Mood Worlds: A Virtual Environment for Autonomous Emotional Expression

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Figure 1: Mood Worlds - a VR application allowing users to visualise emotions by self-creating a VE. This image is based on the Mood World created by P16.

ABSTRACT

Immersive interactive technologies such as virtual reality (VR) have the potential to foster well-being. While VR applications have been successfully used to evoke positive emotions through the presetting of light, colour and scenery, the experiential potential of allowing users to independently create a virtual environment (VE) has not yet been sufficiently addressed. To that end, we explore how the autonomous design of a VE can affect emotional engagement and well-being. We present Mood Worlds – a VR application allowing users to visualise their emotions by self-creating a VE. In an exploratory evaluation (N=16), we found that Mood Worlds is an effective tool supporting emotional engagement. Additionally, we found that an autonomous creation process in VR increases positive emotions and well-being. Our work shows that VR can be an effective tool to visualise emotions, thereby increasing positive affect. We discuss opportunities and design requirements for VR as positive technology.

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CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; *HCI theory, concepts and models*; Visualization systems and tools.

KEYWORDS

Virtual Reality, Well-being, Happiness, Emotions, Emotion Regulation, Positive Technology

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1 INTRODUCTION

Well-being and mental health support are commonly addressed design goals in commercial systems and in Human-Computer Interaction (HCI) research (e.g. [5, 68]). Well-being technologies are now commonplace on our wrists (e.g. stress tracker [19]), in our pocket (e.g. digital gratitude diary) or on our computer (e.g. meditation tutorial [45]). In contrast to such interventions, applications (apps) in virtual reality (VR) allow for deep immersion in a virtual environment (VE). VR can reproduce the complexity of real-life situations while variables such as sound, light, movement of objects can be close to completely controlled to provide meaningful interventions [57]. The unique benefits that VR offers for enhancing well-being have been explored in a variety of areas. VR is used, inter alia, for therapeutic interventions (e.g. to treat anxiety [48]), to create a space for artistic expression [8], and in the area of VR gaming and physical activity [71]. Furthermore, previous work in VR explores the potential of VEs in a variety of different areas in the context of well-being such as mindfulness training [45, 51], stress reduction support [75, 79, 88], VR as positive technology [6, 38], role-play and embodiment for positive change [29], VEs for different forms of journaling [2, 20, 78, 80] and emotion regulation interventions [50], among others.

However, most research in the field of well-being and VR focuses on one of the following two aspects: First, many VR apps aim to induce emotions but the participant remains passive. A review by Montana et al. [50] about VR apps for emotion regulation showed that most interventions change the VE *before* the participant enters it. Though differing in experimental manipulation, the procedures resemble one another to a great extent: participants either choose which preset VE they want to experience [4], or they are assigned to a certain condition [44]. Second, other research allows users to personalise a VE, but only to a limited extent. For example, either passively collected physiological data influences the surrounding, e.g. the colour of the VE changes depending on the measured heart rate or brain activity of the participant [44], or the user can more actively influence the virtual surrounding, e.g. by following breathing exercises [62]. This limits the scope for personalisation of VEs as well as the level of self-determination and autonomy it allows for. We define autonomy as being independent and self-governing [43, 76]; as having agency over one's life [74] and, in the context of this study, also over the content and design of a VR app. This lack of providing personalisation and autonomy in VR well-being apps is not only restricted to HCI research but also extends to commercially available VR apps [84]. Therefore, our work focuses on providing a VR experience for personalised, autonomous emotional expression enhancing a user's emotional well-being.

Schek et al. [70] emphasise the need for advanced technologies supporting well-being and promoting health. Furthermore, caring for one's well-being and mental health at home and designing technologies supporting that endeavour has gained in importance [70, 81, 89]. Thus, emotionally stimulating content should be adjusted in real-time if necessary [59]. Recent work suggests that becoming active in designing emotionally stimulating content is in itself therapeutic and can foster happiness [84]. To address these aspects, we developed *Mood Worlds*, a refined and revised version of the VR drawing application Open Brush that allows users to autonomously create a virtual environment with the purpose to express their emotions. A schematic representation is presented in Figure 1. We conducted a user study (N=16) to inquire how self-creating mood worlds in VR influences the happiness and well-being of participants. We found that autonomously creating a VE to express emotions led to increased happiness and positive affect. We conclude with a set of implications to inform the future design of VR applications for independent self-care and well-being.

This paper contributes the following: (1) the design and implementation of Mood Worlds–a virtual environment for autonomous emotional expression; (2) an exploratory evaluation of Mood Worlds; and (3) insights for designing future VR applications that foster autonomy and support well-being.

2 RELATED WORK

This section introduces the reader to relevant concepts and terms related to emotions and well-being. We then describe how Mood Worlds fits into the space of interactive technologies in general, and VR applications more specifically supporting emotional well-being. We also review examples of how VR is already used to induce emotions.

2.1 Emotion, Mood, Feelings and Affect

Positive emotions are one essential aspect of well-being [73]. Well-being, for the scope of our paper best described as a dynamic optimal state of psychosocial functioning [9], is built upon five core pillars that are part of the so called PERMA-theory: positive emotion (happiness, joy, satisfaction, pride, awe), engagement (flow), relationships (work, familial, romantic, platonic), meaning (purpose), and accomplishments (success, mastery). By addressing positive emotions in more detail in this paper, we strive to increase well-being, which in turn affects mental health as an integral part of holistic health and an effective functioning in society [89].

Previous work discusses two different ways to classify emotions: The discrete model according to Ekman [22] defines six basic emotions that are universally identifiable (happiness, sadness, fear, disgust, anger, surprise), while the dimensional approach, i.e. the Circumplex Model of Affect [61], classifies them on two dimensions; valence (negative to positive), and activation or arousal (low to high). More recent research has found that up to 27 emotions can be identified [15]. All of these approaches have in common that emotions are triggered by a specific event or activity [21], are high in intensity, and, as bioregulatory reactions, last for about six seconds [16].

In Psychology, a *mood* is considered to be an *affective or emotional state*. Moods are lower in intensity than emotions, last longer (potentially even weeks or months) [56], and can be influenced by a range of factors, e.g. the weather, relationships, what we have eaten etc. [21]. While emotions and moods are often collectively described as feelings [33], other work [16] defines feelings as a state between emotions and mood. According to the definition by Damasio [16], processing or thinking about emotions, thus cognitively registering them, are called feelings. Consequently, based on Damasio [16], feelings last for longer than emotions and are often caused by a mix of different emotions. For the scope of our paper, we follow the definition of Russel et.al. [61], defining emotions in a fluid way. It is important to note that a specific emotion-triggering event may evoke more than one single emotion [15]. Thus, a state of *happiness* can include other emotions as well, e.g. excitement, satisfaction or awe. Emotions, moods and feelings can be measured with a variety of different methods. The most common are self-reports, such as the Positive and Negative Affect Schedule (PANAS) [85]. Recently, real-time emotion annotation in VR, e.g. by Xue et al. [90], which is based on the Circumplex Model [61], has been added to the list of self-reports. Other ways of measuring the induction of emotions encompass behavioural measures such as body movement, voice pattern, facial expression, or physiological signals, e.g. heart rate, brain activity or electrodermal activity (for an overview, see [59]). Although these measures could provide more objective data than self-reports, most are time-consuming, expensive, and often too complex in their usability for people to use without assistance of experts.

Mood Worlds aims to go beyond past VR systems by offering the first app (to the best of our knowledge) that allows for experiencing positive emotions and feelings by autonomously creating a VE. Furthermore, the creation of a mood world itself takes time. Thus, by allowing the user to immerse themselves into the VE and design it in their own pace, we hope to evoke a positive mood that (ideally) lasts for longer than the actual creation process. This assumption is based on suggestions of related work [66].

2.2 Technologies for Well-being

The HCI community and related fields have begun to assign more importance to designing interactions that promote well-being and mental health [58]. This has given rise to new research fields, such as Positive Computing [10], Emotional Design [52] and Positive Technology [6, 25]. Regarding VR as positive technology, research has investigated VR as transformative experience [37, 39],physical activity [71], persuasive technology supporting behavioural change [3], for mindfulness and relaxation [62, 63] as well as emotion regulation [50]. These examples showcase the interest of scholars to explore the design space of (VR) technologies for human flourishing and optimal human functioning, thus supporting the overall psychological well-being [25].

Positive technologies can be classified into two, depending on the definition in three, categories [6, 87]. Hedonic elements induce positive and pleasant emotions [18] while eudaimonic technologies stimulate an engaging and self-actualising experiences, i.e. serious gaming or VR therapy, that support the user in self-growth [18]. Social and interpersonal technologies aim to improve social integration and connectedness [6]. One way of integrating well-being into the design of technology is to address specific determinants or psychological needs such as autonomy, competence, empathy and compassion. [25, 30]. The psychological need most relevant for our study is autonomy. Autonomy can be defined as being independent and self-governing [43, 76]; having agency over one's life [74].

Previous work emphasises the importance of designing for autonomy and emotional expression [11]. The HCI field has contributed a number of systems that considered these aspects in their design (e.g. [12, 35]). However, inquiring how we can support personalised emotional expression in VR has not been addressed yet. Some studies allow participants to choose between a preset of different VEs [4], but most randomly assign participants to a specific condition (e.g. [44, 83]). On a similar note, a recent review of commercial VR well-being apps found that only one app offered the possibility to (partly) autonomously design the environment [84]. Other designers fostered autonomy by actively engaging participants during the design process of a VE, but the design could not be further adjusted after entering the VE [28]. However, research suggests that the process of autonomously designing VEs is therapeutic in itself [84] and that emotional content should be adjusted in real-time [59].

2.3 VR as Mood Induction Procedure (MIP)

Emotions, feelings and moods can be actively induced. The so called Mood Induction Procedures (MIPs) are explicitly designed to provoke specific transitory affective states in participants under controlled circumstances [4]. Some MIPs are based on analogue methods such as looking at facial expression [23], interacting with human confederates [42] or doing an Autobiographical Emotional Memory Task (AEMT) [32]. AEMT is a widely used MIP. It is proven to be effective [32], does not require any technology and takes less than 10 minutes [49, 77]. When doing an AEMT, participants write about a specific emotional memory, which can cause them to relive that event. This in turn increases the probability to feel that emotion again [49]. AEMT is a valid MIP, especially for positive mood induction [32]. However, critical studies have found that the intended induced emotion is often accompanied by other incidental emotions that share a common valence [49]. A variety of different MIPs are commonly used in psychotherapy to enhance a mood-congruent recall, which can lead to self-reflection [23]. Reflecting on positive memories can increase positive affect and perceived enjoyment, whereas reflecting on negative memories can promote well-being as well because one can gain emotional distance and achieve cognitive reappraisal of a past situation [40].

