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Touchy-feely: A designerly exploration of haptic representations of three mood states

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Human moods are diffuse, elusive, and often difficult to articulate, yet they hold immense potential for wellbeing-centric design because they play a significant role in shaping our everyday life experiences. A person's mood influences their experiences with a designed system, and in turn, their interactions with the design also influence their mood for better or worse. To enable designers to better comprehend and communicate moods in their design processes, this paper reports a project that explored the possibilities of creating haptic objects as a medium for communicating subtle qualities of specific moods. The project focused on three commonly experienced moods - cheerfulness, grumpiness, and gloominess. We first identified a set of haptic features that represent experiential qualities of these moods. These features were then synthesised into three mood-expressing haptic objects, which were evaluated using a blind test. The results indicated that haptic objects can be purposefully created, and that haptic qualities hold promise to complement verbal and visual forms of mood communication.

Keywords: mood; mood-focused design; designerly exploration; mood-expressing haptic objects

1 Introduction

Close your eyes and imagine running your fingers over the soft, plush fur of a teddy bear. Then, imagine feeling the texture of sandpaper against your fingertips, or the weight of a heavy cast iron in your hands. Each object elicits a unique set of sensations when touched. These haptic qualities can be used to represent different moods – from the cheerful bounce of a rubber ball from the gloomy chill of a cold metal surface. In this manuscript, we explore the fascinating topic of how the qualities of haptic objects can be used to express different human moods. Moods are low-intensity diffuse (pleasant or unpleasant) feeling states that can last for hours or even days (Morris, 1989). A user's present mood state is a significant factor that influences their experiences in human-design interactions (Desmet, Xue, & Fokkinga, 2019). Mood affects what products the user chooses to interact with (Djamasbi & Strong, 2008; Djamasbi, Strong, & Dishaw, 2010), how they prefer to interact with the product (Wensveen, Overbeeke, & Djajadiningrat, 2002), which interaction possibilities they tend to explore (Venkatesh & Speier, 1999), and what information they are likely to pay attention to and process during the interaction (Zhang & Jansen, 2009). Meanwhile, the user's mood also evolves throughout the interaction process (Holbrook & Gardner, 2000).

Mood-focused design offers many new opportunities for design to contribute to people's hedonic and eudemonic wellbeing (Desmet, 2015; Wadley, 2016). For example, products, services and systems can be intentionally created to facilitate an individual's attempts to regulate their mood by supporting effective mood-altering bodily and cognitive activities (Desmet & de Francisco Vela, 2020). A key challenge for designers who aspire to professionally work on mood-focused design projects is that it requires the capability to precisely capture and vividly communicate mood experiences.

Over the past 25 years, the importance of emotions in user experiences has been widely acknowledged and extensively studied in the design community (Desmet, 2002; Desmet, Fokkinga, Ozkaramanli, & Yoon, 2021; Overbeeke & Hekkert, 1999). However, the idea of considering moods as a distinct affective phenomenon from emotions is still relatively uncommon in design research and practice. Furthermore, in contrast with emotions, moods are in nature 'free-floating' (Russell, 2005, p. 28), 'vague, nebulous' (Sizer, 2000, p. 765), and 'unfocused' (Parkinson, Totterdell, Briner, & Reynolds, 1996, p. 8). This makes the appreciation and communication of granular moods and nuanced mood experiential qualities even more challenging than those of emotions through verbal definitions or descriptors.

One way to overcome the difficulties in communicating mood in the design process is to create diverse and rich multimodal representations for different mood states. In line with the dual-processing theories (Evans, 2008), research has shown that non-verbal stimuli, such as visual, audio, and tactile elements, can be more effective in conveying subjective experiences than words (Megehee & Woodside, 2010). Towards this end, design researchers have previously explored using carefully selected and curated images to communicate a variety of moods (Desmet & Xue, 2020; Desmet, Xue, & Fokkinga, 2020; Xue, Desmet, & Fokkinga, 2020). In this paper, as inspired by Isbister and colleague's (2007) earlier work, we report a designerly exploration of haptic representations of moods. Specifically, we developed three haptic objects intended to communicate three commonly experienced mood states (i.e., cheerfulness, grumpiness, gloominess).

This study has two main contributions. First, by exploring the new channel of tactile mood communication, it enriches the repertoire of multimodal mood representations for communicating and measuring nuanced mood qualities during the design process. Second, the study procedure, resulting artefacts, and research findings also showcase a promising approach to affect-based haptic interaction design, which has been gaining popularity in recent years (MacLean, 2022).

In the sections that follow, we first clarify the distinction between emotions and moods, and highlight the distinct roles that these two constructs play in experience design. From there, we discuss the specific challenges that designers face when attempting to communicate moods. Then, we present the procedure and results of the four-step exploratory study in detail. Finally, we offer reflections on the study and draw conclusions about the potential of haptic objects as a tool for mood communication in design.

2 Emotion vs. mood from a design perspective

The differentiation between emotion and mood is sometimes unclear in research, as both concepts frequently fall under the general umbrella concept of 'affect'. Affect refers to a variety of emotionally charged states that have positive-negative or good-bad distinctions, including feelings, sensations, emotions, and moods (e.g., Gross & Thompson, 2007; Parkinson & Totterdell, 1999; Scherer, 1984). However, mood and emotion can be distinguished from one another conceptually, and once these differences are made explicit, it is clear that they serve distinct roles in experience design (Xue et al., 2020).

Emotions are intense, short-lived, and focused affective states directed at specific objects (Beedie, Terry, & Lane, 2005). In terms of design, the objects of user emotions could be any events, service touchpoints, product functions, design features, meaning associations and so on. User emotions that arise during a human-design interaction process typically result from the perceived alignment or misalignment of the design with the user's motives, such as context-sensitive goals, needs, and values (Desmet, 2008). For instance, a person attempting to finish a project before the deadline might experience frustration and anger (negative emotions) about an excessively intricate software interface design (the object of the emotions), as it obstructs the user's goal of accomplishing the tasks punctually (a misalignment with the user's motive).

