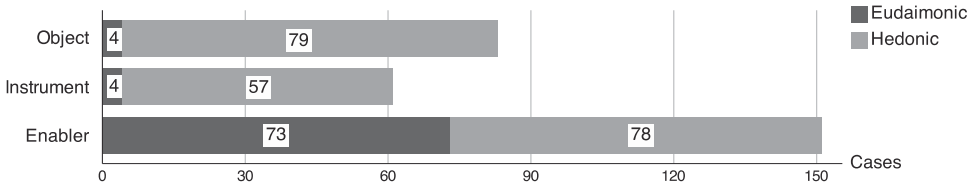

Figure 3. Stacked bar count of three sources of positive emotions by two well-being pursuits.

Table 4. Types of well-being pursuits X sources of positive emotions crosstabulation. In brackets are values of mean and standard deviation of well-being and emodiversity scores (W: Well-being, E: Emodiversity).

		Sources of positive emotions			
		Object	Instrument	Enabler	Total
Well-being pursuits	Eudaimonic	4 cases W (*M*: 7.500, *SD*: 2.041) E (*M*: 94.393, *SD*: 8.943)	4 cases W (*M*: 6.875, *SD*: 1.750) E (*M*: 94.167, *SD*: 4.702)	73 cases W (*M*: 7.226, *SD*: 1.736) E (M: 89.712, SD: 12.822)	81 cases W (*M*: 7.222, *SD*: 1.730) E (*M*: 90.163, *SD*: 12.396)
	Hedonic	79 cases W (*M*: 6.930, *SD*: 1.562) E (*M*: 85.070, *SD*: 17.189)	57 cases W (*M*: 6.780, *SD*: 1.837) E (*M*: 80.670, *SD*: 16.877)	78 cases W (*M*: 7.205, *SD*: 1.673) E (*M*: 84.660, SD: 16.026)	214 cases W (*M*: 6.990, *SD*: 1.680) E (M: 83.747, SD: 16.715)
Total		83 cases W (*M*: 6.958, *SD*: 1.578) E (*M*: 85.517, *SD*: 16.971)	61 cases W (*M*: 6.787, *SD*: 1.817) E (*M*: 81.555, *SD*: 16.682)	151 cases W (*M*: 7.215, *SD*: 1.698) E (*M*: 87.102, *SD*: 14.737)	295 cases W (*M*: 7.054, *SD*: 1.694) E (85.509, SD: 15.890)

(1) as an object with its high-quality sound (Participant 72) and (2) as an instrument through its easy-to-use conversational user interface for managing grocery items (Participant 65), and (3) as an enabler of singing a birthday song together with family members (Participant 30). Likewise, similar to literature on technology-mediated well-being (Karapanos et al., 2016), several cases showed that both hedonic and eudaimonic pursuits could be attributed to a particular technology. For example, Participant 28 had enjoyed watching an animated clock interface on their smartwatch (i.e., hedonic pursuit), while Participant 85 became determined to pursue a healthier lifestyle after tracking their improved progress towards several health goals (e.g., calories and exercise hours), which was informed by their smartwatch (i.e., eudaimonic pursuit). Overall, the samples covered a wide diversity of technology-mediated experiences and were deemed appropriate for further analysis.

5.2. Clustering the reported experiences

The data were clustered into three sources of positive emotions: 83 object-oriented, 61 instrument-oriented, and 151 enabler-oriented experiences (295 in total). There were 214 hedonic and 81 eudaimonic pursuits (295 in total; see Figure 3). Table 4 shows a crosstabulation of these classifications. A chi-square test revealed a statistically significant relationship between the sources of positive emotions and their impact on the types of well-being pursuits, $X^2(2)=67.805$, $p<.001$. While most hedonic pursuits were associated with objects and instruments, most eudaimonic pursuits were attributed to enablers. The results suggest that in eudaimonic pursuits, technologies predominantly served as an enabler of certain positive activities and events (e.g., taking care of grandparents' health by using a heart monitoring device and inviting them to exercise together). The technologies' aesthetic and instrumental qualities (e.g., a beautiful and easy-to-use interface) did not significantly contribute to eudaimonic pursuits.

