



QuintEssence: A Probe Study to Explore the Power of Smell on Emotions, Memories, and Body Image in Daily Life

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Previous research has shown the influence of smell on emotions, memories, and body image. However, most of this work has taken place in laboratory settings and little is known about the influence of smell in real-world environments. In this article, we present novel insights gained from a field study investigating the emotional effect of smell on memories and body image. Taking inspiration from the cultural design probes approach, we designed QuintEssence, a probe package that includes three scents and materials to complete three tasks over a period of four weeks. Here, we describe the design of QuintEssence and the main findings based on the outcomes of the three tasks and a final individual interview. The findings show similar results between participants based on the scent. For example, with cinnamon, participants experienced feelings of warmth, coziness, happiness, and relaxation; they recalled blurred memories of past moments about themselves and reported a general feeling of being calm and peaceful towards their bodies. Our findings open up new design spaces for multisensory experiences and inspire future qualitative explorations beyond laboratory boundaries.

CCS Concepts: • **Human-centered computing** → **User studies; Field studies;**

Additional Key Words and Phrases: Smell, emotions, memories, body image, scents, cultural probes, body awareness, field study

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1 INTRODUCTION

It has been long known that the sense of smell influences how we experience the world around us and ourselves [41, 80]. For instance, scents not only regulate approach and avoidance behavior

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Fig. 1. (a) An icon of the QuintEssence probe package to show how it looks from the outside (with the labels to remind participants to stay safe and wash their hands against the COVID-19 pandemic) and the inside (with the three boxes and the hand sanitizer), (b) an example of Instagram post showing the scent-infused bottle to complete the EssScent task, (c) an example of an EssBody task collage, (d) an example of an EssFun task outcome.

[18] and evoke pleasant or unpleasant experiences [27], but also modulate mood [80], attention [45], stress [57], memories [39], and, as recently demonstrated, body image [12]. The latter has been defined as the way we perceive our own body is not fixed; it changes continuously in response to sensory signals in the environment [76]. While changes in body image have been more prominently studied with visual [19], auditory [75], and haptic metaphors [71], emerging research advance our understanding of how the sense of smell influences our body image. For example, Brianza et al. [12] showed that combining lemon scent and high pitched footsteps sound, resulted in participants walking faster and feeling lighter, in comparison with vanilla scent. In a later study, Brianza et al. [12] found crossmodal associations between a wide range of scents and 2D body silhouettes. However, such studies have been carried out in lab environments, in which participants were required to accomplish tasks under controlled conditions, e.g., the researchers' supervision. No previous study has explored the effect of smell on emotions, memories, and especially body image in daily life. Indeed, by definition, body image is affected by stimuli from outside and inside the body, and to fully explore this concept, auto-biographical memories, personal emotions, and daily life events must be taken into account [70]. Therefore, we decided to run a first-time field study to investigate smell-related personal experiences and associations in everyday life, focusing on how people act, think, and feel on a daily basis for four weeks.

Our field study took place over a four-week period and was inspired by the cultural probe's methodology, [29] especially the technological and sensory cultural probes approach [32]. First, we carried out a preliminary study (i.e., online survey) to identify correlations between scent awareness and body awareness that we could then use as recruitment criteria. We used the survey results to recruit participants for the consequent field study. We adopted the cultural probes approach which involves ideating "evocative tasks" and providing tangible materials "to elicit inspirational responses from people" [30] with regards to exploring participants' emotions, memories, and body image influenced by the smell in everyday life. We developed *QuintEssence*, a probe package containing three bottles with essential oils (lemon, peppermint, and cinnamon scents) that participants carried around during the first three weeks of the study (one scent per week), along with creative materials to engage participants in expressing their own emotions, memories, and body concerns (see Figure 1(a)). *QuintEssence* is composed not only of physical materials but also provides participants with a digital tool to share their thoughts in real-time via a private Instagram account (following prior work [85]). Each participant was encouraged to post their experiences with the scents and to express what they experienced through videos or pictures (see Figure 1(b) and Figure S1 in the Supplementary Material document), which were only shared with the first

author. At the end of the fourth week, a semi-structured online interview was conducted with each participant in order to collect in-depth explanations and descriptions of their own personal experiences using the probe tasks outcomes (examples in Figure 1(c)–(d)) as prompts throughout the interview. It is worth noting that we designed and ran the field study concomitantly with the spread of the COVID-19 pandemic limiting the possibility of face-to-face sessions. All the one-to-one interviews have been carried out online, via the Zoom platform. More details on the design of the probe package are included in Section 4.3. More pictures of the tasks' outcomes are included in the Supplementary Material document.

We present the results that emerged from an iterative coding and analysis process. Our findings include a strong link between scent and memories, which manifested differently among participants depending on the scent used (e.g., cinnamon is found to be associated with blurred memories, peppermint, and lemon with more concrete memories) and personal scent associations (e.g., one participant recalled personal past memories of childhood triggered by peppermint scent). We also found that different scents lead to different types of emotions and different bodily feelings (e.g., the lemon scent was often associated with active, energizing, positive feelings about the body, cinnamon scent with calmer and relaxing feelings, and peppermint scent with nostalgic as well as fresh sensations).

We first display and analyze the results gathered from the *QuintEssence* outcomes and the final interviews. We then discuss how our work contributes new insights into the under-explored relationship between scents, emotions, memories, and body image in daily life, and how such findings can be applied by designers to develop future multisensory experiences, and wearable technologies to bring scents into our everyday life. We conclude with a discussion on how studying the impact of scents on emotions, memories, and body image in a daily life scenario as well as future designing directions that our findings open up. We briefly address the methodological variation that we adopted, and the main comments gathered through the final interviews with participants.