In contrast, moods are subtle, long-lasting (e.g., hours or days), pervasive, and unfocused affective states (Morris, 1989; Parkinson et al., 1996). A person's evolving mood manifests as a continuous 'background affective experience' that is objectless (i.e., not directed at a single specific object), multiple-object directed (Siemer, 2005) or global-directed at one's whole world or life (Frijda, 2009). In addition, moods have an ambiguous onset, and gradually shift from one state to another in the background of one's awareness (Beedie et al., 2005). In this regard, although it is often not consciously registered, we are always in a mood (Davidson, 1994; Dreyfus, 1991), and our current mood influences our feelings, thoughts, and engagement with events occurring around us (Siemer, 2005, 2009). Considering these characteristics of mood, it is important to recognise that an individual who enters an interaction with a designed system always does this with a pre-interaction mood state that provides a pervasive affective base tone that colours their perceptions, thoughts, and actions throughout the interaction. When the interaction ends, the user departs with a post-interaction mood state that may be marginally or substantially altered from the initial mood state, depending on the mood-modifying effects of the interaction. Furthermore, this post-interaction mood state also subsequently impacts the individual's following activities positively or negatively (Xue et al., 2020).

3 The challenge of mood communication in the design process

Having the potential of mood-focused design being appreciated, designers continue to encounter challenges in effectively communicating moods throughout the design process, between design team members, and with users and other stakeholders. For example, when a design research participant is asked to describe their current mood, they typically respond in general terms, saying that they feel either good or bad, sometimes in combination with their level of activation. When asked to provide a more detailed and nuanced description of the mood, people tend to struggle to find the right words. This could be attributed to three reasons. The first one is that such inner experience-focused communication requires one to introspect (Xue & Desmet, 2019), but doing it well, especially for research purposes, is not as simple as 'just-take-a-look' (Varela & Shear, 1999, p. 2), and without dedicated training, 'most people are poor introspectors of their own ongoing conscious experience' (Schwitzgebel, 2008, p. 247). Second, even for a capable introspector, using verbal language to render and disclose those felt inner qualities can be challenging, especially in a cross-cultural context. Third, what makes it even more difficult is the fuzzy nature of the mood experience. Consequently, precise and vivid communication of moods during mood-focussed design processes remains a challenge that demands further attention and development.

While verbal language has long been the primary mode of communication in professional collaborations, it is sub-optimal for accurately describing our inner experiences, especially for free-floating and vague experiences like moods. When designing for experiences, designers overcome this limitation by adopting a multimodal approach, which can include visual (e.g., McDonagh & Storer, 2004), auditory (Tajadura-Jiménez & Västfjäll, 2008), tactile (Isbister et al., 2007), and kinesthetic (Cancienne & Bagley, 2008) channels to complement and strengthen communication with words. This embrace of multimodality connects with the increasing attention in design and HCI research to materiality as a vital aspect of design (Doordan, 2003). Scholars have started to explore the situated experience of materials, examining the impact of materials on perception, experience, and appreciation (Giaccardi & Karana, 2015; Karana, Barati, Rognoli, & Zeeuw Van Der Laan, 2015; Karana, Pedgley, & Rognoli, 2015). Regarding mood experiences, in particular, design researchers have systematically explored the possibilities of combining verbal descriptions and visual representations (Desmet & Xue, 2020; Desmet et al., 2020; Xue et al., 2020), as well as combining verbal descriptions with bodily movements (Desmet et al., 2019) to overcome the difficulties in interpersonal comprehension and empathy building in mood-focused design. However, the modality of touch, which could be promising, has not yet been explored for this purpose. Therefore, we conducted a designerly exploration of haptic representations of mood states.

4 Exploring haptic representations of three mood states

The aim of the study was to explore whether distinct mood states can be communicated through the sense of touch and how designers can identify and creatively synthesise haptic stimuli to represent these distinct mood states. The study consisted of four steps. Step 1: Selecting distinct mood states. Step 2: Identifying haptic features that represent experiential qualities of the selected mood states. Step 3: Designing mood-expressing objects based on insights acquired from Step 2. Step 4: Testing the developed mood-expressing objects.

4.1 Step 1: Selecting mood states

Human moods are more diverse than is often recognised, with a repertoire of at least 20 distinct types (Desmet et al., 2019; Xue et al., 2020). Given the exploratory nature of this study, it is not possible to study all human moods. To work with a manageable set, we selected three mood states from the typology of 20 moods that was developed by Desmet and colleagues (2020). Our selection was based on the following three criteria: familiarity, diversity, and nuance.

The first criterion was that each selected mood state must be commonly experienced in everyday life and labelled with simple and familiar terms. This criterion ensured that our participants can easily relate to the mood, drawing on personal experiences and recalling relevant memories, without having to expend excessive effort in understanding the mood concept. The second criterion was that the selected moods should include both positive and negative states to account for valence differences. The third criterion was that at least two selected mood states should be similar in terms of either valence or activation. This criterion was used to ensure that the research through design process (i.e., Step 3) would be challenging. Given these criteria, we selected cheerfulness (pleasant-activated), grumpiness (unpleasant-activated), and gloominess (unpleasant-deactivated) as the target mood states for the study. Detailed descriptions of these moods states are available from the "Twenty Moods" booklet (Desmet et al., 2020).

4.2 Step 2: Identifying haptic features

In Step 2, we conducted an exploratory interview study that was guided by two research questions: 1) Is it possible to identify haptic features or stimuli that represent the key qualities of mood experiences? 2) If so, what are these haptic features for the three selected moods? Acquiring such an understanding of relationships between haptic features and experiential qualities of moods was intended to inform Step 3 (i.e., the design of mood-expressing haptic objects).