5.3. Influence of demographic factors

5.3.1. Gender effect on emodiversity and well-being

An independent-samples t-test showed that there was no influence of gender on emodiversity: male ($N=161$, $M=86.199$, $SD=16.447$) and female participants ($N=134$, $M=84.679$, $SD=15.211$), $t(293)=-.817$, $p=.168$. No gender effect on well-being was found as well: male ($M=7.056$, $SD=1.772$) and female participants ($M=7.052$, $SD=1.602$), $t(293)=-.018$, $p=.552$.

5.3.2. Age effect on emodiversity and well-being

A Pearson correlation analysis revealed that there was a strong correlation between age ($M=41.46$, $SD=10.644$) and emodiversity ($M=85.509$, $SD=15.889$), $r=.140$, $p=.016$. Further, a simple regression showed that participants' ages explained a significant amount of variance in emodiversity, $F(1, 293)=5.845$, $p=.016$, $R^2=.020$. The relationship between age and well-being ($M=7.054$, $SD=1.694$) was assessed. A Pearson correlation test showed that the two were significantly related, $r=-.224$, $p<.001$. Age also explained a significant variance in well-being, $F(1, 293)=15.523$, $p<.001$, $R^2=.050$. The results indicate that there was a main effect of age on both emodiversity and well-being. Older participants experienced a wider diversity of positive emotions when interacting with technologies, and they were happier than younger participants.

5.4. Hypotheses testing

5.4.1. Effects of emodiversity on well-being

Greater diversity in positive emotions (IV: $M=85.509$, $SD=15.889$) was significantly related to the increase in well-being (DV: $M=7.054$, $SD=1.694$). A simple regression analysis revealed that emodiversity predicted a significant amount of the variance in well-being, $F(1, 293)=49.34$, $p<.001$, $R^2=.144$. This result was consistent across the three sources of positive emotions: (1) object,

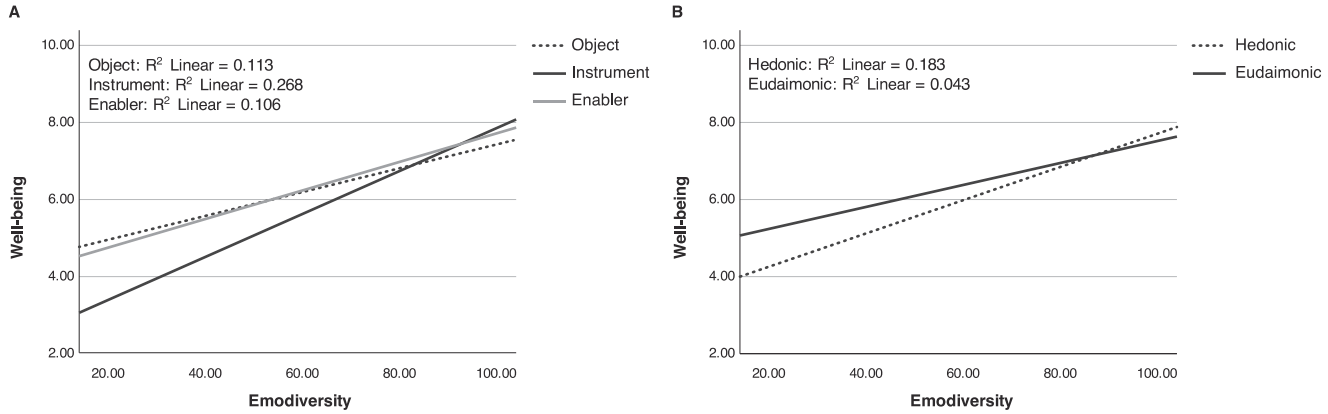

Figure 4. Linear lines of emodiversity and well-being classified by (A) the three sources of positive emotions and (B) the two types of well-being pursuits.