2 RELATED WORK

In this section, we review pertinent related work focused on the established knowledge about the relevance of smell in triggering emotions and memories, and the recent studies exploring the effect of scents on body image. Given the design of the *QuintEssence* probe package is central to this article, we also review important work about the use of the cultural probe's methodology in several HCI contexts.

2.1 The Relevance of Smell for Memories and Emotions

By searching the keyword “smell” in the ACM Digital Library in the last ten years, it shows how the HCI community interest in the sense of smell and its possible application grows annually. Typically, vision and audition have tended to dominate behavioral research [33, 73]. However, while studies focusing on these sensory modalities continue to be predominant, more attention is now being directed towards the sense of smell and particularly to the psychological effect of this sense on human behavior [12, 14, 54, 56]. Indeed, while the smell is often considered a minor sense compared to vision, audio, and touch [69], emerging research suggests that we use it more than we actually think. For example, previous work has shown that humans have scent tracking abilities similar to dogs [64], that scents regulate behavior (from eating behavior [4, 87] to social communication and bonding [56]), trigger pleasant or unpleasant experiences [27], and of particular interest for our study, modulate memories [39, 61], emotions [27] and body image [12]. Such effects of smell have been explained by neural correlates involving an overlapping of anatomical substrates. For example, the amygdala, hippocampus, hypothalamus, and thalamus (parts of the brain that regulate our emotions and memories) can be activated by scents [72]. Additionally,

activation of the orbitofrontal cortex (area of the brain linked to our decision-making behavior) has been found to be activated by pleasant (rostral area) and unpleasant (lateral area) scents [88]. This evidence demonstrates how scents can be very powerful to influence our emotional behavior. Below, we present relevant prior work showing evidence of the effects that smell has on memories and emotions.

2.1.1 Smell and Memories. It has been shown that scents have the ability to spark vivid autobiographical memories, and after a scent has been associated with an experience, it is able to evoke the associated emotions when later encountered [17, 83]. The ability of scents to trigger the recall of a wide range of autobiographical memories about events, places, people, and emotions, highly vivid or blurred, is known as the Proust phenomenon [17]. The first empirical study of this phenomenon was carried out by Rubin et al. in 1984 [66]. Participants were asked to describe a specific auto-biographical memory recalled using scents, to date the memory, and to rate the vividness and the pleasantness of each memory and say how many times that memory had been thought, spoken of, and shared. Also, in the area of HCI, studies about smell and memories have been explored. For example, Obrist et al. [60] collected 439 smell stories about personal memorable experiences involving smell via an online questionnaire. The aim of the authors was to gather enough information about personal attitudes towards the use of the sense of smell to focus on possible future opportunities for designers to create smell technology. Out of the ten identified categories, two are directly related to memories: the one called “Associating the past with a smell” and the one called “Remembering through a smell”.

Based on the fact that smell affects memories, prior research has used scents as a trigger for traumatic experiences for mental disorders treatment [40, 46, 77]. For instance, in [82] the authors found that veterans who served in Iraq and Afghanistan [20], regardless of post-traumatic stress disorder status, reported burning odor-related fighting experiences.

In summary, smell plays an important role in memories. Compared to other sensory modalities, memories evoked by smell are more emotionally loaded [39], more vividly and autobiographically older (ranging back to childhood [17]). The smell is incredibly powerful in bringing people back in time and connecting humans to both short- and long-term memories, blurred recalling of undefined feelings, and vivid concrete past events, experiences, and emotions [17, 39].

2.1.2 Smell and Emotions. The emotion-eliciting effect of smell is not restricted to the context of memories. The smell is particularly useful in inducing emotions due to its peculiarity of triggering pleasant or unpleasant experiences [60]. Previous studies have shown that these affective responses to scents are modulated by physicochemical, physiological, and cognitive factors [68]. Psychophysical investigations have shown that such affective processing of scents is influenced by physicochemical properties. However, it has been shown that also physiological and cognitive factors play an important role in rating scent pleasantness. It seems that both bottom-up processes and top-down processes are salient and primary to build our affective responses to scents [68]. Indeed, the scent-affective response is typically determined by valence, arousal, and intensity [3]. Humans involuntarily categorize scents by their valence, while perceived scent intensity is strongly correlated with subjective arousal [5].

Moreover, scents have been deployed to reduce patient stress in healthcare environments [11, 47, 53]. Also, it has been shown that scents can influence shopping behavior in retail environments [16, 26] and littering behavior in public environments [52]. Supported by this evidence, the sense of smell is gaining increasing attention in several design contexts. For example, in the context of wearable design, Essence [2] and Bioessence [1] are necklaces designed to release scents based on biometric or contextual data (e.g., heart rate and respiration). Similarly, in the context of virtual

systems, the use of scents can be used to enhance the sense of immersion in gaming [10], to provide a more realistic and immersive virtual environment for entertainment [25, 65], to enhance the driver's attention in in-car settings [9, 24], and to reduce mental workload [84]. In the context of interaction design, Maggioni et al. designed a theoretical framework to introduce scents in the interaction space [25]. They demonstrate how the scent detection and lingering time can be acquired under different scents conditions, and investigated the impact of scent type (lemon, peppermint, rose scent), dilution (100% pure essential oil, 50% dilution with water), and intensity, on detection, liking, and level of comfort. Their findings show that any of the three scent types, with two dilution levels each, can be perceived in no longer than 10s. In terms of liking and comfort levels, the highest ratings have been found in the 1.0 bar condition. Moreover, in the context of driving behavior, it has been recently shown that selected scents can impact driving performance in a state of elicited anger. Indeed, in the study by Dmitrenko et al. [24], it was found that the scent of peppermint was rated as positive and highly arousing, the scent of rose as positive and low arousing, and the scent of civet and patchouli as negative and highly arousing. Then, the authors designed a driving simulation scenario in which participants were elicited with anger through an established method (i.e., the IAPS dataset [51]). The authors found that with a rose scent participants drove slowly, and more calmly, no crashes had been recorded, and they reported a general relaxing feeling. With the peppermint scent participants' speed was stable and they reported a general arousing feeling. On the contrary, the unpleasant civet scent caused the highest number of collisions.