More recently, VR has also been used as an MIP [83]. VR can be used to induce fear, which is, for instance, utilised in exposure therapy [48]. However, HCI research has also started to explore VR as a medium for more general well-being support, e.g. its benefits for relaxation [38, 63], and emotion induction [36, 47]. The consensus seems to be that VR is an affective medium whose immersive VEs can evoke emotional states and responses similar to reality [29, 47, 66, 79].

Further research has looked at the impact of specific elements in virtual scenarios [59, 65]. Regarding visual cues, higher saturated

and bright colours are more arousing and pleasant [44, 54, 55], fast-moving objects induce a higher arousal [24, 60], and natural settings are perceived as more relaxing [50, 83]. Previous work mainly focused on specific elements of VR. However, in most cases not one specific element but a synergy of colour, sound, lighting, weather, setting, characters, animals and objects induce a certain affective state [23]. Thus, Pinilla et al. [59] have developed broader guidelines for designing visual content of VR applications used to elicit positive change in their users. Moreover, there might be intra- and interpersonal differences of how the same audio-visual stimuli are perceived regarding affective states, also related to personal experiences [59]. As a consequence, visual representations should be personalised as much as possible [59]. Following Pinilla et al.'s call [59], Mood Worlds explores an alternative way to foster well-being and positive emotions. Mood Worlds is designed for autonomous emotional expression in VR, thereby increasing emotional engagement.

3 DESIGN & IMPLEMENTATION

Offering autonomy and personalisation in VR in order to allow a visualisation of emotions is a challenging endeavour. As a first step towards defining the design space of such a VR app, we conducted a pre-study in an analogue setting. From those results, we derived design requirements for the Mood Worlds applications. This section will conclude with outlining how we implemented those requirements into Mood Worlds.

3.1 Pre-Study: Autonomously Depicting Emotions in Analogue Mood Boards

Most elements that could be used to depict (and to induce) emotions, e.g. colour, weather, animals, environments, among others, have already been well researched individually, primarily in analogue settings (e.g. [54]) and less extensively for VR (e.g. [44]). However, the question remains (1) which elements people will choose if given a choice. Thus, we conducted an exploratory pre-study on expressing emotions in an analogue setting. Results of the pre-study contributed towards the main study by giving a first impression of which elements should be included in the VR setting. Further, we also utilised the pre-study to investigate (2) how the process of autonomous emotion depiction affects the user. What are their thoughts while creating the VE? Which decisions and compromises do they make, and where do they place the most importance?

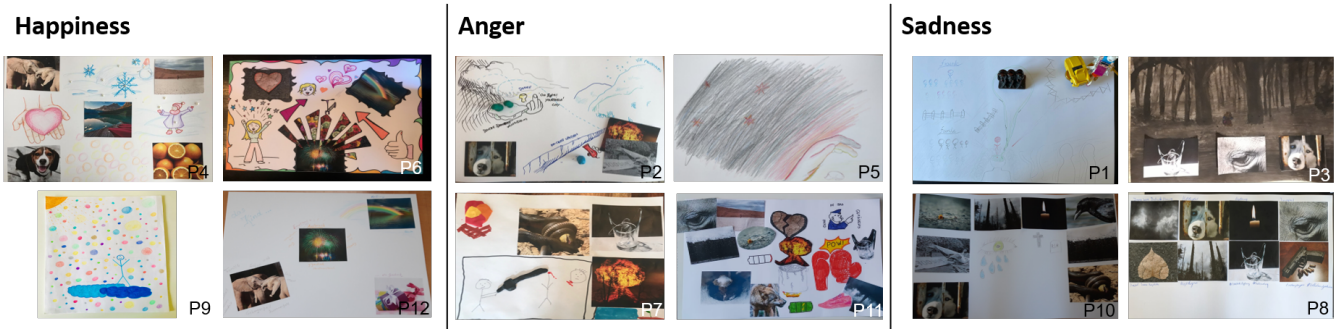
To that end, we conducted a single factorial between-subject study. The independent variable *visualisation of emotions* was analysed with the three factor levels *anger*, *sadness* and *happiness*. We decided on these three emotions as they are the most induced ones according to related research, as analysed by a review of D'Mello et al. [49]. On the other hand, we strived to include both emotions sharing a common valence (anger-sadness) and emotions from different sides of the valence spectrum (anger/sadness-happiness). This decision is based on the findings that due to a shared activation of affective states, emotions with negative valence might get incidentally induced as well (see sec. 2.3). Thus, we wanted to see if anger and sadness are clearly distinguishable from each other.

3.1.1 Material. Participants were asked to create so-called *mood boards*; analogue collages depicting a specific emotion in an unrestricted manner. Material to visualise emotions was packed in a box and given to the participants, inspired by the approach by Gaver et al. [26]. Contents of the box included:

- different crayons and felt pens, in pastel shades and bright colours, selected based on colour psychology [54, 55] and to allow free painting from the imagination [69]
- play-dough clay, based on research about haptics and using sandboxes to express oneself [69]
- a set of 30 postcards/photos (10 per emotion), based on the notion that the process of selecting images is likely to be an expression of self-expression, facilitates spontaneity and represents self-opening [34] and that the so called magazine picture collage technique is beneficial for people without artistic talent [14]. Those images can depict any context, e.g. activities, everyday objects, nature, or caregivers such as families [34]. Having the VR study in mind, we decided against adding pictures depicting humans for several reasons: therapists expressed concerns about feeling watched when avatars share a mood world [84], and research suggests that humanoid avatars could lead to several negative implications for HCI due to the uncanny valley effect such as distraction and distress [72]. Photo content was, thus, selected based on valence and arousal scores of the OASIS data base [41], depicting animals, objects and scenery. For the emotions of anger and happiness, ten photos were selected accordingly. However, the identified sadness pictures did not depict sadness, but rather disgust in the view of the authors. Hence, photos were derived from mood boards available on the Internet. From a pre-selection of 15 pictures chosen by the authors, ten were finally selected based on the assessment of five people not related to the study. Other items available to the participants for their constructions included:
- items we provided, e.g. scissors, glue, rubber, pen, cardboard as mood board, several pieces of paper, and sweets as a treat.
- personal items. Although not included in the box, participants were informed they could use any personal item (photos, 3D-objects, etc) that they wanted.

3.1.2 Participants. We conducted interviews with $N = 12$ (6 female, 5 male, 1 nonbinary) participants ($M = 30.8$ years, $min : 24$, $max : 57$) with differing nationalities (eight German, three Austrian and one Russian). Four were PhD-students, two were teachers, one was a student, one a secretary, one an IT worker, one a software consultant, one a mechanical engineer, and one a lawyer. While selecting the participants we ensured that they were not subject to any psychological illness such as depression and were in general in a good state of mind, to minimise the risk of having lasting effects of negative emotions.

3.1.3 Procedure. Due to the importance of autonomy in our research (see sec. 2.2), we emphasised towards the participants that they should be by themselves in the comfortable setting of their home for the duration of the study. Participants received the box containing the study material and an instruction sheet, which was fully disinfected due to the current COVID-19 pandemic, at their



Happiness	Anger	Sadness
Colours: Red, Pink, Orange, Blue, Violett, …	Colours: Red, Black, Yellow, Orange, Blue	Colours: Black, Grey, Brown
Words (20): Family, Protection, Support, Wild, Huge, Hope, Love, Unstoppable, …	Words (6): Pow, Desire, Go F*** Yourself, DoucheKingdom	Words (15): RIP, Emptiness, Helplessness, Disappointment, Powerlessness, …
Elements: (happiness) elephants, fireworks, heart, oranges, dog, rainbow, flowers, present (sadness) desert (unallocated) snow, bubbles, thumbs-up, stars, clouds	Elements: (anger) explosion, wolf, captured dog, knife, strangling snake, tornado (sadness) tear, broken glass, desert, crashed plane, flower on concrete (unallocated) boxing gloves, sword, prison, low battery, cannon	Elements: (sadness) clouds, broken glass, tear, crashed plane, flower on concrete, candle, raven, rain (anger) strangling snake, gun, captured dog (unallocated) forest

Figure 2: Mood boards created by the participants. To get insights and ideas of what would be needed for transferring mood boards to VR, we analysed the number and variety of colours, words and elements. Implemented photos by participants that were previously allocated to a specific emotion are listed accordingly. Newly emerging elements are called "unallocated".

homes. When they were on their own, they had time to inspected the contents of the box, then emotions were induced using an AEMT as MIP (see sec. 2.3). Participants were asked to write about a recent experience that made them, depending on the randomised condition, angry, sad or happy so that others might feel the same by reading their text. Directly after, they designed their analogue mood board. In the end, a semi-structured interview was conducted via Zoom and the box with the material and the mood board was picked up again.

3.1.4 Data Analysis. As we did not impose any time constraints, users took on average $M = 21$ min to complete the AEMT (min : 10 min, max : 34 min). The content of the AEMT was not analysed further, as the focus of the pre-study was the content of the mood boards. The creation of the analogue mood boards took the participants on average $M = 28$ min (min : 20 min, max : 49 min). Based on the method of exploratory principal component factor analysis by Gutbezahl [27], we analysed the objective number of colours and written words used in the mood boards. Further, we investigated if elements reoccurred in the mood boards. The semi-structured interviews lasted on average 18 min. Interviews were transcribed verbatim and analysed by two authors using a thematic analysis approach [7].

3.2 Design Requirements

Based on the analyses of the mood boards (see Figure 2) and interviews, we derived the themes *Flexibility of Input Methods*, *Single- and Multi-colour* and *Induced Mood States*. Each theme and its implications for the main study will be presented in the following.

3.2.1 Flexibility of Input Method. One theme was the flexibility of creation methods. Participants enjoyed the autonomy during the creation process:

> It was also a bit of fun to think about how I could present this and then simply enjoy this freedom, to simply be allowed to do it. (P1)

Nine participants used photos. They claimed that implementing photos either supported their creativity or were used to tell a story. Participants often used pictures that were originally attributed to represent another emotion as the one they depicted (see Figure 2). This was especially true for elements allocated to anger and sadness. In line with related work, this could indicate that the AEMT induced incidental affects with shared valence [49]. However, three participants exclusively wanted to use individual drawings and three participants additionally used clay or personal elements to express their mood. As a reason, they stated that by drawing or using personal items they could better express their individual experience. For example, participant 5 elaborated:

> I actually looked through the photos first and pulled out a few photos that I associate with anger. But then for my board it was important to me to really visualise specifically what my situation was like. And then

the photos didn't fit so well for me personally and I thought it was better if I just drew it. (P5 - anger)

As a result, Mood Worlds offers both drawing possibilities and pre-defined 3D objects to appeal to all participants and to guarantee a maximum of flexibility. Further, some elements will be animated, such as fireworks, to better show what P12 describes with the words "unstoppable, wild, outburst" on their mood board (see Figure 2).