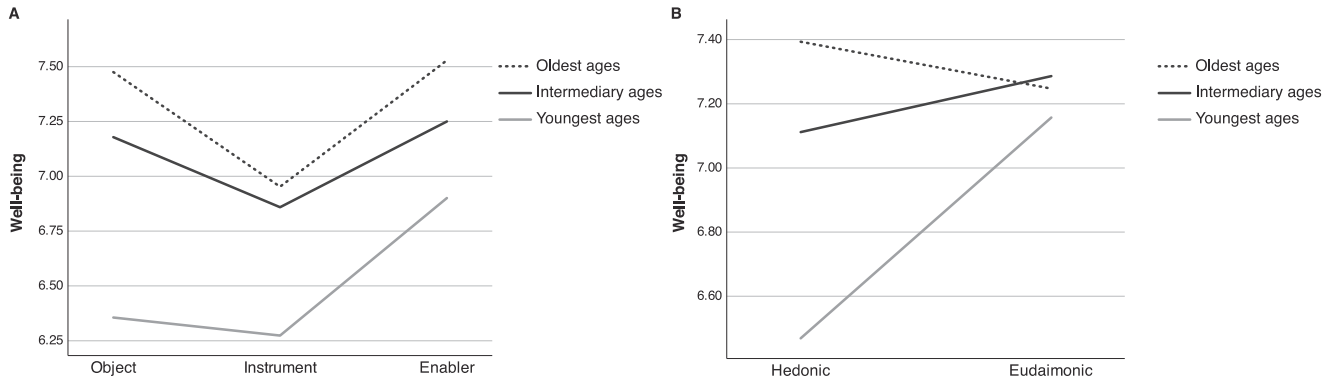

Figure 5. Well-being scores of age-tertile groups (A) across the three sources of positive emotions, and (B) across the two types of well-being pursuits.

$F(1, 81) = 10.309$, $p = .002$, $R^2 = .113$, (2) instrument, $F(1, 59) < 21.622$, $p = .001$, $R^2 = .268$, and (3) enabler, $F(1, 149) = 17.652$, $p < .001$, $R^2 = .106$. Likewise, the two well-being pursuits showed a consistent pattern: (1) hedonic, $F(1, 212) = 47.624$, $p < .001$, $R^2 = .183$, and (2) eudaimonic pursuits, $F(1, 79) = 3.537$, $p = .064$, $R^2 = .043$. Figure 4 shows regression lines categorized by the three sources of positive emotions (Figure 4A) and two types of well-being pursuits (Figure 4B). Taken together, the results confirmed the first hypothesis that greater diversity in positive emotions in technology use predicts increased well-being.

Since both age and emodiversity predicted the increase of well-being, a hierarchical regression analysis was conducted to determine if emodiversity could account for a significant amount of variance in well-being above and beyond age. The result showed that the significance of emodiversity was stronger than age; ANOVA results for change in R^2 for age and emodiversity were: $F(1, 292) = 64.713$, $p < .001$. Further analysis was conducted using multiple regression to test the interaction effect of age, which showed that age moderated the increase in well-being to some extent, $F(3, 291) = 29.262$, $p = .064$, $R^2 = .232$. Figure 5 shows the well-being scores of age-tertile groups: oldest ages ranged between 44 and 68 ($N = 94$, $M = 54.48$, $SD = 7.776$), intermediary ages ranged between 35 and 42 ($N = 108$, $M = 39.92$, $SD = 2.376$), and youngest ages ranged between 24 and 34 ($N = 93$, $M = 31.73$, $SD = 2.905$). These results implied that the effect of emodiversity becomes more positive with increasing age. This pattern was also observed throughout the three sources of positive emotions. A similar pattern emerged across the two well-being pursuits except for the oldest group that showed a lower level of well-being in eudemonic pursuits ($N = 23$, $M = 7.239$, $SD = 2.300$) than the intermediary group ($N = 35$, $M = 7.27$, $SD = 1.624$). However, the difference was not significant. Further, while the oldest group's well-being was higher in hedonic ($N = 71$, $M = 7.394$, $SD = 1.804$) than in eudaimonic pursuits ($N = 23$, $M = 7.239$, $SD = 2.300$), there was no significant difference.