In summary, it has been shown that our sense of smell has a strong effect on triggering emotions, linked with the scent itself (in terms of pleasantness, valence, and arousal) and with the associated memory. However, the link between scent and body image is still not well understood, especially not in the context of everyday life.

2.2 The Effect of Smell on Body Image

As reported by a person affected by smell loss due to COVID-19, "*I feel alien from myself. Like a part of me is missing as I can no longer smell and experience the emotions of everyday basic living. Detached from normality. Lonely in my body. It's so hard to explain*" [14]. With these words, the person described their feelings towards their own body. This sentence emphasizes the importance of smell in everyday life. Indeed, smell serves to orientate us in our environment, towards other people and ourselves [14]. The disruption of these cues was reported as fundamentally changing the relationship with the world, others, and self. Even if we are not always aware of our body and our sense of smell, with the outbreak of the COVID-19 pandemic and the loss of smell as a major symptom, we are starting to unlock a deeper understanding of the role of smell in our daily life and in relation to the perception and construction of our own body image.

Body image is defined as "*the picture that we have in our mind of the size, shape, and form of our body and the feelings towards those body parts*" [70]. This definition defines two relevant components: the body size estimation (as a perceptual task) and the attitudes or feelings towards the body (i.e., tactile, visceral, sensorial, postural, and emotional experience) [70]. Prior studies have shown that our body image is continuously updated according to the feedback received from our actions or to the action exerted on our body (e.g., the role of visual, tactile, and auditory stimuli to induce embodiment) [43, 49, 67]. However, studies on the effect of smell have only recently emerged, such as in the study by Brianza et al. [12, 13], in which it was investigated the concept of body image in a laboratory environment. The authors used the visual analog scale paradigm to explore associations between several scents and two types of 2D body silhouettes (thin and thick) as a visual representation of two opposite types of bodies. They found associations of peppermint and lemon scents with thin body silhouettes and associations of cinnamon and vanilla scents with

thick body silhouettes [12]. In earlier work, Brianza et al. [13] combined scents with sounds to explore the effect of multisensory stimulations on body image. They found that when participants were asked to walk in place, the combination of lemon scent and high-pitch footsteps sound encouraged participants to walk faster and feel lighter. Controversially, the combination of vanilla scent and low footstep sounds made participants walk slower and feel heavier. Both the aforementioned studies focus on the effect of smell on the perceptual side of the concept of body image. They both were run in a laboratory setting with university students as participants, under controlled conditions. However, to the best of our knowledge, no study has been conducted to explore the duality -sensorial and emotional side- of the concept of body image in real-world scenarios outside lab environments with naïve people who do not work and study smell and body-related topics. This informs our rationale for designing a qualitative study to gain deeper insights into such complex topics. Indeed, body image changes according to personal and contextual stimuli (i.e., stimuli outside and inside the body) cannot be fully explored and understood if disregarding everyday life emotions and memories. Differently put, it is doubtful whether the status quo of controlled, lab-based studies can exhaustively investigate the relationship between smell and body image in everyday life. For our study, we drew inspiration from the cultural probe's methodology, which we discuss in the following.

2.3 Cultural Probes Approach

In its early days, HCI research has focused almost exclusively on investigating behaviors (e.g., behavioral outcomes) in lab settings. Drawing upon the concept of emotional usability [55], it has been argued that HCI must be concerned not only with pragmatic aspects of the interaction with a product (i.e., its fit to behavioral goals) but also with affective aspects [37]. Indeed, the key primary concept to recreate an interactive outcome is the user's experience at the moment experienced [81]. Diaries, voice notes and, of particular interest for our research, interviews, and cultural probes are some of the methods that HCI researchers use to condense, remember, share, and communicate their experiences.

Since first being applied and described by Gaver et al [29], the cultural probes approach has been adapted and changed based on a range of different purposes within a vast variety of projects, with different user targets and different aims. The notion of "probe" can refer to several different things that have appeared in multiple HCI studies. For example, robotic probes can return their data over radio links or be physically tethered to controllers [42]; Crabtree et al. [21] adapted cultural probes to inform design in sensitive settings; Hulkko et al. [41] extended the method to cope with mobile settings. More recently, Woytuk et al. [85] designed a variation of cultural probes to study preconceptions about female menstruation and body fluids. Similarly, Gayler et al. [31] designed a variation of cultural probes, called sensory probes, to explore co-designing personalized flavors for emotional communication through the use of 3D food printers in participants' houses [31] or board game-like activities [32]. In both examples, the primary role of the body and bodily feelings requires users to become aware of and articulate their bodily personal experiences. Indeed, the body as a resource for design has received a growing HCI interest, especially focusing on exploring materials through different senses and body parts. For example, in [31] and [32], Gayler et al. developed the sensory probe package with the aim of making participants familiarize and sensitize with the depicted flavors terms and giving them the opportunity to explore the matching of foods with their feelings or memories. They introduced engaging tasks to force participants to think about the other senses and about their own bodily sensations while and after eating. Inspired by these studies, the design of our QuintEssence probe package aims at engaging participants in thinking about their own bodies while performing fixed tasks. As addressed in [32] discussion, we also aim at exploring with our probe package design recommendations for future multisensory

applications, focusing on the impact of the sense of smell on emotions, memories, and bodily feelings.