3.2.2 Single- and Multicolour. In line with previous work, colour was a key aspect of mood boards [54, 55]. Sadness was depicted either in few, subdued shades or completely colourless. For this emotion, uniformity was a recurring theme, where participants wanted to have one predominant colour for the whole mood board. In contrast, the amount of colours as well as the saturation increased significantly for anger and happiness mood boards. In fact, the happier, the more colours were used (see Figure 2). The following quotes illustrate:

I wanted to convey the vibrancy of feelings, of emotions, and hence the vibrancy of colours. (P4 - happiness)

I have tried to accommodate ALL colours. (P6 - happiness)

Although these findings were anticipated due to similar findings in colour psychology [54, 55], we now know to place special importance on offering all shades of colours with differing saturation. Further, Mood Worlds will offer the possibility to completely adjust the surrounding light as well. Thus, we implement two panels, one for adjusting the colour of brushes and another for the lighting setting of the surrounding environment.

3.2.3 Induced Mood States. Participants had the task to visualise one emotion, happiness, anger or sadness. However, similar to findings of previous literature (see sec. 2.3), participants reported the elicitation of several other incidental emotions of the same valence:

There are so many ways to be happy, you can be calm-happy, you can be satisfied-happy, you can be excited-happy, lovingly-happy. There's just so many dimensions to that. (P4 - happiness)

Participants were immersed in their respective emotions for nearly 30 minutes. This process was perceived as fun and therapeutic. Additionally, this long-lasting visualisation process resulted in stronger emotions for some participants. In summary, we found that the AEMT was successful as MIP, and that the visualisation process upheld and prolonged feelings. However, results were unclear on one point: some participants reported that the process of visualising emotions itself was so fun that it increased the mood, while others expressed concerns about being too involved with negative emotions. This dichotomy is best illustrated by these quotes:

It actually gave me a kind of satisfaction in the end. The more I painted, the happier I was actually because I had manifested my thoughts in this way. (P1 - sadness)

I hope the other people who got anger and sadness don't get so carried away as I did. (...) I would probably have gotten involved in exactly the same way and then I don't think that I would have felt as good. (P6 - happiness)

Figure 3: Customised panels attached to the left controller in Mood Worlds. They are placed in an angle of 45° and can be navigated by using the joystick.

These findings have two implications for Mood Worlds: First, as AEMT was successful in our specific setting, we will also apply this MIP in the main study. Second, the inconclusiveness of participants regarding induced mood states makes us hesitant to use Mood Worlds to visualise negative emotions. Negative affective states might be mitigated, which would imply that VR is an effective positive technology. However, literature also suggests that VR can elicit similar, if not even higher valence and arousal than reality, both for positive [66] and negative emotions such as utilised in exposure therapy [47]. As participants' opinion differed strongly on this matter, we cannot foresee the specific effect VR might have on the intensity of emotions. Effectively, we will solely focus on eliciting and visualising positive affective states in this study.

3.3 Final Prototype

Based on the design considerations derived from the pre-study, we modified the VR painting app Open Brush, a fork of Tilt Brush by Google, which was made open source in late January 2021 [1]. We extended and customised its basic functionality which resulted in our self-care VR app called Mood Worlds. Our final prototype is described in the following and is shown in Figure 3.

- *Environments.* We utilised three of the original pre-defined Open Brush environments and added three others: *island* shows a small sandy island with palm trees, *meadow* is a grassy slightly hilly landscape, and *mountains* shows mountains and small trees from afar. Level of realism (*island* = high, *meadow* = middle, *mountains* = low) differed, as did the impact lighting and colour had on the surroundings (*mountain* = high lighting impact, *meadow* = middle lighting impact, *island* = low lighting impact).
- *Add Ons.* This self-designed panel allows users to (de-)activate three animated additional elements. Based on prior findings, environments could be thus enhanced by butterflies, fireworks and flowers.
- *Brushes.* We reduced the amount of original brushes (50+), of which some are animated and have sound effects, because we do not want participants to feel overwhelmed and dissuaded from the task of expressing their own emotions. Additionally, we added a self-created rainbow-coloured brush. We want to highlight that choices for omitting and adding brushes were based on the high frequency of comparable one's in

the pre-study's mood boards, such as rainbows, bubbles and stars. In total, we included 14 variations of brushes.
- *Objects.* Inspired by Open Brush's Media Library panel, FBX-models of 3D-objects, that are stored locally on the participants' computers, can be added to the scene via this panel. These pre-defined objects can be manipulated in size, moved around, and deleted by throwing them away into space. To receive more input about which objects to offer, we asked 18 (10 female, 8 male) people unrelated to the studies what they associate with happiness. Their replies, e.g. cars, butterflies or barbecue smell, were then implemented or substituted with close equivalents.
- *Colour & Lighting.* The colour panel and the lighting panel were not changed from their original counterparts. They allowed adjustments to the brush-colours and the colour, intensity and saturation of the light in the scene.
- *Tools.* We reduced the amount of tools available, to not overwhelm users. Mood Worlds only offers the erase, repaint, teleport and the undo/redo tools. Further, participants could resize themselves to get another perspective on the scene. The basic functionality to save sketches remained untouched.

With all these functionalities, Mood Worlds meets the specific design consideration of XR experiences for eliciting positive affective states and supporting a positive change in users, as established by Kitson et al. [38]. Our design is also inspired the PERMA model of well-being by Seligman [73], which employs play and positive psychology. As input modality, we use VR controllers. Interaction strategies that Mood Worlds addresses encompass nature, play and mood induction. Output modalities encompass object appearance as well as light and colour of VEs [38].

Our application especially targets autonomy as determinant of positive technologies. It comprises both hedonic and eudaimonic elements of positive technologies. Mood Worlds is intended to induce pleasant emotions in users by self-designing the VE while being in a positive affective state, and it offers an engaging and self-actualising experience that could foster self-reflection and well-being.

4 EVALUATION

We called our application "Mood Worlds", which would technically mean that we only identify and change longer lasting moods. However, we do include and measure high-intense short emotions (that may be evoked by specific objects and events in VR), as well as feelings (as participants will be asked to reflect upon their emotions), and moods, as the creation of a mood world itself takes time, and on top of that might evoke a positive mood that (hopefully) lasts for even longer than the creation process. Mood Worlds is evaluated via an exploratory remote VR study, following considerations by Ratcliffe et al. [64] that VR is a suitable medium to collect data remotely. Further, Mood Worlds targets VR users who want to engage with their emotional well-being and mental health at home. Thus, it seems logical to do a remote study in the same setting as it is intended for, namely while comfortably alone with one's feelings at home. As an additional benefit, specific COVID-19 related hygiene considerations do not have to be taken into account. This section first presents how we collected the data, introduces our participant sample and procedure. Then, we present our quantitative and qualitative results, focusing on the themes of *Empowerment*, *Energetic Representations*, *Emotional Experience* and *Use Cases*.

4.1 Participants

We used our extended social network and snowball sampling to recruit participants. In total, $N = 16$ (6 females, 10 males) participants took part in the Mood Worlds study ($M = 27$ years, $min : 18$, $max : 33$) without receiving remuneration. Two were Greek, the rest of German nationality. Our sample consisted of eight PhD students, seven other students and one project manager. People interested in participating but who did not own a VR system at home were able to borrow an Oculus Quest 2 for the duration of the experiment. Ten participants had tried out VR less than ten times in their lives, two use it about five times a year, one once a month and three several times a week. For an overview see Table 1.

4.2 Data Collection

Quantitative data was collected from two questionnaires (Panas and Oxford Happiness Questionnaire). Further, we gained qualitative insights through interviews.

4.2.1 Measures. We used the PANAS questionnaire [85] to measure affective states of users before and after experiencing Mood Worlds. PANAS consists of a list of 20 adjectives used to describe 10 positive emotions and 10 negative emotions. Participants indicated on a 5-point-Likert scale if they feel these emotions in that specific, short-lived moment. Further, the Oxford Happiness Questionnaire [31] was used in the same manner to indicate changes in happiness and well-being. Contrary to the PANAS, it rather indicates eudaimonic elements by measuring a lasting impact on happiness and well-being. Results from the pre-study suggested that some participants felt uneasy by having to record the time spent with creating the Mood Boards. Thus, we decided against measuring the time needed per sketch in the main study.

4.2.2 Interview Protocol. We conducted semi-structured interviews that lasted on average 16 min. All audio recordings were transcribed verbatim and imported into MAXQDA software. Two authors both coded two interviews using open coding. Next, a coding tree was established through iterative discussion. The remaining transcripts were coded individually by one author using the coding tree. A final discussion session between two authors was conducted to identify emerging themes using thematic analysis [7]. The Mood Worlds have all been re-experienced in VR by one author to further understand the meaning of the interviews and to help with identifying themes.

4.3 Procedure

A link providing remote access to the Mood Worlds study was distributed via various platforms such as Discord groups and university mailing lists. By clicking on the link, participants were forwarded to a Google form, which guided them through the whole study. It included detailed information about the study, contact information of the first author, a consent form, questionnaires, instructions for technical set-up, a short tutorial video (see supplementary material), and contact details to reach out to the experimenters who then set

Table 1: Overview of our participants. Participants that also have been taking part in the pre-study are marked with asterisks (*).

	Age	Gender	Nationality	Occupation	VR System	VR Usage
P1	29	male	German	Project Manager	Oculus Quest 2	< 10
P2	28	male	German	Student	Oculus Quest 1	weekly
P3	18	male	German	Student	Oculus Quest 2	< 10
P4*	28	male	German	PhD	Oculus Quest 2	5x per year
P5*	28	male	German	PhD	Oculus Quest 2	5x per year
P6	29	male	German	PhD	Oculus Quest 2	< 10
P7	26	female	Greek	PhD	Oculus Quest 2	< 10
P8	26	female	German	PhD	Oculus Quest 2	< 10
P9	25	male	German	Student	Oculus Quest 2	< 10
P10	28	female	German	PhD	Oculus Quest 2	< 10
P11*	29	female	German	PhD	Oculus Quest 2	weekly
P12	33	female	German	Student	Oculus Quest 2	< 10
P13	24	male	German	Student	Oculus Quest 2	< 10
P14	25	male	German	PhD	Oculus Quest 2	once a month
P15	26	male	German	Student	Valve Index	weekly
P16	23	female	Greek	Student	Oculus Quest 1	< 10

up date and time of the post-test interview with each participant individually.