5.4.2. Effects of sources of positive emotions

5.4.2.1. Effects on well-being. The level of well-being was highest when technologies served as an enabler (M: 7.215, SD: 1.698), followed by an object (M: 6.958, SD: 1.578) and an instrument (M: 6.787, SD: 1.817). Although the results aligned with the second hypothesis, one-way ANOVA analysis showed that the differences between the three sources were not significant, $F(2, 292) = 1.581$, $p = .207$ (see Figure 6A). This result suggests that the sources of positive emotions could not be confirmed as a main effect, thereby rejecting the second hypothesis.

5.4.2.2. Effects on emodiversity. Since emodiversity was found to be a main predictor of well-being, we compared the three sources of positive emotions in relation to emodiversity. The level of emodiversity was higher in the group of "enabler" (M: 87.102, SD: 14.737) than in the groups of "object" (M: 85.517, SD: 16.971) and "instrument"

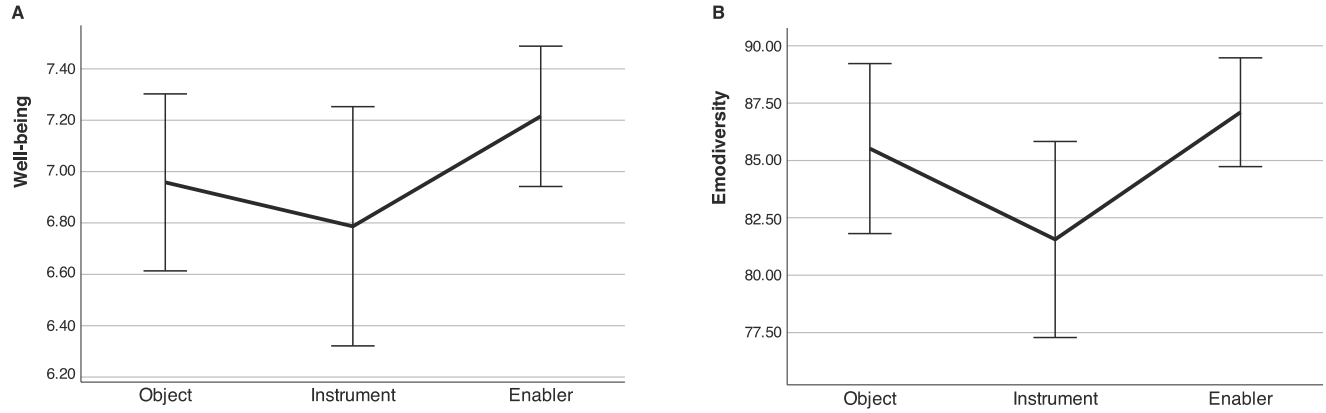

Figure 6. (A) Well-being scores across the three sources of positive emotions, (B) Emodiversity across the three sources of positive emotions (error bars: 95% CI).