Despite all these different applications, the final aim of the traditional cultural probes approach, as Gaver reported in 1999, is to create a methodological variant of ethnographic studies in order to limit the negative effects of researchers taking part in field studies and to enable the investigation of daily life without the researchers' presence and bias [29]. This approach has a strong art and design influence and is not based on typical user studies' practices but single user experiences and behavior in situ. Usually, participants receive a so-called "probe package" which is a box that contains materials and artifacts useful to gather as much information as possible during the entire period of the study. It might contain diaries, cameras, postcards, and sometimes maps for capturing and collecting data [8]. Blythe et al [7], for example, adapted one aspect of cultural probes by giving their users a "three wishes" exercise: three pieces of paper with the words "*I wish I had...*" to be filled in when users "*encountered problems that might be solved by future technological developments*".

Other researchers expanded the probe package range by developing variations of evocative tasks, such as using Indian rasas to categorize feelings [50], Gardner's theory of multiple intelligence to design probes that engage alternate forms of self-expression [78] and using matchbooks littered around the city [8].

Researchers mostly do not intervene, and rather wait for the manifold and expressive objects created in participants' interactions with the supplied artifacts and materials. A prominent point stressed by HCI researchers is the value of this method in not knowing exactly what participants will do with the materials [30]. Usually, at the end of the study, a final in-depth interview is arranged between the researcher and the participants [6].

An example of a new participatory design strategy inspired by the traditional cultural probes methodology, in which the researchers actively introduce tasks and objects in the real-world setting, is the so-called technology probes approach [42]. Technology probes are a particular type of probes that combine the goal of collecting insights about the users' behaviors in a real-world setting, field-testing the technology, as well as inspiring users and designers to think about people's needs and desires in light of new technologies. Even if we did not develop any technological tool as part of our QuintEssence probe package, we introduced the use of Instagram as a technological platform to collect daily data, and we took the idea of interfering with the daily life of participants by introducing tools and objects to accomplish different tasks.

One of the values of the cultural probes approach is the ability for accounting of participants' individual lives and actively engaging with them. As Gaver noted, "*probes encouraged us to tell stories about them, much as we tell stories about the people we know in daily life..They give us a feel for people, mingling observable facts with emotional responses.*" [29]. This approach supports reflection by participants themselves as part of data acquisition (e.g., [48, 74]). With this approach, participants take responsibility for and control what information they record or share in the probes [36]. Along this same line, since probes are often associated with a focus on emotional aspects of interaction design, the playful, engaging and creative nature of taking part in a probe study can be a valid motivation for using such an approach in research in the relationship of smell and body image in everyday life. However, similar to other qualitative design research approaches, care must be taken to avoid over-interpretation of probe results by researchers.

In summary, inspired by previous literature, we adopted and reinvented the cultural probes approach in a four-week field study to explore the relationship between smell, emotions, memories, and body image in a real-world environment. We designed *QuintEssence*, a probe package with a set of materials and defined tasks to guide participants to pay more attention to their olfactory experiences in daily life, all the emotions and memories elicited by the scents, and, especially, the effect of smell on the way they feel and perceive their own body.



Fig. 2. Timeline of the overall study: the preliminary study (online questionnaire) to establish the main criteria to recruit participants → the recruitment phase → the field study adopting the cultural probes approach and designing QuintEssence, our probe package.

3 QuintEssence: STUDYING EMOTIONS, MEMORIES, AND BODY IMAGE IN THE FIELD

In this article, we explored the effect of selected scents (cinnamon, peppermint, and lemon) on people’s emotions, memories, and, especially, body image, in everyday life situations. To the best of our knowledge, we are the first to investigate smell in relation to body image in daily life, taking inspiration from [32]. We are interested in exploring (i) if and how the persistent use of scents in a four-week period affects people’s intimacy and behavior, (ii) if and how different scents impact emotions, memories, and body image, and (iii) if the effect of scents changes according to daily life events and personality traits. We aimed to involve people with no expertise in smell research and body image research, outside of a laboratory environment, and applied both quantitative approaches (preliminary study to recruit participants) and qualitative approaches (field study) (see Figure 2). To design the field study, we took inspiration from Gaver’s et al.’s cultural probes method [29], Gaylers’s sensory probes approach [31, 32], Hutchinson’s technology probes approach [42], and adapted their methodologies to develop ad hoc tasks and instructions. We designed three main tasks and we asked participants to complete each of them at defined times across the four weeks. We organized a final semi-structured in-depth interview with each participant and we used the outcomes of the probe package as prompts for the discussion. Below, we firstly describe the preliminary study (i.e., online survey) and the recruitment criteria, then we present the four-week field study and details of the *QuintEssence* probe package.

3.1 Preliminary Study and Recruitment Criteria

As shown in Figure 2, we ran an online survey as a preliminary study with 100 English-speaking participants living in the UK, to explore whether there is a correlation between scent awareness and body awareness of people with no previous knowledge or interest in smell, multisensory, and body image research. Moreover, we were interested in correlations between those body and scent awareness-related questions with socio-demographic characteristics (e.g., gender, age, ethnicity, and education) to establish the key criteria to recruit participants for the following field study. We adopted standardized questionnaires adding new questions to investigate body awareness, as the **Silhouette Body Image Test (SBIT)** [15] to detect the difference between desired and perceived body image and the **Body Uneasiness Test (BUT)** [23] part A & B to rate the level of body image concerns, and smell awareness, as the **Importance of Olfaction Questionnaire (IOQ)** [22]. The adoption of an online survey as a preliminary study allowed us to collect sufficient data in a short time-window (less than one week) and gain primary insights on this new topic (correlation between smell and body awareness). We found significant correlations between socio-demographic data and body and smell awareness scores. As shown in Figure 2, we used the findings

from this preliminary online survey to guide the selection of the field study participants. The selected key criteria include:

- High scores in body and smell awareness questionnaires (SBIT [15], BUT A&B [23], IOQ [22]);
- BMI between 18.5 and 33 (we avoided lower and higher BMI values on purpose being classified as clinically “worrying” enough to seek GP’s help according to the NHS website).
- No past of smoking (tested in the online survey);
- No pregnancy (tested in the online survey);
- No small impairments (e.g., allergies, cold, flu) or head traumas (tested by the Olfactory Assessment Test [57] in the online survey);
- Normal or corrected-to-normal vision;
- Age between 18 and 39 (we selected 39 years old as maximum age to take part in the study for two reasons: the known decrement in olfactory perception due to aging [58], and the assumption that people above 40 years old might struggle with the use of Instagram).

We aimed to recruit 12 participants for the field study (to allow all the possible randomizations of the order of the three scents), gender balanced (6 male, 6 female), with different body types (different BMIs), gender balanced (6 male, 6 female), with different body types (based on different BMIs to avoid any possible bias in our results). We recruited two males and two females with a BMI between 19 and 25 (considered as “healthy” by the NHS website www.nhs.uk/live-well/healthy-weight), two females and two males with a BMI between 26 and 31 (considered as “overweight”), and two males and two females with a BMI higher than 31 (considered as “obese”), for a total of six males and six females.

4 FIELD STUDY: THE *QuintEssence* PROBE PACKAGE

To move beyond laboratory environments and explore the effect of scent on emotions, memories, and body image in everyday life, we conducted a field study adopting the cultural probes approach (assembling a probe package, called *QuintEssence*). We recruited eight participants from the online survey participant pool and further four participants through word-of-mouth advertisement following the aforementioned criteria (four participants within the BMI “healthy” category, four within the BMI “overweight” category, and four within the BMI “obese” category). Out of twelve participants who received the probe packages and started the field study, one male participant (within the “healthy” category) dropped after the second week. Here, we present the findings based on 11 participants (5 male, 6 female, Mage = 28.7, SD = ± 5.16) who fully completed the four-week study and took part in the final interview.

In this section, we present our methodological approach, our selection of scents, a detailed description of our *QuintEssence* probe package development (materials and tasks), and the overall study design. An important note is that this study was carried out during the COVID-19 pandemic, which is reflected in the design of the probe package and study procedure. In the end, we present our analyses and discuss our main findings based on observations of the collected outcome and the final interviews.

4.1 Our Methodological Approach

We developed a variation of the cultural probes approach by designing *QuintEssence*, a probe package that encourages people to be more aware of the effect of smell and its peculiarity to recall memories, enhance emotions and affect body image. We present a brief rationale on the use of the probes method in the following.



Fig. 3. Materials provided in the *QuintEssence* probe package: (a) scent-infused bottles to complete the *EssScent* task; (b) modeling clay, fabric, sticker emojis, sticky notes to complete the *EssFun* task; (c) body templates, environments, fabric, stationery, sticker emoji to complete the *EssBody* task.

We took inspiration from Gaver et al.’s cultural probes method which has been widely applied in HCI research [29, 86]. Moreover, we have also been inspired by the sensory probes approach by Gayler et al. [31, 32], and the technology probes approach by Hutchinson et al. [42]. These two approaches are examples of redesigned cultural probes that focus reciprocally on multisensory stimulation and technological introduction in real-world environments. In both cases, differently from the traditional methodology applied by Gaver [29], the probe packages consist of objects and tasks that actively interfere with people’s daily life, but without disrupting their habits. Indeed, probes are generally designed to be composed of various materials and designed artifacts, accompanied by a set of (often loose) instructions or tasks. The peculiarity of this method is to offer rich insights into how people live their lives, and how the introduction of certain cues, scents in our case, can affect their everyday circumstances, emotions, memories, and concerns about their own body image, main novelty of this study.

Our probe package, *QuintEssence*, is therefore designed as a tool for data collection [31, 32, 36]. We use the cultural probes approach in combination with interviews to help people articulate aspects of daily life that they ordinarily do not reflect on. These insights can then be used to refine ideas for future multisensory user experiences and olfactory artifacts. The *QuintEssence* package’s components are designed to be used both at home and outside (see Figure 3). We developed ad hoc tasks that require the deployment of all the materials inserted in the probe package (physical component) and the use of an Instagram account (virtual component, inspired by [85]) (more details in Section 4.4). With the introduction of selected materials and ad-hoc tasks, we were aware of the possible “disruption” in people’s daily life. However, our purpose was to introduce an element, scents in our case, and study the interference that such element would have caused in a real-world environment, focusing especially on the emotional side and on personal bodily feelings. To understand participants’ personal experiences and feedback, we set up a final one to one in-depth interview between the first author and each participant, at the end of the fourth week to avoid further distractions. The study was approved by the local University ethics committee (ER/GB359/6).

4.2 Scent Stimuli

As the basic structuring element of our probe package field study, we included three scents as olfactory conditions. Each scent would be the focus of the first three weeks of the study. Since we are interested in the effect of scents on body image, as main contribution, as well as on emotions and memories, based on previous literature [14, 15], we selected:

- *Cinnamon*: mainly associated with relaxing and warm feelings and thick body silhouettes;
- *Peppermint*: strongly associated with arousing feelings and thin body silhouettes;
- *Lemon*: strongly associated with arousing and energizing feelings and thin body silhouettes.