Similar to Prpa et al. [62], for example, we chose an exploratory study design. First, after giving consent, participants filled out the PANAS questionnaire [85] and the Oxford Happiness Questionnaire [31] to establish a base line of emotions felt at that moment. Then, participants set up VR, watched a tutorial, and tried out Mood Worlds without any task given to get familiar with the functionality. Afterwards, a positive affective state was induced using an AEMT as MIP. To make it more approachable for participants, they were asked to recall a happy memory from their recent past, but we also welcomed incidental emotions sharing the same valence, such as excitement, satisfaction or awe [15] as we were striving to create general mood states instead of specific emotions, as recommended by D'Mello et al. [49]. To make use of the emotions as best as possible, and because the pre-study had shown that the AEMT successfully induced emotions for our setting, we did not measure induced emotions via questionnaires again at this point in time. Instead, participants directly started with creating the Mood Worlds. Afterwards, participants answered the PANAS and Oxford Happiness Questionnaire a second time, then contacted the experimenters who conducted a post-test interview as soon after the study as possible.

5 RESULTS

Based on the evaluation, we gathered quantitative results from the questionnaires as well as qualitative insights from the interviews. Our findings will be presented in this section.

5.1 Quantitative Results

Participants reported spending approximately between 5 and 30 minutes to construct their Mood World. Each participant created a single Mood World, resulting in 16 sketches to analyse. Six participants used the island environment, three night sky and meadow each, and two the mountain and the standard environment. Four participants used add-ons (all of them), and four adjusted the colours and lights of the VE. Eleven participants utilised pre-defined objects to enrich their Mood World (min = 0, max = 10 kinds of objects). In line with the pre-study, Mood Worlds were overall bright with a lot of colours. Though hard to count due to various shades used, Mood Worlds were made up by 3.44 (min = 1, max = 6) distinct colours on average, mostly yellow (used in nine Mood Worlds), pink/magenta, red, orange and white (six each), followed by blue and green (five each). This does not include various shades of one colour (e.g. light blue and dark blue would be counted as one colour), the seven colours of the rainbow brush, and colours of pre-defined objects. Thirteen participants used animated brushes. The list is led by blinking stars (eight), plasma (six), smoke (four) and bubbles (three). Seven types of non-animated brushes were used. Nine participants used both animated and non-animated brushes. The specifics can be found in the supplementary material.

The data of the PANAS and Oxford Happiness Questionnaires were analysed using the Wilcoxon signed-rank test for paired samples with Bonferonni correction as post-hoc test. It was measured on a .05 confidence level. The results are shown in Figure 4. One data set had to be removed due to incomplete data. Results of the PANAS questionnaire are presented in Figure 4. We found a statistical significant difference between positive emotions when measured before and after experiencing Mood Worlds, $p = .00$ (before: $M = 20.2$, $SD = 2.7$; after: $M = 33.7$, $SD = 3.9$). Participants felt significantly better after Mood Worlds. Felt negative emotions differed insignificantly between the time of measurements, $p = .42$ (before: $M = 15.6$, $SD = 5.8$; after: $M = 15.6$, $SD = 3.1$).

We further measured happiness with the Oxford Happiness Questionnaire, again before and after completing Mood Worlds (see Figure 4). There were no significant differences, $p = .31$ (before: $M = 131.8$, $SD = 14.3$; after: $M = 137.6$, $SD = 14$).

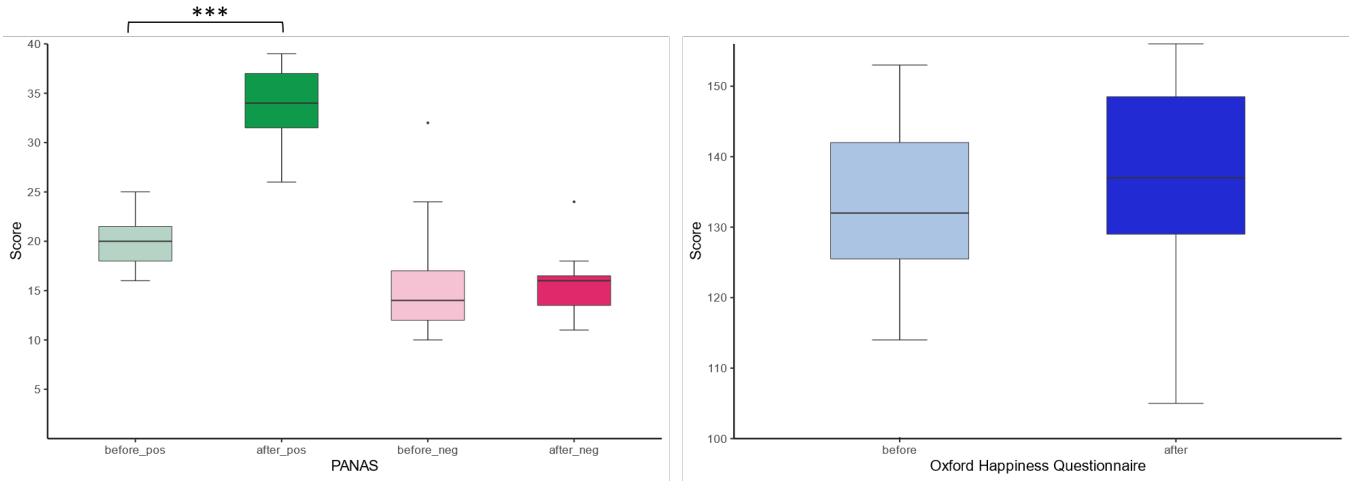


Figure 4: Results of the PANAS questionnaire, categorised in positive and negative items before and after experiencing Mood Worlds (left). Results of the Oxford Happiness Questionnaire, divided into scores before and after Mood Worlds (right). Statistically significant results are marked with asterisks (*).

5.2 Qualitative Results

Based on our qualitative inquiry, four themes were derived from the data: *Empowerment*, *Energetic Representations*, *Emotional Experience* and *Use Cases*. Our findings are described below and illustrated with excerpts from the interviews.

On a general note, some experienced technical issues, especially due to movement restrictions due to the cable being attached to the PC. Some also mentioned needing time to get adjusted to the complex functionality. They did not mention any other cognitive burden. However, all participants found the system still intuitive to use after the trial phase, and stated that with a more frequent usage they would feel even more confident. More importantly, all the participants enjoyed using the application, and stated that it was worth their time.

> It's an easy tool to use, I think. And it brings you happy feelings. (P16)

> It was very positive, both for my well-being and my creative possibilities. It was a positive experience. (P6)

5.2.1 Empowerment. The first theme derived from our data focused on what participants feel empowered to do in the Mood Worlds application. The theme consists of three codes: *Autonomy*, *Self-Confidence* and *Creativity Through Constraint*.

Participants especially enjoyed the flexibility and free choice that Mood Worlds offers. They liked that they had the *autonomy* to design the environment how they liked it, and found joy in trying things out quite freely. They further emphasised the benefits of being allowed an own choice, as participant 11, for example, emphasised:

> You were just so free, like with the example of the people and the armchairs. I could have drawn stick figures, but you could also choose armchairs or something else [to represent people]. Just to have the possibility to decide, that was great. (P11)

The range of choices how emotions can get visualised can be seen in some example sketches in Figure 5.

As a second code, we found that Mood Worlds enhances *creativity through constraint*. As an explanation, the feature of adding pre-defined environments and objects to the scene provided a framework. One participant elaborated:

> Somehow you had a certain framework within which you moved, it wasn't completely free, so that I could design everything myself, I had certain guidelines. (...) But I somehow had the feeling that by trying out and experimenting with the possibilities I had, I realised relatively quickly: This somehow fits my feeling. So, for example, fireworks, that's what I associated with it without knowing before. (P12)

Effectively, the restraints through pre-defined settings actually supported the creativity process of some. Participant 1 and 2 elaborated:

> At first I didn't know what I should draw at all, because conveying emotions in a drawing is in itself hard, I think. Since I can't draw anyway, it wasn't that easy at first. And then it was made easier by the fact that you could bring these pre-fabricated objects into it. (P1)

> There were a lot of objects that also fit to a variety of different scenarios. And that also stimulated the creativity to see: Which could fit in my case? What could I put in there that could reflect my scene? (P2)

Nevertheless, some participants reported being concerned, at first, about the aesthetics of their scene. Many mentioned not being an artist and not being able to draw well. Thus, they were worried, as the following quote shows:

> I was also a little worried at the beginning whether it would be aesthetically pleasing afterwards. (P7)

However, participants gained *self-confidence* in their creative skills with the help of Mood Worlds. All participants were satisfied with their results in the end. Participant 10 reflected:

> Actually, I think it [Mood Worlds] is a very good tool, because I thought, actually it makes everything look just nice. (P10)

5.2.2 Energetic Representations. The second theme describes what participants can design and how this affected them. The theme encompasses three codes, *Corporeal Emotions*, *Reminiscence of People* and *Energy & Motion*.

Some participants chose to recreate the situation of the AEMT quite graphically, either by reconstructing a scene (e.g. Figure 5A) or by extending pre-defined environments through objects, drawings and by adjusting the lighting (e.g. Figure 5B). These participants wanted to immerse themselves again in the past experience. As an example, participant 4 stated:

> I tried to recreate as closely as possible with the possibilities I had there (...) that you can continue [in thoughts] where you left off. (P4)

Other participants consciously chose a more abstract design method (e.g. Figure 5C). Some emphasised the importance of colours and others the desire to express what was in their head, as exemplified in the following quotes:

> You can't actually see feelings, but nevertheless I associate certain feelings with certain colours in my mind's eye. (P10)

> I didn't have the ambition to make it completely real, because it was already clear to me that showing emotions doesn't necessarily mean that I'm making something photo-realistic, but that it's more like I had it in my head. (P6)

Thus, Mood Worlds helped to give emotions a visible, nearly physical form, to design *corporeal emotions*. Some even expressed the desire to physically touch the emotions. These aspects were described as follows:

> I actually had no idea at first what the feeling looked like. Because you don't see a feeling, you feel it. And because I then had these different possibilities [in Mood Worlds], I was able to try things out a bit. (P12)

> I thought to myself, you could really stand in my work of art, in the middle of it, and feel it [participant does meandering movement] everywhere. (P10)

Besides the relation between emotions and haptics, participants also included other senses in their mood worlds. Some added objects they associated with something they enjoy or made them feel relaxed, reminding them of a special taste (e.g. blueberries) and smell (e.g. coffee beans, e.g. see Figure 5C):

> I chose [the blueberries] because I like eating blueberries. I put the coffee beans there because I like drinking coffee and I think that's such a positive pleasure, also the way it smells.

Besides giving emotions a physical form, happiness was also often associated with people and the resulting feeling of togetherness. Beloved ones were often at the forefront of thoughts when creating Mood Worlds. We call this code *Reminiscence of People*. For example, participant 10 wanted to remember a friendship and created a VE which would suit both of them. Participant 4 gave homage to a romantic relationship by having the partner in mind while creating a rosy and romantic environment, and participant 11 was inspired by the memory of a recent family visit and created the Mood World to regain the feeling of togetherness.