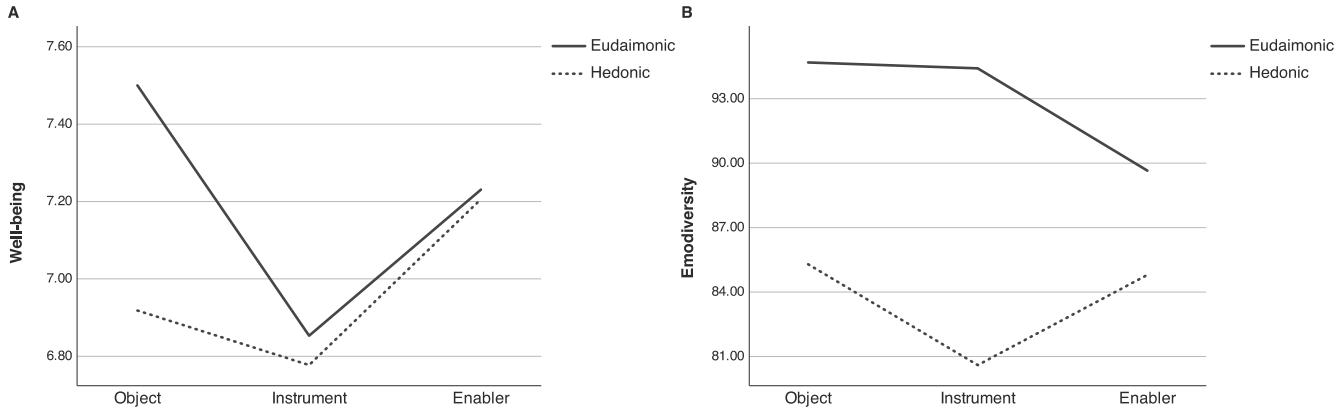

Figure 7. (A) Well-being scores in relation to hedonic and eudaimonic pursuits and (B) emodiversity level of hedonic and eudaimonic pursuits across the three sources of positive emotions.

(*M*: 81.555, *SD*: 16.682). One-way ANOVA analysis revealed that there was no significant difference between the three sources, $F(2, 292) = 2.678$, $p = .070$. However, further analysis that compared the difference between "enabler" and "instrument" showed that these two sources were significantly different, $F(1, 210) = 5.698$, $p = .018$ (see Figure 6B). However, the difference between "instrument" and "object" was not significant, $F(1, 142) = 1.944$, $p = .165$. The results suggest that the emodiversity level was higher when positive emotions are indirectly evoked through activities enabled by technologies (i.e., enabler) than when they were directly evoked through usage interactions (i.e., instrument).

5.4.3. Effects of types of well-being pursuits on well-being

5.4.3.1. Effects on well-being. The overall effects of hedonic and eudaimonic pursuits supported by technologies on well-being were not statistically different, one-way ANOVA analysis: $F(1, 293) = 1.098$, $p = .296$. As reported earlier, most of the reported cases of eudaimonic pursuits took place when technologies played as an enabler (73 out of 81 cases). Although well-being score was especially higher in eudaimonic than hedonic pursuits within the scope of "object," the sample size of eudaimonic pursuits was too small to compare each other (4 out of 83 cases, see Figure 7A). These results reject the third hypothesis that eudaimonic pursuits are more closely associated with increased well-being than hedonic pursuits in human-technology interactions.

5.4.3.2. Effects on emodiversity. The level of emodiversity was higher in eudaimonic than in hedonic pursuits. One-way ANOVA analysis showed that the difference was significant: $F(1, 293) = 9.870$, $p = .002$. As Figure 7B illustrates, the difference was noticeable across the three sources of positive emotions. The results suggest that participants experienced a wider variety of positive emotions when they were engaged in eudaimonic than in hedonic pursuits. The result that most eudaimonic pursuits were attributed to the enabler group (73 out of 81 cases) implies that when technologies play a role as an enabler of eudaimonic activities, the emodiversity level was higher.

5.5. Brief discussion of the findings

The present paper investigated if and how diverse positive emotions evoked by everyday technologies foster user's well-being. The results showed that when participants experienced a more comprehensive range of positive emotions, their well-being level was higher. While hedonic pursuits were comparably attributed to all three sources of positive emotions (i.e., object, instrument, and enabler), eudaimonic pursuits were predominantly supported by activities enabled by technologies (i.e., enabler). In general, the level of

well-being was higher when positive emotions were evoked by technologies that served as an enabler than the other two sources. However, the difference between the three sources was not significant. What is noteworthy is that the level of emodiversity was highest when the primary source of positive emotions was an enabler, implying its effectiveness in increasing well-being. The level of emodiversity was higher in eudaimonic than in hedonic pursuits.

Furthermore, it was found that age moderated the level of both well-being and emodiversity in human-technology interactions, i.e., the older participants aged between 44 and 68 reported more fine-grained positive emotions and higher happiness than the younger groups (i.e., the intermediary group aged between 35 and 42, and the youngest group aged between 24 and 34). This finding is consistent with the theories suggesting that age is associated with greater emotional complexity and well-being because people begin to have more granular distinctions between positive emotions as they age, being exposed to a broader range of positive emotional experiences (Hay & Diehl, 2011; Kirby et al., 2014; Quoidbach et al., 2014). The highly developed ability to differentiate positive emotions implies that people become highly adaptive to situational opportunities and challenges (e.g., prosocial behaviors motivated by kindness and sustained commitment motivated by hope), leading to a higher level of well-being (Lindquist & Barrett, 2008). Further, our findings broadly support the work of other studies in design research linking age with positive experiences. For example, a recent study by Yoon et al. (2020a) on positive experiences and demographic factors showed that older users were more appreciative of their everyday technologies and reported higher satisfaction than younger users across all stages of a product lifecycle (i.e., from adoption to disposal).