All three scents have been previously rated as pleasant [15], since we wanted to avoid aversive reactions to any unpleasant scents (e.g., civet [24]) and prevent possible dropouts during the entire duration of the study. We randomized the order of administration between participants, to minimize any bias. We provided participants with three plastic bottles that contained cotton bud infused essential oils (<https://www.hollandandbarrett.com>). They were asked to carry around each scented bottle for one week.

We also provided three incense sticks (respectively, cinnamon, peppermint, and lemon scented) to recreate an ambient scent while accomplishing the weekend task (i.e., EssScent box, see Figure 4).

4.3 QuintEssence Probe Package Design

We designed and assembled a probe package which contains the materials required to complete the tasks and instructions to guide participants throughout the four-week study (see Figure 3). *QuintEssence* consists of a physical and a digital part: a cardboard box holding physical objects, and a private individual Instagram account which allows participants to share in real time their thoughts, feelings, comments in both verbal and visual ways. In the following sections, we present content and materials stored in the probe package, the instructions to complete each task, and the use of Instagram.

4.3.1 Content and Materials. As shown in Figure 3, the cardboard box includes two small boxes (called EssScent and EssFun) and a medium box (EssBody) with tangible objects inside, an A4 calendar of the full month to help participants remembering when they need to switch scent, a booklet with all the instructions, FAQs, and first author's contacts, a bottle of hand sanitizer, and a plastic bag to wrap the box at the end of the study before shipping it back. Each box includes labels with the main instructions and hints on how, when, and where to use the materials provided inside the box.

In Figure 4, we describe all the boxes, their components, the general tasks, and how, when, and where to use the materials.

4.3.2 Instagram Account. In addition to the tangible probe package, following the study of Woytuk et al. [85], we created a private individual Instagram account for each participant that allows them to share experiences with the first author. In order to overcome a posthumous recollection of memories, as done by the traditional diary method (e.g., [34]), we opted to use a more engaging, playful, and social platform that allows participants to immediately share their experience via pictures, videos, posts. We selected Instagram, as a social platform, with the aim of engaging participants in doing something funny as well as useful, without requiring them to learn how to use additional apps. Indeed, during the first contact between the first author and each participant, aside from the main explanation of the study, the author ensures that participants knew how to use the platform and they were confident with it. In order to set up the account, we provided all the



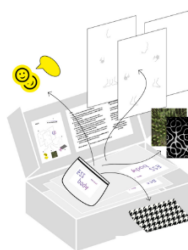

<p>QuintEssence Package</p> 	<p>What's Inside:</p> <ul style="list-style-type: none"> • 2 small boxes (EssScent & EssFun); • 1 medium box (EssBody); • Antibacterial gel; • Manual (instructions, FAQs, contacts); • Calendar. <p>When to use the material: As specified for each item in the box: weekly or at specific times within the 4 weeks.</p> <p>Where to use the material: At home & on the go.</p>	<p>How to use the material:</p> <ul style="list-style-type: none"> • EssScent during week 1, 2, and 3; • EssBody during the weekends of week 1, 2, and 3; • EssFun during week 4. <p>Task: Use the content of the box as instructed and complete all the tasks over the duration of 4 weeks.</p>
<p>EssScent Box</p> 	<p>What's Inside:</p> <ul style="list-style-type: none"> • 3 plastic travelling bottles individually wrapped in sealed plastic bags and corrugated paper; • 1 keyring to easily carry the plastic bottles around; • 3 packs of scented incense sticks individually wrapped in sealed plastic bags and corrugated paper. <p>When to use the material:</p> <ul style="list-style-type: none"> • Each bottle package has a sticker with the number of the week participants were supposed to use it; • Incense Sticks were supposed to be used during the designated weekends. <p>Where to use the material:</p> <ul style="list-style-type: none"> • Using the keyring, participants could easily carry around the bottles anywhere; • The incense Sticks were meant to be lighted at home. 	<p>How to use the material:</p> <ul style="list-style-type: none"> • We used plastic travelling bottles as containers for the 3 different scents used in the study. In each bottle, we inserted cotton buds infused with the respective essential oil; • The incense sticks were used while accomplishing the EssBody and the EssFun task. <p>Task: Participants were asked to use the bottles throughout their daily life whenever they wanted by actively squeezing the bottle to provide themselves with a puff of scent.</p>
<p>EssBody Box</p>  <p><small>*List of fabric swatches: acetate, viscose, wool, cashmere, silk, knit fabric, raw linen, linen, cotton.</small></p>	<p>What's Inside:</p> <ul style="list-style-type: none"> • 3 packages - one per week 1,2 3; • Each package contained 4 paper envelopes labelled as (i) body parts (2pages of abstract, rounded, spiky shapes), (ii) templates (1x static, 1x dynamic, 1xplain A4 page), (iii) environments (10 options), (iv) 9 fabric swatches*); • A pencil case with scissor, glue, 16 color markers, 7-point emoji stickers, 1 pack of sticky notes. <p>When to use the material: Each package had a sticker which represents the associated week. The task had to be completed over the weekend at the end of the associated week.</p> <p>Where to use the material: In a quiet place with a table or a flat surface.</p>	<p>How to use the material: Participants were asked to choose a body template, create a body silhouette cutting and gluing the body parts, or drawing them, choose a fabric that can be associated with their experience in the past week and with the scent, choose the most relevant environment, use the emojis to express their emotions and sticky notes to share the rationales behind their choices.</p> <p>Task: Participants were asked to focus on how they felt and visually represent the way they perceived their body in the past week while being subjected to a particular scent –delivered through the plastic bottle and the incense stick.</p>
<p>EssFun Box</p>  <p><small>*List of fabric swatches: acetate, viscose, wool, cashmere, silk, knit fabric, raw linen, linen, cotton.</small></p>	<p>What's Inside:</p> <ul style="list-style-type: none"> • One labelled package for week 4. • 57g uncoloured and unscented modelling clay; • 9 fabric swatches*; • 1 pack of sticky notes; • 7-point emoji stickers. <p>When to use the material: During week 4.</p> <p>Where to use the material: In a quiet place with a table or a flat surface.</p>	<p>How to use the material: With all the given material, participants were asked to create a representation of how their preferred scent made them feel.</p> <p>Task: Participants were asked to focus on how their favourite scent from the past weeks made them feel and create a visual representation of that feeling.</p>

Fig. 4. Detailed description of each box included in the QuintEssence probe package. For each box, there is a list of all the provided material, how, when, and where to use the material. In the gray section, we highlighted the task to complete with the material provided.