> I wanted to remember our friendship, so to speak, and take that with me. (P10)

> I remembered my partner (...), this being in love and this rosy and romantic and also very happy feeling. (P4)

> It felt like home that way. (P11)

Users reported that they either represented humanoid avatars via objects (e.g. see Figure 5A) or that they used objects as placeholders to support a *reminiscence of people*:

> An avatar would never look exactly like that person. And then, I think, I would perceive that as a foreign person. (P11)

> You don't need avatars. I mean, you can do like metaphors. (...) So with the teddy bear, it represented my younger cousin. (P16)

> In my memory I can fill in this armchair (...) and in my imagination I sort of complete it. (P11)

Apart from realistic and abstract depiction of emotions as well as using objects to represent and remember people, happiness and movement were also often described as positive *energy and motion*. Ways of such energetic representation varied. For example, participant 6 had a volleyball game in mind and drew the positive energy that he felt in this situation:

> So I didn't draw the players but only the energy that goes back and forth over the net, you could also see it as a ball exchange, the positive energy that goes back and forth and there is an exchange between the two sides (...). With the plasma tool I immediately had the feeling, oh yes, that is the positive energy.

Some participants used round (animated) shapes to represent the energy they felt during a real-life situation (e.g. see Figure 5C). One participant reflected on using animated winding lines drawn in their Mood World.

> Happiness for me is not an angular shape, but rather a round, soft shape. And that's why my painting has no corners. And snake movements have something calming for me, something positive, and I tend to associate it with happiness. (P10)

Others commented on the importance of including movement in the scene itself. It represented activity and life. Movement was represented via animated brushes, such as in the plasma brush or blinking stars, and could be found in animated objects, such as butterflies or fireworks.

> [Movement represents] more life in the scene and that's why I thought it was great that something [butterflies] was buzzing around and moving. (P6)

A. Gaming Evening with Friends (P2) B. Sunset Beach Scene (P4) C. Swirls, Colour, Smell and Taste (P12)

Figure 5: Sample sketches from participants.

> The feeling of joy, of being active, was reflected through the movement (...) it also moves a little bit after you have drawn it, it is also a little bit pulsating and somehow also shows activity. (P12)

Some participants also touched upon the unique way of VR to immerse them in a 360° digital world and which allowed them the opportunity to physically move through one's emotions. These quotes illustrate this aspect:

> My feeling is somehow with me and then everything is all around my body and then I have also designed around my body. (...) An emotion circle (...), because I realised: 'Oh, you can design around yourself easily.' That freed me. (P12)

> You are not much in 3D, in VR, and it's kind of cool as soon as you realise that you can do something in three dimensions. (...) I want to do things where I can run through like this. So I can kind of stick my head into a swirl or something [participant looks around themselves in all directions]. (P5)

5.2.3 Emotional Experience. Participants experienced a variety of emotional sensations in Mood Worlds. This theme is divided into four codes, *Childlike Excitement*, *Happy and Safe Place*, *Inspiration* and *Reflection*.

Users of Mood Worlds felt *childlike excitement*, wonder and awe. For instance, one participant compared it to a precious childhood memory:

> It's that feeling, the childlike feeling, that's something new and I felt a bit like I did when I first got my Nintendo, I also had that feeling: Oh yes, great, this is mine now, what can I do with it now? It's going to be fun. And that's exactly how I felt here at the beginning. So full of anticipation. (P3)

Childlike excitement further showed itself in impulsive behaviour and spontaneous drawings. The following quotes highlight these aspects:

> (...) somehow having an environment where I say: oh yes, this is a happy environment and then I didn't think so much about the actual situation. (P14)

> There was a bit of childlike joy for experimentation, where I just tried things out and there was no right or wrong. (...) As an adult, you are often very focused on the cognitive and perhaps go into something with a plan. And I didn't have that now because it was supposed to represent a feeling, where I didn't have any direct visual planning beforehand. (12)

On the other hand, some Mood Worlds showed a more calm-happy and mature setting, which focused on creating a *happy and safe space*. Participants expressed a desire to create a protecting, carefree and relaxing atmosphere. They imagined being there for being mindful of oneself or meditating. In such happy places, participants felt relaxed, had no negative thoughts.

> [I created this] protecting, relaxed, carefree atmosphere. (P11)

> [I felt] a kind of inner peace. (P2)

A key reason why Mood Worlds was perceived to have calming effects was due to facilitating immersion. Presence made it possible to take a break from reality and dive into another virtual world. Participant 12 reflected:

> You were really in there in this world. And, yes, I had the feeling that I had actually forgotten the outside while I was in there (...). I forgot all the stress that was actually today. (P12)

Besides feeling excitement and awe, as well as to just exist in a relaxing and happy place, participants also felt actively involved. Mood Worlds supported them in their *reflection* about their own feelings. One participant referred to the experience as being meditative and at the same time reflective. In particular, the duration of Mood Worlds was perceived as beneficial in this regard. For one reason, participants stated that by spending time visualising emotions, they experienced more head space for deep reflection about their emotional affect. Nevertheless, as no time limit was given, Mood Worlds felt like a short-lived experience. These aspects are well expressed by these quotes:

> I also think it's kind of nice when you recall such a happy experience and reflect on it and then meditate on it for half an hour and visualise it a bit. That is a beautiful exercise. It was fun. But at the same time it was also short-lived. (P10)

> It [Mood Worlds] hasn't strengthened the feeling, but perhaps it has somehow internalised it a little more, because I spent a certain amount of time with it. Normally I remember the moment briefly and ah yes, nice, and then, a few seconds later, I'm back to everyday life. (P11)

While reflection is directed back to what was in the past, Mood Worlds also evoked *inspiration*, which points towards the (near) future. Besides feeling inspired, it also gave the participants strength for the near future. Further, it was mentioned that one can regain perspective by receiving a positive reality check.

> I have found this very inspiring, like creating my own world this way. (P12)

> It also brings back a bit of perspective or that levels you a bit. (...) This gave me a bit of a reality check again. (P11)

Thus, emotional experiences were induced and lived by all our participants for the duration of Mood Worlds. However, some also reported a lasting effect of the induced happiness, as participant 8, for example, reflected :

> So I actually thought about whether that [Mood Worlds] somehow made me happier and I had the feeling that I sat there afterwards, grinning happily, and thought: Okay, yes, it seems to be like that. (P8)

5.2.4 Use Cases. In the last theme, *Use Cases*, participants imagined how they could use Mood Worlds in the future. Use cases encompass *Intrapersonal Experiences*, *Interpersonal Experiences* and *Negative Emotion Worlds*.

A big focus of many participants was to have an *intrapersonal experience* in which they designed just by and for themselves. Participant 11, for example, stressed:

> That's for me now, I paint it the way I think it and the way I can. And that's how it is. And it doesn't really have to be pretty or appealing. And that's enough for me, as long as I know what means what and so on. And then that is completely sufficient. (P11)

Some further imagined repeatedly using Mood Worlds. One could even say that they wanted to share their own feelings presented in a former Moody World again with themselves. By using Mood Worlds more often, participants imagined gathering a catalogue of different self-designed places which they could re-experience and repeatedly re-design if they wished. For instance, participant 8 and participant 12 elaborated:

> I think I would like to do that more often, go back I mean. (P8)

> It would also be exciting to have different places where you could travel to and where you could create again. (P12)

Apart from placing the importance on the self, there were also others who could fathom having *interpersonal experiences* by sharing the experience with others. By interacting with others, they imagined strengthening the relationship with friends, which further supports creativity through this multi-personal design process.

> (...) to have another one with you and you both draw together. (P7)

> I could also imagine that it would be really interesting to experience this creative process together with other people because it's just fun to be able to see each other a little bit and just interact, so to speak. (P5)

As a last use case, some participants envisioned that Mood Worlds could also help them when feeling down. As already elaborated on above, relaxing emotional states occurred frequently with the Mood World's application when a positive mood state is induced. Moreover, some participants mentioned that *negative mood worlds* could be also beneficial when in a negative affective state. Participant 10 clarified:

> If you had a really shitty day, then that [Mood Worlds] could help. (...) You feel emotions and let go of them and then you feel better. And in VR with such an anger painting, it also ends when you take off the VR-glasses, and I could imagine that being helpful. (P10)

6 DISCUSSION

In this work we endeavoured to understand how self-designing a VE affected emotional engagement and well-being. The quantitative results regarding the sketches indicate that the adjustments to Open Brush, resulting in the app Mood World (see sec. 3.3), were suitable and beneficial, and that our custom-built components were actively used by participants. Although using a more familiar system, such as a smartphone or PC, could have ameliorated the usability aspect, interview results (e.g. walking through one's sketch, feeling immersed, forgetting the reality for the moment) suggest that VR offers a unique way of engaging with one's emotions. In this section we first discuss how Mood Worlds supports positive emotions. We then outline design recommendations for VR as positive technology. We then reflect on limitations and opportunities for future work.

6.1 Mood Worlds as Positive Technology

Users of Mood Worlds reported feeling empowered, more creative and self-confident after using the application. Thus, they felt success and a sense of mastery. Through providing autonomous self-creation and flexible methods, Mood Worlds allowed them to represent emotions in a corporeal way, either graphically or abstract, and by that it enhanced, amongst other things, their feelings related to people through reminiscence. Participants further imagined different use cases for Mood Worlds. Their ideas ranged from intra- to interpersonal experiences. We hypothesise that interpersonal experiences such as showing another person one's own Mood World could further strengthen interpersonal relationships and foster empathy. Mood Worlds also generated presence and flow while creating them. Our interviews indicate that this in turn resulted in emotional engagement. More precisely, participants felt satisfaction and pride with what they created, awe when being excited "like a child", and happiness and joy when they dived into their personal happy place. Last but not least, Mood Worlds offered room for "taking a break from reality" and offered a space for deep reflection and inspiration for the future, thereby intensifying the purpose in life by re-adjusting the perspective. These aspects show that Mood Worlds successfully addresses each core pillar of the PERMA-theory by Seligman [73], namely accomplishment (success, mastery), relationships (work, familial, romantic, platonic), engagement (flow), positive emotions (happiness, joy, satisfaction, pride, awe) and meaning (purpose). Regarding the aspect of positive emotions, our qualitative results are supported by quantitative

findings. The PANAS questionnaire showed a significant increase in immediate positive emotions after completing Mood Worlds.

Besides successfully addressing the PERMA-theory [73], we also assume that Mood Worlds functions as positive technology. Mood Worlds comprises hedonic elements by mediating positive experiences, as shown by the qualitative results. The induction of positive and pleasant emotions [18] could further be shown by significant results in the PANAS. Additionally, interview results indicate a stimulation of reflection and awareness of personal abilities, and an increase in general happiness, which suggest the existence of eudaimonic elements, as well. However, the results of the Oxford Happiness Questionnaire were not significant. As the Oxford Happiness Questionnaire measures happiness on a more general basis, we assume that the one-time intervention Mood World offers might be too short to have a measurable effect on eudaimonic elements (e.g. life satisfaction). To determine potential long-term effects, a long-term study should be conducted.