On average, the youngest group reported a lower level of well-being in hedonic than in eudaimonic pursuits, while the intermediary and oldest groups reported a similar level of well-being in both hedonic and eudaimonic pursuits. This generally accords with Van Boven and Gilovich (2003) that showed young adults' happiness was lower in relation to the pleasure stimulated by a material possession (i.e., hedonic pursuits) compared to the happiness fostered by investing in meaningful experiences (i.e., eudaimonic pursuits). The current study's results imply that technology-supported hedonic pursuits can be less effective in fostering well-being, especially when the intended users' age is young. Thus, it would be advantageous for designers to focus their attention on virtuous and moral activities that technologies can support as resources to increase the well-being of young users.

Contrary to our expectations, eudaimonic pursuits supported by technologies as an object showed a higher level of well-being relative to the other two sources (i.e., instrument and enabler). While there were only four cases in the collected data, the result suggests that technologies as an object can also be an effective pathway to eudaimonic well-being. Further analysis of these four cases revealed that they were linked to symbolic representations of positive relations with others and personal growth, conveyed by the technologies. For example, Participant 88 referred to the symbolic meaning of their healthcare device regarding their aspiration to stay healthy ("*it's a visual reminder. Seeing it makes me feel accountable for keeping my health goals.*"), while Participant 79 noted the significance of their speaker as a symbol of a good relationship with their neighbors ("*it conveys a feeling of connectedness. My neighbors felt happy when I played music loudly with my speaker during the pandemic.*"). These data indicate that object-based symbolic representations can refer to positive activities supported by the technology. The result reflects those of Casais et al. (2018), who proposed six well-being enhancing symbolic meanings in artifacts associated with positive activities: positive relations, personal growth, autonomy, environmental mastery, purpose in life, and self-acceptance. In general, the result echoes their claim that as symbolic representations, design and technology can lead users to positive aspects of meaningful experiences, contributing to their happiness.

Technologies as an instrument showed the lowest levels in well-being. Karapanos (2013) and Yoon et al. (2020a) showed that instrumentality (i.e., how useful and efficient a technology is in achieving task-oriented goals) is critical in the early stages of a technology lifecycle. This differs from the findings presented here because our focus was on the contribution of technologies to long-term well-being (i.e., how much a technology contributes to one's happiness in life). We assume that, as the Kano model (Kano, 1984) suggests, participants became less attentive to their technologies' instrumental quality due to the maturation of the technologies they referred to (e.g., smartphones and home appliances). Instrumentality as a differentiator may have become a new standard over time, and they may have no longer perceived it as a primary contributor to their well-being. Kim and Christiaans (2016) showed that it happens more frequently in response to instrumental qualities of a technology (e.g., usability). Further, increased usability has been considered namely useful in minimizing and neutralizing negative experiences, but not particularly helpful in fostering positive experiences (Chitturi, 2009; Desmet & Hassenzahl, 2012). The present study supports evidence from previous observations.

6. General discussion and conclusion

6.1. Summary and contributions

The present study is the first to investigate how the diversity of positive emotions mediated by technologies affects users' well-being. Consistent with our prediction, results showed that increased positive emodiversity leads to increased well-being. The effect was predicted by the three sources of positive emotions (i.e., object, instrument, and enabler) and the two types of well-being pursuits (i.e., hedonic and eudaimonic pursuits). The results also showed the effectiveness of technology-supported positive activities in facilitating a breadth of positive emotions.