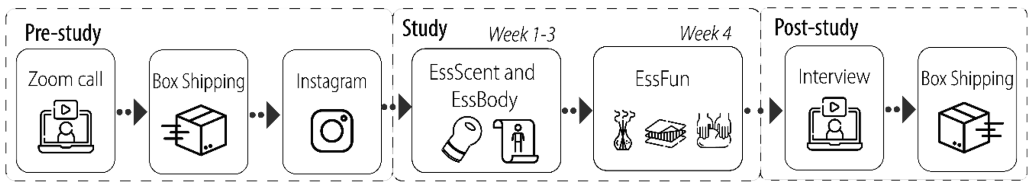


Fig. 5. Timeline of the three phases: (a) Pre-Study (arranging the first introductory Zoom call, shipping the box, setting up the Instagram profile); (b) Main Study (completing all the tasks with the materials provided in the box); (c) Post-Study (arranging the final Zoom interview, packing all the outcomes in the box, and shipping it back).

required credentials (ID and password) and we asked participants to choose their personal name. Each profile was set on private mode, participants were not allowed to have followers or to follow any other accounts apart from the first author’s account. While it was a useful tool for the authors to check the level of engagement of participants, there has been no direct communication, feedback, or reactions between the first author and the participants via Instagram during the study. We treated the collected outcomes as valuable material to support the final interview.

4.4 Field Study Design and Procedure

As shown in Figure 5, we organized the field study into three main phases: a pre-study phase before sending the *QuintEssence* probe package out, in which we established a one to one relationship with each participant and we collected all the forms for eligibility and consensus (usually lasted one week); the study phase which started when the participant received the box and ended when the participant completed the final task (lasted four weeks); the post-study phase which included the final in-depth interview and shipping the box back (usually lasted three days).

4.4.1 Pre-study Phase. Before finalizing participants’ selection, we set up a video call to describe the study design and explain the tasks to potential participants. After showing the content and scope of the study, participants were asked to fill and sign the information sheet, consent form, and olfactory assessment questionnaire to confirm their willingness and eligibility to take part in the study. They were also asked to share their address, phone number, age, and household condition (e.g., living with the partner) to check if someone could potentially be annoyed by the scents. All the information has been stored in password-protected files accessible only by the first author. As soon as we received the consent form and the olfactory assessment questionnaire, we shipped the probe package to the provided address. In the meantime, the first author, who is the primary person that took care of the front-line communication with the participants, set up the Instagram account.

4.4.2 Study Phase. Once the participants received the package, they were asked to familiarize themselves with the manual and the calendar inside the box but not to unwrap the packages till the first coming Monday. The study phase lasted four weeks and it was composed of three main tasks, explained below and in Figure 4:

- *EssScent task:* carrying around plastic scented bottles, one per week, and sharing experiences and moments while using the bottles via Instagram during the weekdays of week 1, 2, and 3. The three plastic bottles have been previously provided with infused cotton buds of three different essential oils (cinnamon, peppermint, lemon scents). We used cotton buds and not liquid oils to prevent leakage. We included similar bottles in terms of shape, size, and color

in order not to bias the participants (see Figure 3(a)). We randomized the sequence of scents for each participant.

- *EssBody task*: creating body collages using all the materials contained in the EssBody box (see Figure 4). The box was fitted with three smaller packages (one per each week). In each package, we inserted four envelopes containing (i) three body templates (static, dynamic, plain white sheet for self-drawing), (ii) geometrical shapes of different forms and sizes to simulate body parts, (iii) a selection of ten different environments selected through an online survey with thirty-eight participants (two environments rated as natural and stressful, two as natural and peaceful, two as artificial and stressful, two as artificial and peaceful, two as neutral) (see Figure 3(c)), (iv) a selection of nine different fabric swatches from very soft to very rough (listed in Figure 4). Moreover, we provided participants with basic stationery (e.g., glue, scissor, and markers) and a range of seven different emojis (from happy to upset) to express their emotional state (see Figure 3(c)). Participants were required to complete one collage each weekend of week 1, 2, and 3. To have an ambient scent that matches the one smelled during the previous weekdays, we inserted scented incense sticks to be lightened in the room while working on the collages (see Figure 4).
- *EssFun task*: creating a representation of how the participants' favorite scent made them feel. As materials, we included uncolored and unscented modeling clay, the same selection of fabric swatches and emojis as in the EssBody box, and sticky notes to leave comments (see Figure 3(b)). The task was supposed to be accomplished anytime during week 4 (see Figure 4).

During the study, participants received a reminder every Sunday of what to do in the coming week from the first author via email. The data collection took place in November 2020 and end of December 2020. In the Supplementary Material document, pictures of the three tasks' outcomes are included. Respectively, [S1](#) shows some of the Instagram posts collected as part of the EssScent task, [S2](#) clusters all the EssBody outcomes based on the inspired scent, and [S3](#) represents all the EssFun outcomes.