Further, we found that negative emotions are not significantly altered by Mood Worlds, which was also not intended in our study. Redoing the study when inducing negative emotions would shed light on this aspect. Based on our findings, we hypothesise that Mood Worlds could help processing negative and increase positive emotions.

6.2 Considerations for Design

Empowerment was one key finding of the Mood Worlds evaluation, and both a completely unrestricted interaction and offering a pre-defined framework resulted in increased self-reported creativity and self-confidence. Because of the differences in personal preference regarding pre-set options or a completely unrestricted experience, we recommend that VR well-being applications **should provide autonomous design options combined with a pre-defined framework**. We hypothesise that this, in turn, could potentially address the three basic psychological needs, autonomy, competence and relatedness [17]. This will potentially enhance self-motivation and engagement with the virtual experience, which increases the user experience, broadens the target group and frequency of usage [58].

Furthermore, we observed that a moving VE (i.e. elements in motion) also moves the user (i.e. on an emotional level), which can lead to emotional engagement. This refers to the visual content as well as to the desire to move one's body. For the latter, offering unrestricted movement through a cable-free experience (which was technically not possible in our study) would empower people to sit or lie down to further increase their relaxation or to be more physically active and walk through their emotions when feeling excited. Additionally, our findings support the recommendation that VR well-being applications should be **designed so that corporeality of emotions can be expressed in multi-sensory experiences**. Regarding the visual content, visualising emotions in VR seems especially effective when activity and energy of a feeling can be made corporeal. Besides visibly giving emotions a physical form ("corporeal emotions"), applications should include haptic feedback so that users can physically feel the shape [13] and textures [86] of their emotions. Further, applications should increasingly place importance on providing animated options, such as swirling lines that keep on moving after being implemented, or more complex moving entities such as butterflies. We further suggest that VR well-being applications should be designed in such a way that the interaction with elements includes motion of the user. For example, being more or less active in one's body movement could increase or decrease the pace of moving objects or volume and length of music. The latter, through fostering the experience of autonomy, could lead to more creativity [12]. To illustrate, participant 16 envisioned the following scenario:

> You could select how long the melody would play, you do this [draws short line in air with own hand], then, okay, I want the melody to play that long, and if I do that [draws longer line in air] I want the melody that I chose to go for longer. (P16)

Additionally, based on participants implementing and drawing objects reminding them of smell and taste of a specific situation, we further recommend implementing olfactory [46] and gustatory [53] experiences in digital well-being apps. As a starting point for designers, we refer to works by Maggioni et al. [46] for olfactory and Obrist [53] for gustatory implementation possibilities for VR.

Well-being apps and technologies need to meet the high demands of users that feel differently inter- and intrapersonally, depending on the envisioned feeling and situation [59], and different use cases. Apps need to be as applicable for a short break from reality during work (where users just want to forget and relax) as for a longer intervention with the aim to explore and reflect. Effectively, we recommend that VR applications **should be adaptable to personal use cases**. For Mood Worlds, we imagine that an augmented reality application could be developed as a side application to be usable in a lunchbreak, for example, or that a created mood world could be downloaded onto a smartphone for a short glimpse of happiness in a stressful day.

6.3 Limitations & Future Work

As a limitation, from our quantitative data we cannot deduce if the significant difference in positive affect felt after completing Mood Worlds can be traced back to the successful AEMT or designing mood worlds. However, results of the interviews strongly indicate that the latter is the case. To study the long-term impact Mood Worlds might have on happiness and well-being, and, second, to measure the influence the feeling of excitement, seeing Mood World as a new toy, has on our findings future work should conduct controlled experiments and longitudinal field studies. Conducting a long-term study could further mitigate the impact that the duration in VR to create mood worlds and the number of sketches could possibly have on survey responses. Although our interviews did not indicate those, we cannot exclude such potential correlations.

While the focus was placed on creating VEs for oneself, multi-personal shared experiences would be interesting to investigate in the future. Research has started to investigate interpersonal distance in VR [67, 82]. It would be, first, interesting to see how friends in contrast to strangers in real-life interact with each other in a virtual sketching environment. Second, it would be fascinating to discover if and how hearing and seeing others affects the user, especially regarding the perceived importance of creating something aesthetically pleasing, felt autonomy and feelings such as

childlike excitement. Furthermore, future work could explore the experience of sharing personal mood worlds with friends or family and how this might affect familial social bonds. Additionally, we suggest inquiring the effects of implementing Mood Worlds for negative affective states as well. Our findings demonstrated that Mood Worlds intensifies feelings and that those can last beyond the scope of the application itself. This can be positive when the process of self-designing a VE induces a positive affective state independent of the mood you recreate. On the other hand, this could have undesired effects when Mood Worlds intensifies instead of mitigates negative moods. More research is needed to investigate the relationship between autonomous self-creation and negative affective states.

7 CONCLUSION

This paper explored how the autonomous creation of a VE affects emotional engagement and well-being. To that end, we presented Mood Worlds – a VR application allowing users to visualise their emotions by autonomously creating a VE. Quantitative and qualitative results of N=16 participants showed that Mood Worlds supports emotional engagement and positive affect. Users felt empowered and explored ways on how to give their emotions and energy a corporeal form. Further, Mood Worlds supported them in reflecting on previous positive experiences. We further found that Mood Worlds supports well-being, as defined by the PERMA-theory. With our work we showed that VR can be an effective tool to engage with and autonomously visualise emotions in a VE, thereby increasing positive affect. Our results emphasise the importance of autonomy as a determinant of positive technologies when visualising affective states. We hope that our research provides a starting point for defining the design space of VR well-being support apps.

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REFERENCES

[1] Tom Aidley and Jon Corralejo. 2021. The Future of Tilt Brush. https://opensource.googleblog.com/2021/01/the-future-of-tilt-brush.html

[2] Steven J Baker, Jenny Waycott, Jeni Warburton, and Frances Batchelor. 2019. The Highway of Lige: Social Virtual Reality as a Reminiscence Tool. *Innovation in Aging* 3, 1 (2019), 306–306. https://doi.org/10.1093/geroni/igz038.1121

[3] Rosa M. Baños, Víctor Liaño, Cristina Botella, Mariano Alcañiz, Belén Guerrero, and Beatriz Rey. 2006. Changing Induced Moods Via Virtual Reality. In *Persuasive Technology*, Wijnand A. IJsselsteijn, Yvonne A. W. de Kort, Cees Midden, Berry Eggen, and Elise van den Hoven (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 7–15.

[4] Rosa M. Baños, Ernestina Etchemendy, Diana Castilla, Azucena García-Palacios, Soledad Quero, and Cristina Botella. 2012. Positive mood induction procedures for virtual environments designed for elderly people. *Interacting with Computers* 24, 3 (04 2012), 131–138. https://doi.org/10.1016/j.intcom.2012.04.002

[5] Ann Blandford. 2019. HCI for health and wellbeing: challenges and opportunities. *International Journal of Human-computer Studies* 131 (2019), 41–51.

[6] Cristina Botella, Giuseppe Riva, Andrea Gaggioli, Brenda Wiederhold, Mariano Alcañiz Raya, and Rosa Baños. 2011. The Present and Future of Positive Technologies. *Cyberpsychology, Behavior, and Social Networking* 15 (12 2011), 78–84. https://doi.org/10.1089/cyber.2011.0140

[7] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2 (2006), 77–101. https://doi.org/10.1191/1478088706qp063oa

[8] Christian Brown and Rick Garner. 2017. *Serious Gaming, Virtual, and Immersive Environments in Art Therapy.* 192–205.

[9] Julie Butler and Margaret Kern. 2016. The PERMA-Profiler: A brief multidimensional measure of flourishing. 6 (2016), 1–48. https://doi.org/10.5502/ijw.v6i3.526

[10] Rafael A. Calvo and Dorian Peters. 2014. *Positive Computing: Technology for Wellbeing and Human Potential.* MIT Press. 304 pages. https://ieeexplore.ieee.org/servlet/opac?bknumber=6981846

[11] Rafael A. Calvo, Dorian Peters, Daniel Johnson, and Yvonne Rogers. 2014. Autonomy in Technology Design. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems* (Toronto, Ontario, Canada) *(CHI EA '14).* Association for Computing Machinery, New York, NY, USA, 37–40. https://doi.org/10.1145/2559206.2560468

[12] Alan Chamberlain. 2017. Are the Robots Coming? Designing with Autonomy & Control for Musical Creativity & Performance. In *Proceedings of the 12th International Audio Mostly Conference on Augmented and Participatory Sound and Music Experiences* (London, United Kingdom) *(AM '17).* Association for Computing Machinery, New York, NY, USA, Article 54, 6 pages. https://doi.org/10.1145/3123514.3123568

[13] Inrak Choi, Eyal Ofek, Hrvoje Benko, Mike Sinclair, and Christian Holz. 2018. *CLAW: A Multifunctional Handheld Haptic Controller for Grasping, Touching, and Triggering in Virtual Reality.* Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3173574.3174228

[14] Peter J. Comber. 2020. Collage. In *The Forces of Collaborative Creativity: A practical guide to creative teamwork in the healthcare business*, Peter J. Comber (Ed.). Practical Inspiration.

[15] Alan S. Cowen and Dacher Keltner. 2017. Self-report captures 27 distinct categories of emotion bridged by continuous gradients. *Proceedings of the National Academy of Sciences* 114, 38 (2017), E7900–E7909. https://doi.org/10.1073/pnas.1702247114

[16] Antonio R. Damasio. 2004. Emotions and feelings. In *Feelings and emotions: The Amsterdam symposium.* Cambridge University Press Cambridge, 49–57.