This paper makes empirical and methodological contributions to the field of design for well-being. The benefits of designing for nuanced positive emotions have been mainly discussed from designers' perspectives. For example, Yoon et al. (2016) investigated how designers' ability to

differentiate and communicate nuances between positive emotions can support several design activities in product development processes, such as getting an in-depth understanding of users' positive experiences and determining the distinct emotional impact to design for. These advantages have stimulated the introduction of design tools that support designers in developing a nuanced understanding of positive emotions (for an overview, see Yoon et al., 2020b). However, the benefits of positive emodiversity for users' well-being have been hardly studied. The novelty of our approach to investigating the impact of positive emodiversity lies in its focus on the relative roles of the three sources of positive emotions and two types of well-being pursuits. While these different aspects have been considered design opportunities when designing for emotions (e.g., evoking satisfaction by focusing on technologies as an object, an instrument, or an enabler; Desmet, 2012), their relevance to emodiversity and well-being has not been systematically studied. Our study was grounded in established theories and measures of positive emotions and well-being in design research and positive psychology, which enabled us to detail the relationship between technologies, emodiversity, and well-being. In particular, the study ensured the validity of the collected data by considering the participants' ability to differentiate positive emotions.

Our findings imply several aspects for the practice of design for emotion and well-being. Our study offers evidence that designing for a wide diversity of positive emotions, as opposed to generalized pleasure or one single emotion, can enrich users' emotional experiences, enhancing their well-being. Further, it was found that technologies can effectively act as resources for activities that provide a diverse range of positive emotions; apart from directly taking pleasure in the technology itself, users can indirectly experience a multitude of positive emotions by engaging in the positive activity in which the technology is used. In particular, the majority of technology-supported well-being outcomes (e.g., personal growth, meaning, and mastery) were facilitated by activities. The positive relationship between activities, emodiversity, and well-being identified in this study confirms the literature of design for well-being that addressed the importance of focusing on activities instead of direct manipulation of technology properties (e.g., an artifact's appearance and material) (Wiese et al., 2019; Yoon et al., 2022). ; Thus, we encourage that designers should be aware of these different pathways to evoke positive emotions, and start their design processes by gathering insights about what kinds of activities would be effective and relevant in the intended contexts and determining how such activities can be supported through technologies (for a detailed methodological discussion, see Klapperich et al., 2019; Wiese et al., 2019). In addition, the lower impact of a technology's instrumentality on well-being signifies the importance of holistically considering different spheres of experience, including technology-enabled tasks (e.g., using a smartwatch's self-tracking feature), technology-enabled activity (e.g., committing to exercise), and technology-enabled lifestyle (e.g., pursuing to stay healthy). For example, as in Peters et al. (2018), a timer with superior usability would make the cooking process more accurate. Yet, the timer on its own would not measurably increase a user's satisfaction with life if it did not contribute to the activities pertinent to their happiness (e.g., preparing and having dinner with loved ones). Thus, acknowledgment of different experience spheres and aligning them in a complementary way is crucial if designers aim to avoid developing technologies that are satisfactory in one sphere but undermining in another (for a detailed discussion of how different spheres of user experience affect user well-being, see Peters et al., 2018; Smith et al., 2022).

6.2. Limitations and future work

While the present paper offers new insights into technology-mediated positive emodiversity and well-being, we acknowledge some limitations to be addressed in future research. A note of caution is that our data themselves do not explain the underlying mechanisms of the effects of positive emodiversity; the data revealed that positive emodiversity enhances the well-being of users, but they do not show how it enhances well-being. As theorized by Kirby et al. (2014) and Griskevicius et al. (2010), experiencing a wide diversity of positive emotions and recognizing their distinctiveness may support users' adaptive coping because it can guide their thoughts and behaviors in a self-beneficial way (e.g., savoring the current situation and rewarding oneself when feeling satisfied and proud, respectively). Alternatively, as proposed by the broaden-and-build theory (Fredrickson & Cohn, 2008), positive emodiversity may come with opportunities for building resources (e.g., knowledge and social bonding) that make a long-lasting contribution to one's growth and well-being. For example, the physical exercise stimulated by joy, while using a smartwatch can lead to long-term improvements in health while the strategies for collaborating with peers to run as a group can foster intellectual resources, resulting in strengthened social relationships. However, these hypothesized processes have yet to be empirically investigated. Therefore, we invite initiatives aiming to further explore the antecedents and consequences of the interplay between positive emodiversity and well-being in human-technology interactions.