4.2.1 Participants

16 master students (male=6, female=10) from the Faculty of Industrial Design Engineering, Delft University of Technology were recruited to individually participate in a one-hour haptic objects-facilitated exploratory interview. The participants represented 10 different cultural backgrounds: 7 were Chinese, 1 Dutch, 1 Indian, 1 Italian, 1 Japanese, 1 Korean, 1 Singaporean, 1 South African, 1 Spanish, and 1 Turkish. Their ages ranged from 23 to 28. Each participant was given an identification code (e.g., P1, P2) for anonymous data analysis.

4.2.2 Materials

We collected over 100 objects from second-hand stores, supermarkets, and nature, following the categories of haptic object and surface properties proposed by Lederman and Klatzky (2009). These objects represent a rich variety of haptic properties, including texture, compliance (i.e., deformability under force), temperature, weight, volume, global shape, and shape details. These objects were presented on a large table (Figure 1) during the interviews, enabling participants to explore their haptic features conveniently and freely.

Figure 1: The environment in which the interviews were conducted. A table of over 100 objects with highly diverse haptic features were collected as stimuli for the interviews.

4.2.3 Procedure

After being introduced to the research purpose, the participant focused on the three moods one by one for exploration. To sensitise the participant, we employed an 'imagery and recall' technique, a widely-used method for inducing affect, to bring the target mood to the consciousness of the participant (Maryam Fakhrhosseini & Jeon, 2017; Quigley, Lindquist, & Barrett, 2014). Specifically, for each mood, the participant first read a verbal and visual description of the mood, which was taken from the mood typology booklet (Desmet et al., 2020). Then, they were asked to recall, mentally relive, and share an autobiographical account of being in that particular mood, specifying when, where and with whom this mood occurred. With the mood in mind, they were guided to the table to freely touch and interact with the objects on the table. Later, the haptic 'exploratory procedures' developed by Lederman and Klatzky (1987, 2009) were used for a more structured exploration of the haptic features. Participants could see the objects for the efficiency of exploration process. But they were asked to close their eyes after having picked up an object, and it was emphasised that the exploration and selection should be based on the sense of touch. During their explorations, participants were encouraged to think out loud. Once they had explored the objects, they were asked to select and rank three that best communicate the given mood trough their haptic features, and three that least communicated the mood. Finally, they were asked to explain the reasons for their selections and ranking, and to specify the perceived relationships between the objects' haptic features and the mood qualities.

4.2.4 Data analysis

The interview recordings were transcribed and analysed in two rounds. The first round focused on sorting the properties by frequency, and a Vivo Coding (Manning, 2017) was combined because the description from participants provided nuanced information. In the second round, focused coding was done to identify the most important properties and their relations with the qualities of mood. The analysis was combined with a visual mapping of the selected objects (Figure 2-4). Ultimately, we summarised the most important haptic properties that express cheerful, grumpy and gloomy moods.

4.2.5 Results

Cheerful: A cheerful object is responsive and has relatively a high degree of freedom. The most crucial properties that define a cheerful are open, bouncy, and light. By contrast, being cold, hard, and spiky are least cheerful. Following are some inspirational quotes from the interview transcripts.

- P6 on 'scraps of paper': *The openness of the box, in contrast to being inside a box that shows the way you should be in, makes you feel you can do something else out of the box.*
- P6 on 'play spring': *It's fun to play with it. It's a lot of things happening. Wee!*
- P7 on 'play spring': *The random movements are playful. But if they're tangled, it would be less cheerful*.
- P11 on 'flour in a box': *When you grasp the flour, it slips through your finger in an elegant way.*
- P13 on 'bubble film': *They are same bubbles in a row, changing their positions. They are the same but also different.*
- P13 on 'radial ball of yarn': *It's light, floating* (pat it in the air).
- P7 on 'plastic brick': It's too plain, no texture at all. Very low energy.
- P11 on 'wire': *It's cold, still, messy, and emotionless.*