[17] Edward L. Deci and Richard M. Ryan. 2000. The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry* 11, 4 (2000), 227–268. https://doi.org/10.1207/S15327965PLI1104_01

[18] Pieter Desmet and Marc Hassenzahl. 2012. *Towards Happiness: Possibility-Driven Design.* Vol. 396. 3–27. https://doi.org/10.1007/978-3-642-25691-2_1

[19] Xianghua (Sharon) Ding, Shuhan Wei, Xinning Gui, Ning Gu, and Peng Zhang. 2021. Data Engagement Reconsidered: A Study of Automatic Stress Tracking Technology in Use. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21).* Association for Computing Machinery, New York, NY, USA, Article 535, 13 pages. https://doi.org/10.1145/3411764.3445763

[20] Aaron Duane and Cathal Gurrin. 2019. *User Interaction for Visual Lifelog Retrieval in a Virtual Environment.* Vol. MultiMedia Modeling: 25th International Conference, MMM 2019. 239–250. https://doi.org/10.1007/978-3-030-05710-7_20

[21] Panteleimon Ekkekakis. 2013. The measurement of affect, mood, and emotion: A guide for health-behavioral research. *The Measurement of Affect, Mood, and Emotion: A Guide for Health-Behavioral Research* (2013), 1–206. https://doi.org/10.1017/CBO9780511820724

[22] Paul Ekman. 1992. An argument for basic emotions. *Cognition and Emotion* 6, 3-4 (1992), 169–200. https://doi.org/10.1080/02699939208411068

[23] Anna Felnhofer, Oswald D. Kothgassner, Mareike Schmidt, Anna-Katharina Heinzle, Leon Beutl, Helmut Hlavacs, and Ilse Kryspin-Exner. 2015. Is virtual reality emotionally arousing? Investigating five emotion inducing virtual park scenarios. *International Journal of Human-Computer Studies* 82 (05 2015). https://doi.org/10.1016/j.ijhcs.2015.05.004

[24] Chao Feng, Lyn Bartram, and Bernhard E. Riecke. 2014. Evaluating Affective Features of 3D Motionscapes. In *Proceedings of the ACM Symposium on Applied Perception* (Vancouver, British Columbia, Canada) *(SAP '14).* Association for Computing Machinery, New York, NY, USA, 23–30. https://doi.org/10.1145/2628257.2628264

[25] Andrea Gaggioli, Giuseppe Riva, Dorian Peters, and Rafael A. Calvo. 2017. Positive Technology, Computing, and Design: Shaping a Future in Which Technology Promotes Psychological Well-Being. In *Emotions and Affect in Human Factors and Human-Computer Interaction*, Myounghoon Jeon (Ed.). Academic Press, San Diego, 477–502. https://doi.org/10.1016/B978-0-12-801851-4.00018-5

[26] William Gaver, Anthony Dunne, and Elena Pacenti. 1999. Design: Cultural Probes. *Interactions* 6 (01 1999), 21–29. https://doi.org/10.1145/291224.291235

[27] Jennifer Gutbezahl and James R. Averill. 1996. Individual Differences in Emotional Creativity as Manifested in Words and Pictures. *Creativity Research Journal* 9, 4 (1996), 327–337. https://doi.org/10.1207/s15326934crj0904_4

[28] Irit Hacmun, Dafna Regev, and Roy Salomon. 2018. The Principles of Art Therapy in Virtual Reality. *Frontiers in Psychology* 9 (10 2018). https://doi.org/10.3389/fpsyg.2018.02082

[29] Wendy Hadley, Christopher Houck, Larry Brown, Josh Spitalnick, Mirtha Ferrer, and David Barker. 2019. Moving Beyond Role-Play: Evaluating the Use of Virtual Reality to Teach Emotion Regulation for the Prevention of Adolescent Risk Behavior Within a Randomized Pilot Trial. *Journal of pediatric psychology* 44 (2019), 425–435. https://doi.org/10.1093/jpepsy/jsy092

[30] Marc Hassenzahl, Sarah Diefenbach, and Anja Göritz. 2010. Needs, affect, and interactive products–Facets of user experience. *Interacting with computers* 22, 5 (2010), 353–362. https://doi.org/10.1016/j.intcom.2010.04.002

[31] Peter Hills and Michael Argyle. 2002. The Oxford Happiness Questionnaire: a compact scale for the measurement of psychological well-being. *Personality and Individual Differences* 33, 7 (2002), 1073–1082. https://doi.org/10.1016/S0191-8869(01)00213-6

[32] Christophe Jallais and Anne-Laure Gilet. 2010. Inducing changes in arousal and valence: Comparison of two mood induction procedures. *Behavior research methods* 42, 1 (2010), 318–325. https://doi.org/10.3758/BRM.42.1.318

[33] Myounghoon Jeon. 2017. Emotions and Affect in Human Factors and Human–Computer Interaction: Taxonomy, Theories, Approaches, and Methods. *Emotions and Affect in Human Factors and Human-Computer Interaction*, 3–26. https://doi.org/10.1016/B978-0-12-801851-4.00001-X

[34] Girija Kaimal, Janell L. Mensinger, and Katrina Carroll-Haskins. 2020. Outcomes of collage art-based and narrative self-expression among home hospice caregivers. *International Journal of Art Therapy* 25, 2 (2020), 52–63. https://doi.org/10.1080/17454832.2020.1752756

[35] Da-jung Kim. 2016. Design for User Autonomy in the System-Driven Personalization of Social Media. In *Proceedings of the 19th ACM Conference on Computer Supported Cooperative Work and Social Computing Companion* (San Francisco, California, USA) *(CSCW '16 Companion)*. Association for Computing Machinery, New York, NY, USA, 155–158. https://doi.org/10.1145/2818052.2874343

[36] Young Kim, Min Hong, and Nak-Jun Sung. 2019. Correlation between selected gait variables and emotion using virtual reality. *Journal of Ambient Intelligence and Humanized Computing* (09 2019), 1–8. https://doi.org/10.1007/s12652-019-01456-2

[37] Alexandra Kitson, Elizabeth Buie, Ekaterina R. Stepanova, Alice Chirico, Bernhard E. Riecke, and Andrea Gaggioli. 2019. Transformative Experience Design: Designing with Interactive Technologies to Support Transformative Experiences. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI EA '19)*. Association for Computing Machinery, New York, NY, USA, 1–5. https://doi.org/10.1145/3290607.3311762

[38] Alexandra Kitson, Mirjana Prpa, and Bernhard E. Riecke. 2018. Immersive Interactive Technologies for Positive Change: A Scoping Review and Design Considerations. *Frontiers in Psychology* 9 (2018), 1354. https://doi.org/10.3389/fpsyg.2018.01354

[39] Alexandra Kitson, Ekaterina R. Stepanova, Ivan A. Aguilar, Natasha Wainwright, and Bernhard E. Riecke. 2020. Designing Mind(Set) and Setting for Profound Emotional Experiences in Virtual Reality. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 655–668. https://doi.org/10.1145/3357236.3395560

[40] Artie Konrad, Simon Tucker, John Crane, and Steve Whittaker. 2016. Technology and Reflection: Mood and Memory Mechanisms for Well-Being. *Psychology of Well-Being* 6, 1 (2016), 2211–1522. https://doi.org/10.1186/s13612-016-0045-3

[41] Benedek Kurdi, Shayn Lozano, and Mahzarin Banaji. 2016. Introducing the Open Affective Standardized Image Set (OASIS). *Behavior Research Methods* 49 (02 2016). https://doi.org/10.3758/s13428-016-0715-3

[42] Dalibor Kučera and Jiří Haviger. 2012. Using Mood Induction Procedures in Psychological Research. *Procedia - Social and Behavioral Sciences* 69 (12 2012), 31–40. https://doi.org/10.1016/j.sbspro.2012.11.380

[43] William Littlewood. 1996. "Autonomy": An anatomy and a framework. *System* 24, 4 (1996), 427–435. https://doi.org/10.1016/S0346-251X(96)00039-5

[44] Valentina Lorenzetti, Bruno Melo, Rodrigo Basílio, Chao Suo, Murat Yücel, Carlos J. Tierra-Criollo, and Jorge Moll. 2018. Emotion Regulation Using Virtual Environments and Real-Time fMRI Neurofeedback. *Frontiers in Neurology* 9 (2018), 390. https://doi.org/10.3389/fneur.2018.00390

[45] Kai Lukoff, Ulrik Lyngs, Stefania Gueorguieva, Erika S. Dillman, Alexis Hiniker, and Sean A. Munson. 2020. From Ancient Contemplative Practice to the App Store: Designing a Digital Container for Mindfulness. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 1551–1564. https://doi.org/10.1145/3357236.3395444

[46] Emanuela Maggioni, Robert Cobden, Dmitrijs Dmitrenko, Kasper Hornbæk, and Marianna Obrist. 2020. SMELL SPACE: Mapping out the Olfactory Design Space for Novel Interactions. *ACM Trans. Comput.-Hum. Interact.* 27, 5, Article 36 (Aug. 2020), 26 pages. https://doi.org/10.1145/3402449

[47] Ben Meuleman and David Rudrauf. 2018. Induction and profiling of strong multi-componential emotions in virtual reality. *IEEE Transactions on Affective Computing* PP (2018), 1–1. https://doi.org/10.1109/TAFFC.2018.2864730

[48] Katharina Meyerbröker and Paul Emmelkamp. 2011. *Virtual Reality Exposure Therapy for Anxiety Disorders: The State of the Art.* Vol. 337. 47–62. https://doi.org/10.1007/978-3-642-17824-5_4

[49] Caitlin Mills and Sidney D'Mello. 2014. On the Validity of the Autobiographical Emotional Memory Task for Emotion Induction. *PloS one* 9 (04 2014), e95837. https://doi.org/10.1371/journal.pone.0095837

[50] Jessica Isbely Montana, Marta Matamala-Gomez, Marta Maisto, Petar Aleksandrov Mavrodiev, Cesare Massimo Cavalera, Barbara Diana, Fabrizia Mantovani, and Olivia Realdon. 2020. The Benefits of emotion Regulation Interventions in Virtual Reality for the Improvement of Wellbeing in Adults and Older Adults: A Systematic Review. *Journal of Clinical Medicine* 9, 2 (2020). https://doi.org/10.3390/jcm9020500

[51] Marivi Navarro Haro, Hunter Hoffman, Azucena Garcia-Palacios, Mariana Sampaio, Wadee Alhalabi, Karyn Hall, and Marsha Linehan. 2016. The Use of Virtual Reality to Facilitate Mindfulness Skills Training in Dialectical Behavioral Therapy for Borderline Personality Disorder: A Case Study. *Frontiers in Psychology* 7 (2016). https://doi.org/10.3389/fpsyg.2016.01573

[52] Donal A. Norman. 2004. *Emotional Design: Why We Love (or Hate) Everyday Things.* Basic Books. 257 pages.

[53] Marianna Obrist. 2021. Multisensory Experiences: Where the Senses Meet Technology. In *Human-Computer Interaction – INTERACT 2021*, Carmelo Ardito, Rosa Lanzilotti, Alessio Malizia, Helen Petrie, Antonio Piccinno, Giuseppe Desolda, and Kori Inkpen (Eds.). Springer International Publishing, Cham, 9–13.

[54] Nilgün Olguntürk, Cengiz Yener, and Dilek Guvenc. 2002. Effects of hue, saturation, and brightness on preference. *Color Research & Application* 27 (04 2002), 199 – 207. https://doi.org/10.1002/col.10051

[55] Stephen Palmer and Karen Schloss. 2010. An ecological valence theory of color preferences. *Proceedings of the National Academy of Sciences of the United States of America* 107 (05 2010), 8877–82. https://doi.org/10.1073/pnas.0906172107

[56] Jaak Panksepp. 1998. *Affective neuroscience: The foundations of human and animal emotions.* Oxford University Press.