We are aware that there may have been memory biases because the positive emotional experiences were collected based on the participants' recalled memories. The retrospective responses would reflect the participants' beliefs about themselves or the related events instead of accurately representing their emotions (Robinson & Clore, 2002). Besides, the retrospective self-report could be influenced by their feelings at the moment of reporting (Karahanoğlu & Ludden, 2021). More specifically, there may have been an inadvertent effect of "savoring"; writing about feelings associated with a positive experience could increase positive affect (Pennebaker, 2004), which may have heightened the level of well-being reported in the study. However, given our overarching interest in the long-term impact of positive emotions elicited by technologies on well-being, we argue that collecting retrospective responses was not problematic. In our view, in line with Norman (2009)

and Xue and Desmet (2019), it can be more important to delve into how a person looks back on and remembers a certain felt experience and how they currently assess its impact on their well-being rather than focusing on actuality in the past. That said, we also find it relevant to replicate our study with other moment-to-moment data collection approaches that could enable a long-term repeated measurement because the current study's results were based on reports of one-time instances. For example, an Ecological Momentary Assessment (Shiffman et al., 2008) would allow taking intensive repeated measurements of peoples' emotions and behaviors in real-world settings, and observing the patterns in their reports that unfold over time. Here, one issue is that although these approaches are increasingly used in studies on emotion differentiation in psychology (e.g., Tugade et al., 2004), they tend to require constant interruptions, making their applications too intrusive and increasing participants' fatigue in responding (Karahanoğlu & Ludden, 2021). This challenge was also prevalent in our pilot test (Park et al., 2022; see Section 3.1). Thus, further studies on data collection tools and techniques that take the challenges into account in collecting nuanced positive emotions will need to be undertaken.

Despite the promising results regarding the relationship between positive emodiversity and well-being, questions remain about how it contributes to different sub-components of well-being. The current study focused on overall happiness with an aim to make the study setup efficient and manageable for the participants. An important goal of future research lies in investigating the relative impact of positive emodiversity on sub-components of well-being such as emotional well-being, psychological needs satisfaction, life satisfaction, and general well-being. These could be addressed through, for example, the Scale of Positive and Negative Experience (Diener et al., 2010), the Basic Psychological Needs Satisfaction and Frustration Scale (Chen et al., 2015), the Satisfaction with Life Scale (Pavot et al., 1991), and the Subjective Happiness Scale (Lyubomirsky & Lepper, 1999), respectively. We expect to find the impact of technology-mediated positive emodiversity on different well-being components in the future.

6.3. Conclusion

Experiences of positive emotions are central to human nature and contribute to the quality of life (Diener, 2000; Fredrickson & Losada, 2005). With the emerging realization of the contribution of technology-supported positive emotions to well-being, research that explores the possibilities of designing for positive emotions has advanced in design research and HCI. In this paper, we examined the effects of emotional complexity, focusing on diverse positive emotions stimulated by everyday technologies. We took a fine-grained perspective on the roles that technologies play in stimulating a higher level of positive emodiversity by considering the three different sources of positive emotions: object, instrument, and enabler. Further, we evaluated how technology-supported hedonic and eudaimonic pursuits are associated with well-being. One of the significant findings is that when users engage in positive activities supported by a technology (i.e., an enabler), they tend to experience more diverse positive emotions, and increased positive emodiversity leads to increased well-being. The main contribution is the establishment of initial evidence that greater diversity in positive emotions in technology use can enhance the well-being of users. To this end, we conclude that users' well-being can be better supported by designing for a wide diversity of positive emotions that transcend the traditional unitary concept of pleasure-displeasure distinction. We hope that this paper will serve as a good starting point for further investigation into the impact of technology on emotional complexity and well-being, and the development of methods and tools that assist designers to make a positive impact through their designs.

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Author contributions

JY and CJ designed the project and conducted the study. JY and CJ analyzed the data. JY wrote the original draft of the manuscript. JY and CJ revised the manuscript. All authors contributed to the article and approved the submitted version.

Disclosure statement

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