- P13 on ‘steel comb’: *It’s dangerous, too hard, and spiky to touch.*

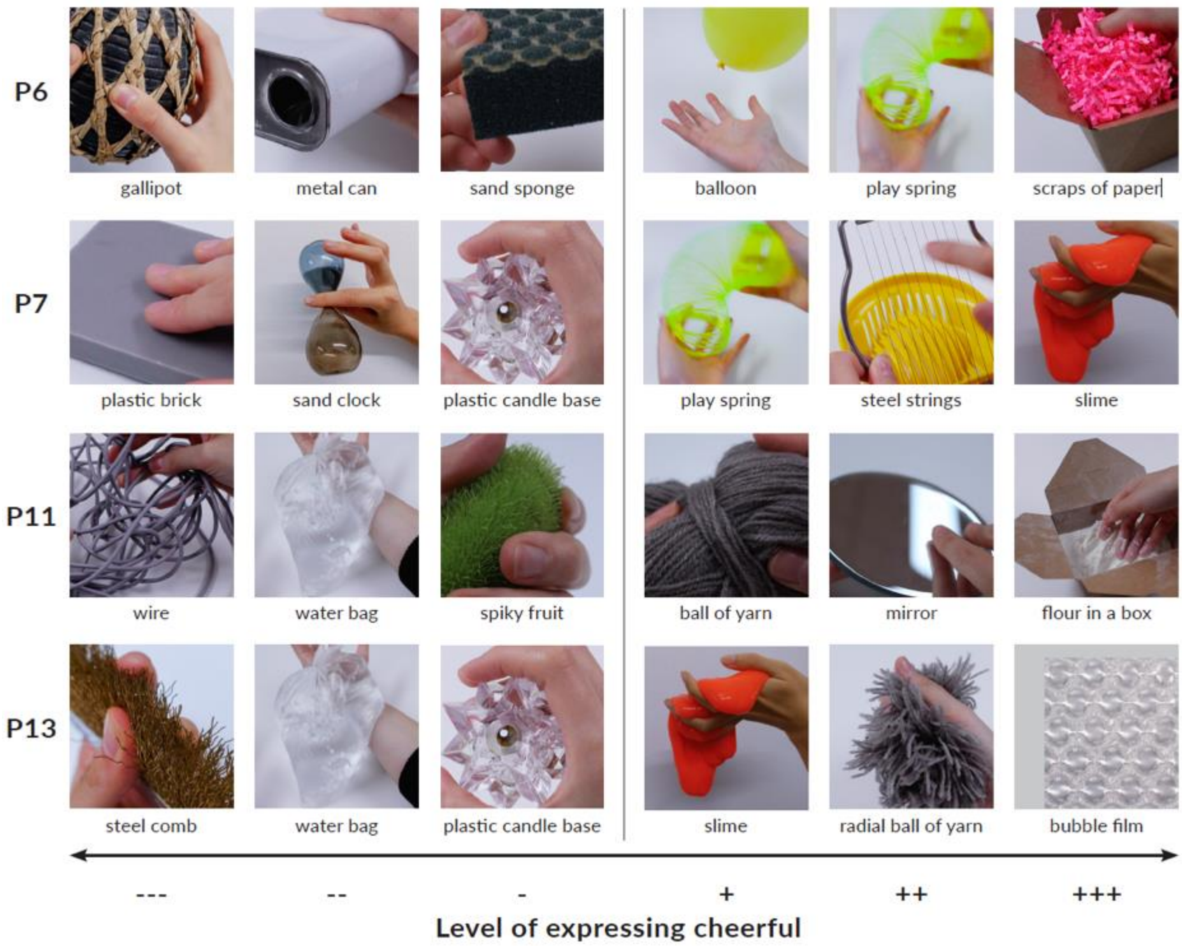

Figure 2: Sample objects that best and least express cheerfulness identified and ranked by participants P6, P7, P11, P13.

Grumpy: A grumpy object huddles up while having an intimidating surface. It is passive to interaction initiated by other agents. It may comply with gentle treatment but hurts back when more pressure is applied. The most critical properties that define a grumpy object are *soft yet spiky, counteractive, rough,* and *compact yet irregular shape*. Being *light, warm, soft, smooth,* and *harmoniously curvy* are properties that are typically associated with the opposite of grumpiness.

- P5 on ‘rubber cube’: *I’m trying to twist it really hard, using all of my force, but still, it goes back. It looks like a hard one. When you touch it, it’s soft, but it’s hard.*
- P5 on ‘steel comb’: *The steel comb hurts too much. That one feels like I want to kill someone... but I just want to beat someone…But at the same time, I'm not trying to hurt anyone. It's just my mood taking over me... it's not something I do consciously*.
- P7 on ‘ABS fibre material’: *Like me going up and down, this texture is a mess. I don't know what's happening. Sometimes I'm fine, sometimes I just snap.*
- P5 on ‘tinfoil’: *Every time I feel grumpy, I’m triggered to become angry any time, like grabbing this tinfoil.*
- P16 on ‘plastic chippings’: *It’s sticky… I need an effort to get rid of it.*
- P5 on ‘slime’: It’s playful. I touch it, it changes.

- P7 on ‘feathers’: *It’s super light, relaxed, cosy, and everything is soft.*
- P 16 on ‘stuffed toy’: *It’s furry and soft.*

Figure 3: Sample objects that best and least express grumpiness identified and ranked by four participants P6, P7, P11, P13.

Gloomy: A gloomy object is isolated, hollow, and messy, and traps anything that comes to interact with it. Its defining haptic features include being *cold, heavy, closed, hard yet fragile* and *drowning*. The opposite of gloominess appears to have haptic features of being *soft, warm, gentle, smooth,* and *bouncy.*

- P5 on ‘ice in glass sphere’: *It’s nice outside, but cold inside. It's cold. It’s heavy and intense. I want to get rid of it. Gloomy is something cold for sure.*
- P7 on ‘wood figure in vase’: *It's really isolated. It’s the mental stated that you’re being trapped.*
- P10 on ‘rubber cube’: *It’s heavy and solid, making me unable to breathe.*
- P10 on ‘wire’: *It was so messy, and I felt hard to breathe. A lot of things are tangled together.*
- P16 on ‘dry leaves’: I chose fragile objects because when you’re gloomy, it’s very easy that something happens during the day makes you sadder. This is interesting that it is fragile even though it's metal.
- P5 on ‘glass grapes’: *It feels like a present. It’s glass but it really has the warmth, because of the shape, surface, and the right weight.*

- P16 on 'face brush': *It's very soft and fluffy. It's a very pleasant sensation. It's warm like having contact with another person.*

Figure 4: Sample objects that best and least express gloominess identified and ranked by participants P5, P7, P10, P16.

4.3 Step 3: Designing three mood-expressing haptic objects

Using the insights acquired in Step 2, we engaged in a research-through-design process to explore the possibility of creating three objects that can communicate the moods through their haptic features.

4.3.1 Concept design stage

Five master design students, including the second author, teamed up for three conceptual design sessions, each one focusing on one of the three mood states. The sessions included three rounds of divergent-convergent ideation. The session started with an introduction to the objective of Step 3 and to the research findings of Step 2, in verbal and visual formats. Next, the designers individually generated as many as possible ideas by freely combining the identified haptic features that best represent the mood. In their creative process, the were also informed by the haptic features that represent the opposite. Each round of ideation ended with a design concept sharing and collaborative reflection step. Eventually, with the collective creative efforts of all the designers, each design session resulted in one final concept for the mood under exploration. This process was repeated for all three moods (See Figure 5 for the selected results of the concept design stage).

Figure 5: Concept design stage and selected results

4.3.2 Prototyping stage

Taking the design concepts as starting point, we further engaged in iterative low-fi and high-fi prototyping processes, through restructuring everyday objects, computer modelling, and 3D printing as techniques (Figure 6). Silicon and plastic were chosen to be the main materials for the final designs because they allowed us to make fine-tuned adjustments to a greater variety of properties, such as the surface texture, shape, elasticity, weight, and density.