[57] Thomas Parsons, Giuseppe Riva, Sarah Parsons, Fabrizia Mantovani, Nigel Newbutt, Lin Lin, Eva Venturini, and Trevor Hall. 2017. Virtual Reality in Pediatric Psychology. *Pediatrics* 140 (11 2017), s86–s91. https://doi.org/10.1542/peds.2016-1758I

[58] Dorian Peters, Rafael A. Calvo, and Richard M. Ryan. 2018. Designing for Motivation, Engagement and Wellbeing in Digital Experience. *Frontiers in Psychology* 9 (2018), 797. https://doi.org/10.3389/fpsyg.2018.00797

[59] Andres Pinilla, Jaime Garcia, William Raffe, Jan-Niklas Voigt-Antons, Robert Spang, and Sebastian Möller. 2021. Affective Visualization in Virtual Reality: An Integrative Review. *Front. Virtual Real.* 2, 630731 (2021). https://doi.org/10.3389/frvir.2021.630731

[60] Lukasz Piwek, Frank Pollick, and Karin Petrini. 2015. Audiovisual integration of emotional signals from others' social interactions. *Frontiers in Psychology* 9 (05 2015). https://doi.org/10.3389/fpsyg.2015.00611

[61] Jonathan Posner, James A. Russell, and Bradley S. Peterson. 2005. The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology* 17, 3 (2005), 715–734. https://doi.org/10.1017/S0954579405050340

[62] Mirjana Prpa, Kıvanç Tatar, Jules Françoise, Bernhard Riecke, Thecla Schiphorst, and Philippe Pasquier. 2018. Attending to Breath: Exploring How the Cues in a Virtual Environment Guide the Attention to Breath and Shape the Quality of Experience to Support Mindfulness. In *Proceedings of the 2018 Designing Interactive Systems Conference* (Hong Kong, China) *(DIS '18)*. Association for Computing Machinery, New York, NY, USA, 71–84. https://doi.org/10.1145/3196709.3196765

[63] Denise Quesnel, Ekaterina Stepanova, Ivan Aguilar, Patrick Pennefather, and Bernhard Riecke. 2018. Creating AWE: Artistic and Scientific Practices in Research-Based Design for Exploring a Profound Immersive Installation. 1–207. https://doi.org/10.1109/GEM.2018.8516463

[64] Jack Ratcliffe, Francesco Soave, Nick Bryan-Kinns, Laurissa Tokarchuk, and Ildar Farkhatdinov. 2021. *Extended Reality (XR) Remote Research: A Survey of Drawbacks and Opportunities.* Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3411764.3445170

[65] Giuseppe Riva, Fabrizia Mantovani, Claret Capideville, Alessandra Preziosa, Francesca Morganti, Daniela Villani, Andrea Gaggioli, Cristina Botella, and Mariano Alcañiz Raya. 2007. Affective Interactions Using Virtual Reality: The Link between Presence and Emotions. *Cyberpsychology & behavior : the impact of the Internet, multimedia and virtual reality on behavior and society* 10 (2007), 45–56. https://doi.org/10.1089/cpb.2006.9993

[66] Radiah Rivu, Ruoyu Jiang, Ville Mäkelä, Mariam Hassib, and Florian Alt. 2021. Emotion Elicitation Techniques in Virtual Reality. In *Human-Computer Interaction – INTERACT 2021*, Ardito C. et al. (Ed.). Springer International Publishing, Cham, 93–114. https://doi.org/10.1007/978-3-030-85623-6_8

[67] Radiah Rivu, Yumeng Zhou, Robin Welsch, Ville Mäkelä, and Florian Alt. 2021. When Friends Become Strangers: Understanding the Influence of Avatar Gender on Interpersonal Distance in Virtual Reality, Ardito C. et al. (Ed.), Vol. 12936. Springer. https://doi.org/10.1007/978-3-030-85607-6_16

[68] Pedro Sanches, Axel Janson, Pavel Karpashevich, Camille Nadal, Chengcheng Qu, Claudia Daudén Roquet, Muhammad Umair, Charles Windlin, Gavin Doherty, Kristina Höök, and Corina Sas. 2019. *HCI and Affective Health: Taking Stock*

of a Decade of Studies and Charting Future Research Directions. Association for Computing Machinery, New York, NY, USA, 1–17. https://doi.org/10.1145/3290605.3300475

[69] David Sandmire, Sarah Gorham, Nancy Rankin, and David Grimm. 2012. The Influence of Art Making on Anxiety: A Pilot Study. *Art Therapy* 29 (06 2012). https://doi.org/10.1080/07421656.2012.683748

[70] Esther Schek, Fabrizia Mantovani, Olivia Realdon, João Dias, Ana Paiva, Sarit Schramm Yavin, and Ruth Pat-Horenczyk. 2017. *Positive Technologies for Promoting Emotion Regulation Abilities in Adolescents*. Vol. 181. 169–174. https://doi.org/10.1007/978-3-319-49655-9_23

[71] Peter Schulz, Dmitry Alexandrovsky, Felix Putze, Rainer Malaka, and Johannes Schöning. 2019. The Role of Physical Props in VR Climbing Environments. 1–13. https://doi.org/10.1145/3290605.3300413

[72] Valentin Schwind. 2018. Implications of the uncanny valley of avatars and virtual characters for human-computer interaction. https://doi.org/10.18419/opus-9936

[73] Martin Seligman. 2018. PERMA and the building blocks of well-being. *The Journal of Positive Psychology* 13, 4 (2018), 333–335. https://doi.org/10.1080/17439760.2018.1437466

[74] Kennon Sheldon, Andrew Elliot, Youngmee Kim, and Tim Kasser. 2001. What Is Satisfying About Satisfying Events? Testing 10 Candidate Psychological Needs. *Journal of personality and social psychology* 80 (03 2001), 325–39. https://doi.org/10.1037/0022-3514.80.2.325

[75] Florian Soyka, Markus Leyrer, Joe Smallwood, Chris Ferguson, Bernhard E. Riecke, and Betty J. Mohler. 2016. Enhancing Stress Management Techniques Using Virtual Reality. In *Proceedings of the ACM Symposium on Applied Perception* (Anaheim, California) *(SAP '16)*. Association for Computing Machinery, New York, NY, USA, 85–88. https://doi.org/10.1145/2931002.2931017

[76] Hilfa J. Spear and Pamela R. Kulbok. 2004. Autonomy and adolescence: a concept analysis. *Public health nursing* 21, 2 (2004), 144–152. https://doi.org/doi.org/10.1111/j.0737-1209.2004.021208.x

[77] Fritz Strack, Norbert Schwarz, and Elisabeth Gschneidinger. 1985. Happiness and Reminiscing. The Role of Time Perspective, Affect, and Mode of Thinking. *Journal of Personality and Social Psychology* 49 (12 1985), 1460–1469. https://doi.org/10.1037/0022-3514.49.6.1460

[78] Simeon Taylor. 2018. Designing Virtual Interactive Environments for Autobiographical Memory Recall. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts* (Melbourne, VIC, Australia) *(CHI PLAY '18 Extended Abstracts)*. Association for Computing Machinery, New York, NY, USA, 85–89. https://doi.org/10.1145/3270316.3270598

[79] Jennifer G. Tichon and Timothy Mavin. 2019. Using the Experience of Evoked Emotion in Virtual Reality to Manage Workplace Stress: Affective Control Theory (ACT). https://doi.org/10.4018/978-1-5225-8356-1.ch011

[80] Myrthe L. Tielman, Mark A. Neerincx, Rafael Bidarra, Ben Kybartas, and Willem Paul Brinkman. 2017. A Therapy System for Post-Traumatic Stress Disorder Using a Virtual Agent and Virtual Storytelling to Reconstruct Traumatic Memories. *Journal of Medical Systems* 41, 8 (2017). https://doi.org/10.1007/s10916-017-0771-y

[81] John Torous, Jän Myrick, Natali Rauseo-Ricupero, and Joseph Firth. 2020. Digital Mental Health and COVID-19: Using Technology Today to Accelerate the Curve on Access and Quality Tomorrow. *JMIR Mental Health* 7 (2020), 18848. https://doi.org/10.2196/18848

[82] Maurizio Vergari, Tanja Kojic, Francesco Vona, Franca Garzotto, Sebastian Moller, and Jan-Niklas Voigt-Antons. 2021. Influence of Interactivity and Social Environments on User Experience and Social Acceptability in Virtual Reality. 695–704. https://doi.org/10.1109/VR50410.2021.00096

[83] Jan-Niklas Voigt-Antons, Robert Spang, Tanja Kojić, Luis Meier, Maurizio Vergari, and Sebastian Möller. 2021. Don't Worry be Happy - Using virtual environments to induce emotional states measured by subjective scales and heart rate parameters.. In *2021 IEEE Virtual Reality and 3D User Interfaces (VR)*. 679–686. https://doi.org/10.1109/VR50410.2021.00094

[84] Nadine Wagener, Tu Dinh Duong, Johannes Schöning, Yvonne Rogers, and Jasmin Niess. 2021. The Role of Mobile and Virtual Reality Applications to Support Well-being: An Expert View and Systematic App Review. *Interact 2021: Proceedings of the International Conference on Human-Computer Interaction* 12935. https://doi.org/10.1007/978-3-030-85610-6_16

[85] David Watson, Lee Anna Clark, and Auke Tellegen. 1988. Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology* 54, 6 (1988), 1063–1070. https://doi.org/10.1037//0022-3514.54.6.1063

[86] Eric Whitmire, Hrvoje Benko, Christian Holz, Eyal Ofek, and Mike Sinclair. 2018. *Haptic Revolver: Touch, Shear, Texture, and Shape Rendering on a Reconfigurable Virtual Reality Controller*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3173574.3173660

[87] Brenda K. Wiederhold and Guiseppe Riva. 2012. Positive technology supports shift to preventive, integrative health. *Cyberpsychology, behavior and social networking* 15, 2 (2012), 67–68. https://doi.org/10.1089/cyber.2011.1533

[88] Kieran Woodward, Eiman Kanjo, David Brown, Thomas McGinnity, Becky Inkster, Athanasios Tsanas, and Donald Macintyre. 2020. Beyond Mobile Apps: a Survey of Technologies for Mental Well-being. *IEEE Transactions on Affective Computing* (2020), 21. https://doi.org/10.1109/TAFFC.2020.3015018

[89] World Health Organization. 2004. Promoting Mental Health. (2004). https://www.who.int/mental_health/evidence/en/promoting_mhh.pdf

[90] Tong Xue, Abdallah El Ali, Tianyi Zhang, Gangyi Ding, and Pablo Cesar. 2021. *RCEA-360VR: Real-Time, Continuous Emotion Annotation in 360° VR Videos for Collecting Precise Viewport-Dependent Ground Truth Labels*. Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3411764.3445487