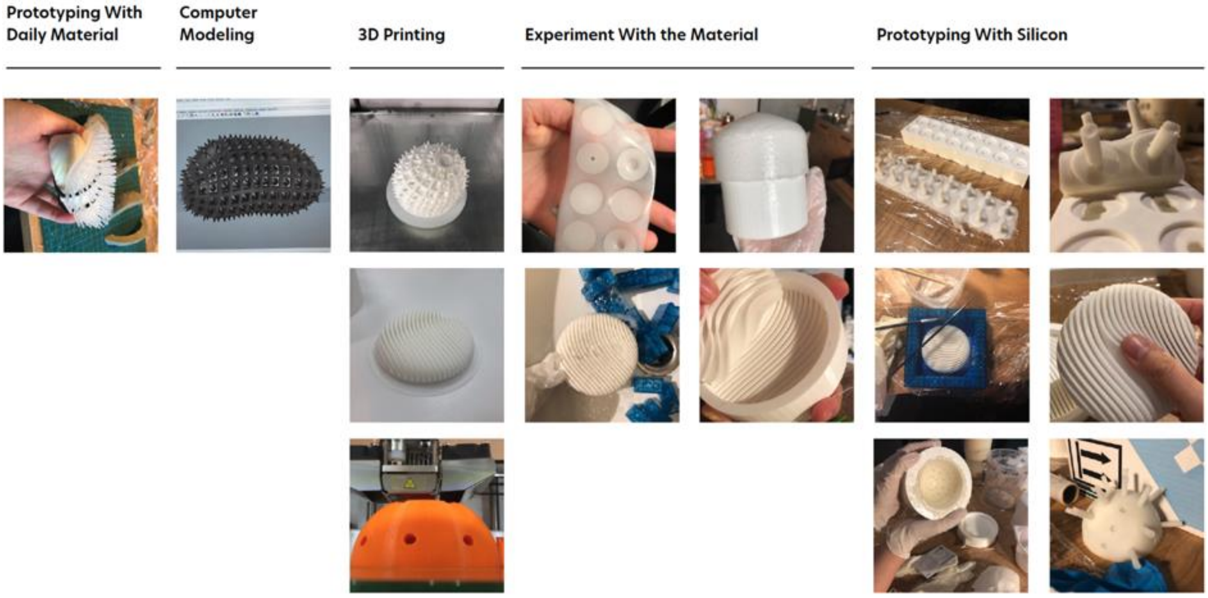

Figure 6: An illustration of the prototyping processes

4.3.3 Presentation of the mood-expressing haptic objects

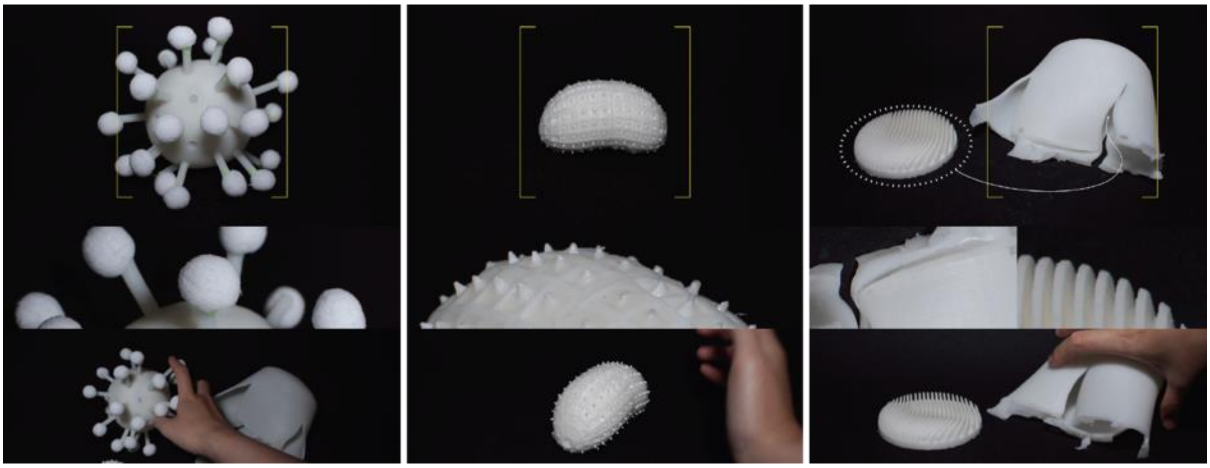

Figure 7. The final design outcomes of three haptic objects that represent and convey cheerfulness (left), grumpiness (middle) and gloominess (right).

The cheerful object (Figure 7, left) bursts with energy from its core. It is light and bouncy, yet its energy is still controllable. The overall shape of the object is round, and small, bouncy cotton balls extend in various directions. The object hangs in middle of the air, allowing it for a relatively high freedom of movement, and it evokes a sense of fun and energy when stroked.

The grumpy object (Figure 7, middle) has been designed to express a combination of *passivity* and *aggression*. When people gently hold it, the object remains harmless, but when pressed, it reacts with some discomfort. The overall shape resembles a cashew nut, tending to rebound. It attracts people to grasp and hold it. The size ensures most of the surface contacts the palm. The surface consists of many 3D-printed hard spikes covered with a layer of soft silicon. Each spike 'grows' from the body and hides its bottom part in a grid. The grids store silicon, which is softer than plastic and slightly sticky, so that the surface acquires more compliance. When people touch the object, they first feel the softer surface without being hurt. However, when they turn it or apply more gripping force, they experience an increasingly painful sensation caused by the hard tips of the spikes, as well as the unpleasant stickiness.

The gloomy object (Figure 7, right) has a hollow structure that cannot support itself. It is tangled and rough, consisting of two parts: a soft, loose, messy, irregular hollow shell, and a corrugated plate hidden inside it. The shell opens from the bottom, inviting people to use their hands to explore inside and more clearly perceive the negative weak, limp, and ruminating state.

4.4 Step 4: Testing the mood-expressing haptic objects

In this step, we evaluated if the three mood-expressing haptic objects communicate the intended mood states. A blind test was used, in order to maintain the participants' focus on the sense of touch.

4.4.1 Participants

17 master students (male=6, female=11) from the Faculty of Industrial Design Engineering, Delft University of Technology were recruited, including 11 Chinese, 2 Dutch, 2 Italian and 2 Spanish, whose age ranged from 23 to 25. Among the 17 participants, two participated in the exploratory interview study (i.e., Step 2), all the rest had no previous knowledge about this project.

4.4.2 Materials

The three haptic objects were placed in three separate boxes and covered with a dark cloth to keep them out of sight for the participants. The boxes were open on the opposite side, enabling the researcher to observe the participant's interactions (Figure 8).

Because people often do not have a precise vocabulary for expressing nuanced mood experiences, we provided the participants with verbal definitions of eight different moods as possible options. These moods, which were selected from the mood booklet developed by Desmet and colleagues (2020), included 'giggly', 'cheerful', 'amiable', 'relaxed', 'agitated', 'grumpy', 'anxious', and 'gloomy'. Because the aim was to test if the haptic objects can convey nuanced experiential qualities that distinguish one mood from other similar ones, the selection of the mood options was based on following considerations: 1) similarity in valance (i.e., four positive and four negative); 2) similarity in arousal (i.e., four activated and four deactivated); 3) similarity in overall phenomenology (e.g., cheerful and giggly; agitated and grumpy).

4.4.3 Procedure

After introducing the study purpose, the participants were guided to use their hands to first freely interact with the three objects. For each object, they selected the best, the second-best, and the worst fitting mood from the set of eight. In their selection process, they were invited to focus on what mood the object expressed, as opposed to what the object made them feel. In addition, they were encouraged to think out loud during their tactile explorations, and to elaborate on the reasons for their choices. At the end of the test, they were shown the three objects and invited to further reflect on their results.

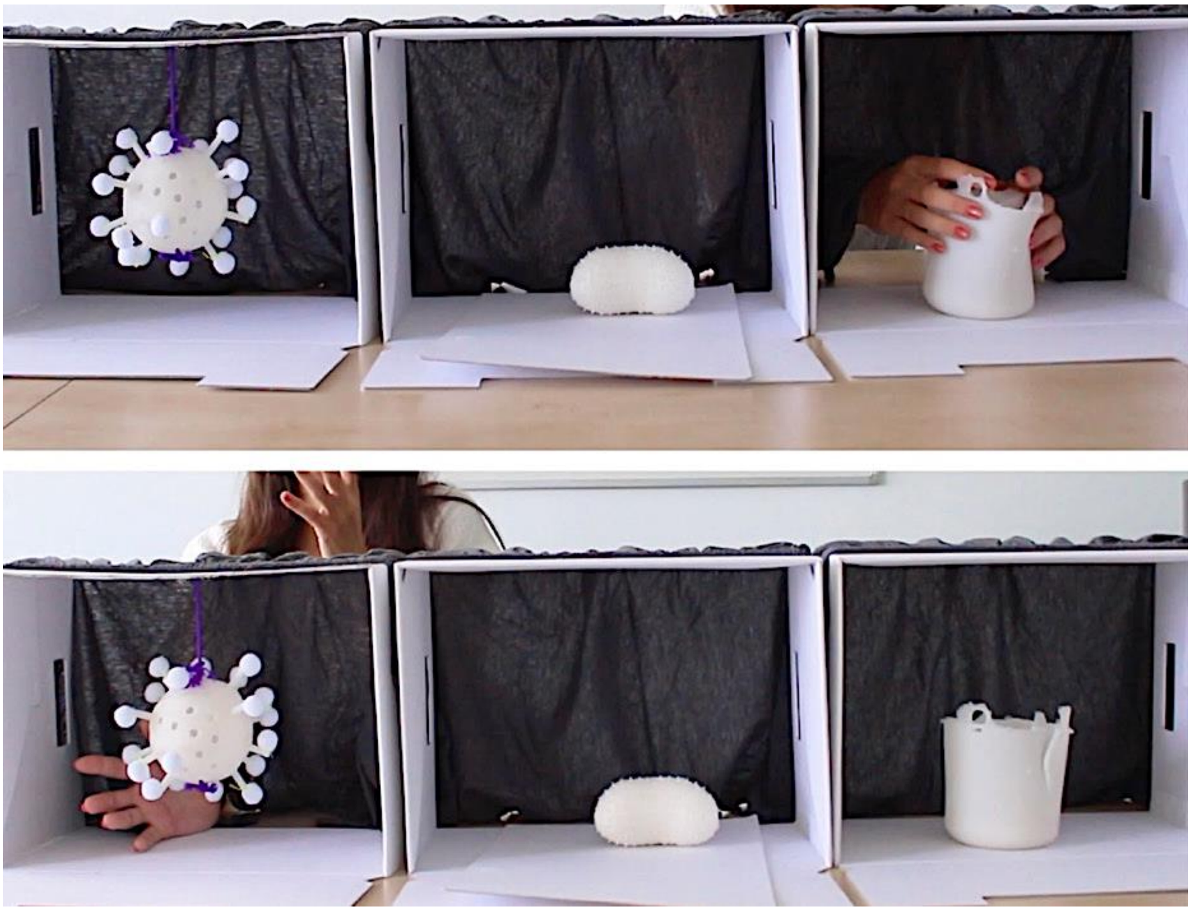

Figure 8: Blind test of the three mood-expressing haptic objects.

4.4.4 Results

Generally, the test results indicated that the participants perceived the three mood-expressing haptic objects as they were intended, as can be seen in the bar graphs in Figure 9.

For the cheerful object (Figure 9, upper left), the majority of the participants selected 'cheerful' (4 selected 'cheerful' as the best fitting; 9 as the second-best fitting). The second most selected mood was 'giggly' (8 selected it as the best fitting; 4 selected it as the second-best fitting), which is very similar to cheerful. Gloomy was most selected as the worst fitting by 9 participants.

Regarding the grumpy object (Figure 9, upper right), most participants selected 'grumpy' (5 selected it as the best fitting; 8 as the second-best fitting). 11 participants selected 'agitated', which is similar to grumpy, as the best fitting and the second-best fitting. 'Amiable', 'relaxed', and 'cheerful' were most often selected as the worst fitting moods for the grumpy object.

For the gloomy object (Figure 9, lower left), more than half of the participants selected 'gloomy' (5 selected it as the best fitting; 4 selected it as the second-best fitting). However, 9 participants mentioned that it could express a relaxed mood (4 selected 'relaxed 'as the best fitting; 5 selected it as the second-best fitting). The moods that were most often selected as worst fitting, were 'agitated', 'anxious', and 'cheerful'.

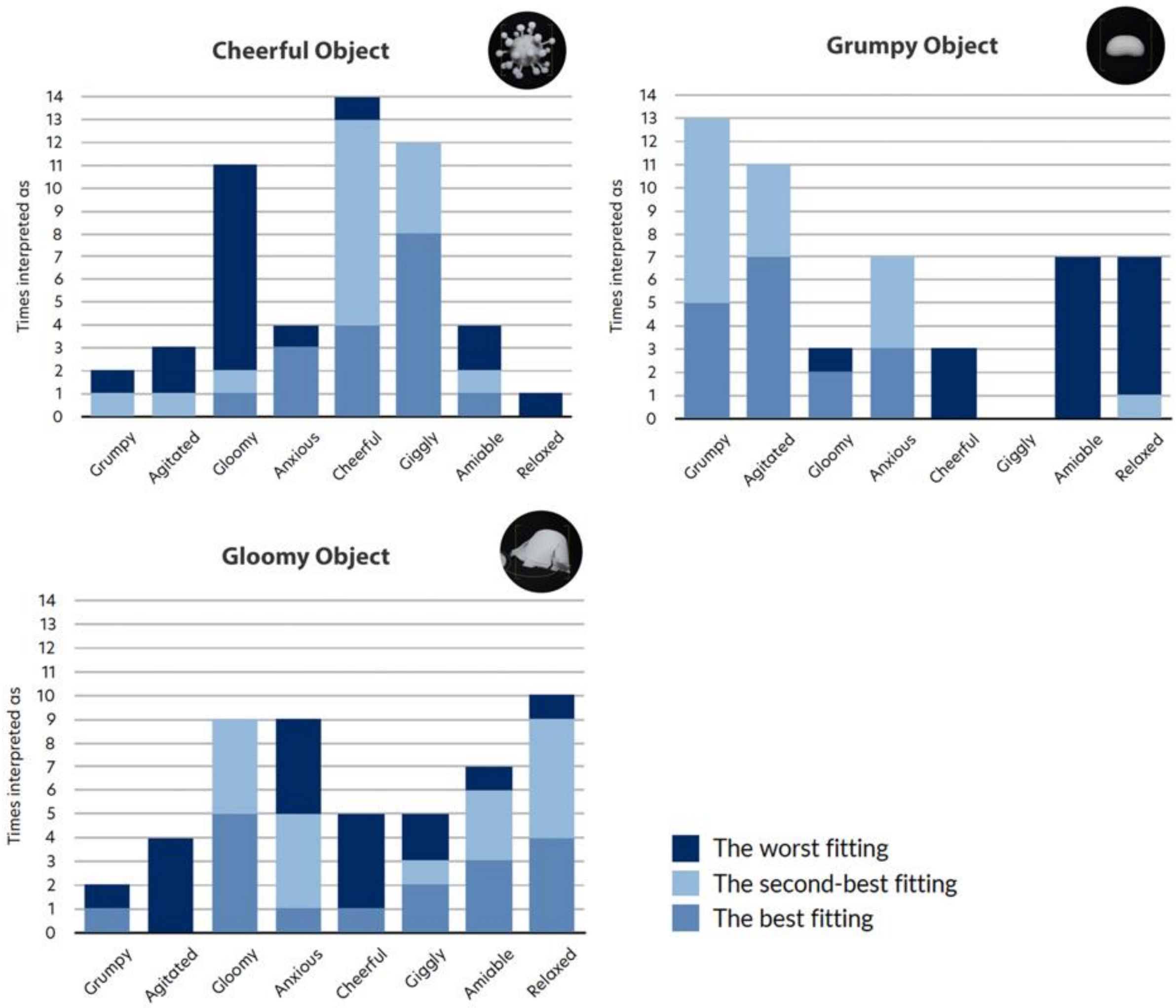

Figure 9: Blind test results of the cheerful object (upper left), grumpy object (upper right), and gloomy object (lower left).

5 Discussion

The results of our exploration demonstrated the feasibility of designing objects that convey nuanced experiential qualities of various moods through tactile interaction. This project sparked insights into the perception of mood-expressing haptic objects and how we might design them accordingly, enabled us to envision the potential applications for developing haptic mood objects, and also prompted a critical understanding of the limitations of our current approach. These insights and reflections have, in turn, shaped our ideas for future research within this thread of study.

5.1 Insights into the perception of mood-expressing haptic object

First, haptic objects that express moods can be ambiguous in terms of valence (positive versus negative) or activation (inactive versus active). From the 'thinking out loud' processes observed in Steps 2 and 4, we noticed that most participants initially tried to determine whether the objects haptically expressed positive or negative affect, and to what extent they were active or inactive. When an object was ambiguous in one of these two aspects, participants found the mood-expressing haptic object difficult to interpret. This was particularly evident in the blind test of the gloomy object. Although its low arousal was clear, the expression of negativity was less clear. It was neutralised by its hidden corrugated plate, whose *round* and *regular* structure appeared to express a positive quality. As a consequence, 'relaxed' was selected by many too. While this indicates that it is a challenge to create haptic objects that clearly communicates positivity or negativity, it may offer opportunities for the expression of complex mood states as 'sentimental', for which being ambiguous or mixed with both positive and negative elements is a defining feature.

Second, after determining valance and activation, people tend to seek for more nuanced haptic information that enables them to make more granular differentiations between similar mood states. Thus, in some cases, we may integrate ambiguous or even conflicting features to facilitate such granular mood expressions. For example, our design of the grumpy object combined a relatively soft silicon surface and semi-hidden aggressive plastic spikes to enable an interactive process that communicates the passive aggression of this mood – which emerges in the interaction. In comparison, the aggression of such moods as *agitation* or *irritation* is more overt and active. Therefore, in the case of irritation, haptic properties (e.g., high temperature, prominently spiky and rough surface) may be integrated to better create a synergy that facilitates a perception of direct hostility.

Thus, haptic features may be deliberately crafted and combined to communicate distinct, ambiguous, or even conflicting qualities in mood valence, activation, and nuanced action-thought tendencies, depending on the intended mood.

5.2 Potential applications

We foresee several potential applications for developing mood-expressing haptic objects. For example, they could be used in user tests, providing participants with a non-verbal alternative for exploring and expressing their feelings towards design concepts (see also, Isbister et al., 2007). In addition, by selecting one or more objects, people can express their current moods, or the moods they would like to be in, which can inform design processes. To this purpose, haptic mood objects can complement those more conventional means to communicate moods, such as words and images. Furthermore, with the increasing popularity of social touch technology (Huisman, 2017) and affect-based haptic interaction design for wellbeing (MacLean, 2022), designers have started exploring new opportunities that were unimaginable in conventional mouse-keyboard-screen-based interface/interaction design. An example of these opportunities is technology-mediated non-verbal or multimodal communication about everyday affective life in long distance relationship (Li, Häkkilä, & Väänänen, 2018). Progress towards this direction requires a continuous advancement in the understanding of human multimodal affective perception.

5.3 Limitations and future research

We should also note some limitations of our exploratory study. Firstly, while the validation study deliberately limited perception to the tactile sense through the use of the boxes, it is essential to acknowledge that our exploration and design processes encompassed a combination of visual cues, tactile sensations, and verbal descriptions. Embracing this viewpoint, we consider exploring a design process that exclusively prioritises the tactile sense throughout all stages presents an intriguing avenue for future experimentation. By more strictly isolating the tactile aspect, researchers can gain a deeper understanding of how touch alone contributes to the overall experience of the designed objects. Meanwhile, as Howes (2010) criticised the fact that studies of sensory perception typically focus on individual senses in isolation, neglecting the interaction among them, we also envision that explicitly focus on a more interactive and holistic understanding of multimodal communication of moods, highlighting the role of visio-tactile-audio-verbal mode in future research, would be valuable as well.

A second limitation concerns the scope of the object collection used in the exploratory study. While the objects were carefully selected to ensure the diversity of haptic features, we recognise that we did not explicitly account for the potential influence of symbolic and cultural/social factors on tactile perception. To deepen the understanding and add more nuance to tactile mood expression, future studies should address these factors and explore sensory perception and mood communication as an integrated, socio-culturally mediated phenomenon rather than taking only the personal psychological and perceptual perspectives.

A third limitation relates to participant diversity and inclusivity. While our research involved participants from diverse nationalities, we acknowledge that broader inclusivity is essential for enhancing the generalisability and depth of our findings. For future research, we propose implementing an explicit stratified sampling strategy to ensure representation across various demographic categories, including age, gender, socio-economic status, and cultural background. Additionally, we recognise the significance of attending to intersectional factors that may influence sensory perception, acknowledging that experiences can significantly vary even within specific demographic groups. Additionally, actively engaging participants with diverse abilities and comparing their experiences can provide a deeper understanding of the topic and promote greater inclusivity as well (e.g., understanding how individuals with visual impairments perceive haptic features and associate them with moods might differ from the experiences of the sighted population).

Lastly, it's important to recognise that both the exploratory interview study (conducted in Step 2) and the evaluation study (conducted in Step 4) took place within a lab environment. Participants were required to rely on their memories of relevant mood incidents to identify mood-expressing haptic features and evaluate our final designs. Though we carefully utilised an 'imagery and recall' technique to induce the target mood (See, Maryam Fakhrhosseini & Jeon, 2017; Quigley et al., 2014), the insights captured may have been further nuanced had participants explored the relationships between haptic features and the experiential qualities of specific moods while naturally experiencing those moods in real-life contexts, such as at home or work. To complement and deepen our understanding, future research could engage a select group of committed participants in a more extended and immersive exploration, spanning 1-2 weeks, within their natural settings. Such an approach may yield a richer and more authentic understanding of the interplay between haptic sensation and mood expression.

In addition to the aforementioned avenues for new research, we foresee two exciting opportunities for expanding the practical dimensions of this work. First, we plan to broaden the repertoire of haptic mood objects by incorporating additional moods, such as irritation, anxiety, and calmness. Our second priority is to refine the designs to enable scalable production, thereby making them accessible to designers, design students, and researchers who may be interested in this burgeoning field.

6 Conclusion

In our current quest to empower designers with tools to comprehend and communicate moods in their design processes more effectively, we undertook an exploration into the potential of using haptic objects as vehicles to convey the subtle qualities of specific moods. Concentrating on three universally experienced moods, cheerfulness, grumpiness, and gloominess, we pinpointed haptic characteristics that embody the experiential essence of these feelings. These identified features were then woven into the creation of three tangible objects, each representing one of the moods. A blind test evaluation affirmed the intentional design of these haptic objects and highlighted the promise of tactile qualities as valuable supplements to the traditional verbal and visual means of mood expression. The results of this study open doors to new avenues in the intersection of mood communication and affect-based haptic interaction design.

We trust that this project, including its exploratory stage, design process, and evaluation study, will inspire designers who aspire to create artefacts that can communicate one's current mood in nuance to another person through haptic qualities. By doing so, we hope to advance well-informed mood-focused design, and expand knowledge of the development of haptic mood objects that can enrich our daily interactions and enhance our general wellbeing.

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