4.4.3 Post-study Phase. At the end of the fourth week, having completed the EssFun task, we invited each participant to schedule a final in-depth one to one Zoom interview with the first author. The aim of the interview was to gather detailed descriptions of participants' experience throughout the entire duration of the study in terms of emotions, feelings, memories, behaviors, body concerns, events relevant to better understand the rationales behind the outcomes of the tasks. The first author conducted the semi structured interviews, focusing on the overall experience, on each single scent and task, participants' personal relationship with scents before, during, and after the study. Furthermore, at the end of the interview, the researcher asked participants' feedback about the design of the package, the use of Instagram, and the choice of the scents. Inspired by [13], at the end of the interview the first author asked participants to envision future wearable garments with an in-built scent delivery system that they would like to have based on their personal experiences with scents in the past month. They were questioned to describe the technology and to describe a moment in the past month when they would have liked to have such a device. By including this question, we wanted to understand more whether our use of the probe methodology could support a participant-led exploration of the olfactory design space, and thus complement technology-focused research. After the interview, participants were asked to ship the box back to the first author's university address.

Upon receiving the box, we analyzed the outcomes from the *QuintEssence* probe package (i.e., the EssBody collages and the EssFun outcome) and the interview transcripts.



Fig. 6. Pictures of all the EssFun outcomes. Each group represents a scent: (a) cinnamon inspired group; (b) peppermint inspired group; (c) lemon inspired group.

4.5 Analysis Approach and Process

The data collected through the deployment of *QuintEssence* probe package were analyzed using a combination of approaches to account for different *QuintEssence* outcomes (e.g., visual and textual media) and to analyze the interview transcripts. The first author coordinated the analysis process and initially familiarized themselves with the data (Instagram posts, EssBody outcomes, EssFun outcomes, and interviews) and pre-processed the data for further analysis and discussion with the co-authors.

4.5.1 QuintEssence Data Description. The EssScent task was carrying around plastic scented bottles, one per week, and resulted in sharing personal experiences via Instagram. The Instagram posts were mainly used to inform and guide the discussion in the final interview (post-study phase) and did not go through a rigorous analysis process.

The EssBody collages were analyzed with regards to the frequency of use of the probe materials (e.g., how many times the same template was selected, what fabric was used the most, what environment). The first author clustered the collages based on the scent and extracted common features within the same clusters. We also added the content from the sticky notes to better understand the rationales behind the collages.

The EssFun visual artifacts were analyzed following an open, descriptive approach and clustered based on the chosen scent as inspiration (see Figure 6). These tangible representations were a useful prompt during the interview to uncover participants’ feelings, emotions, memories, body associations triggered by their favorite scent.

4.5.2 Interview Analysis. The final in-depth one to one Zoom interview was based on the probe materials and the overall experience and gave us additional and deeper insights into the various research topics (see Section 4.6.2). We applied an iterative analysis approach to the interview data.

Initially, the first author transcribed all the interviews and uploaded them in NVivo 12. Then, they created a first version of a codebook applying a deductive approach following the interview questions. This included the following main NVivo nodes: “Activity”, “Scents”, “Feelings/Emotions”, “Memory”, “Scents/Body Awareness”, and “Olfactory Wearable Device”.

Starting from this initial codebook, two other researchers (co-authors of this article) and the first author coded the interviews independently from each other. Each coder used the codebook

and additionally applied an exploratory inductive approach, which resulted in a refinement of the existing nodes and addition of one new node in the codebook.

- “Olfactory Wearable Device” was divided in three sub-nodes: “Device”, “Purpose”, “Scenario”;
- “Feelings/Emotions” was extended by two more sub-nodes: “Influenced by daily life”, “Influenced by scents”;
- Newly added “Meta Reflection” to summarize participants’ feedback on the study itself, acceptance of the *QuintEssence* experience as part of daily life.

The first author and all co-authors then reviewed a final version of the codebook. A second round of coding using the final codebook has been done by the first author.

After this second round of coding, the first author ran designated queries inside NVivo to explore relevant correlations across nodes and sub-nodes. The selection of the queries was based on the primary research aim at exploring the effect of scents on emotions, memories, and body awareness in a daily life environment. We discuss the results in Section 4.6.2.

4.6 Results

Below, the steps and the discussion of our results are described in detail. Figure 7 summarizes the results from the visual artifacts analysis; Figure 8 summarizes the results from the interview analysis. In the following sections, we describe the coding process and the main queries we ran, followed by a description of the visual artifacts.

4.6.1 QuintEssence Probe Package Results. Following the analysis approach described above, we summarize here the key findings from the *QuintEssence* probe package, focusing on the EssBody (see Figure 7) and EssFun (see Figure 6) tasks that follow on from the EssScent task (whose outcomes are the Instagram posts discussed during the final interview).

Based on the EssBody collages, we extracted features such as the type of template chosen, selected emojis, fabrics and environments, and we gathered all the comments and details written by participants on sticky notes to describe their creation (see Figure 7). In Figure 7, we summarize the main commonalities across participants based on the same scent inspired EssBody collages, and we also provide examples of EssBody collages (see Figure 7). As has been evidenced before (see Section 2.2), participants associated cinnamon with feelings of warmth, coziness, happiness, and relaxation. With peppermint, participants expressed a general feeling of relaxation and calm with signals of positivity, happiness, and refreshing sensations. Similarly, with lemon, they expressed a general feeling of positivity, energy, and lightness.

Based on the outcomes from the EssFun task (shown in Figure 6), completed in the final week 4, we made the following observations. Four participants selected cinnamon as their favorite scent (see Figure 6(a)), three selected peppermint (see Figure 6(b)), and four selected lemon (see Figure 6(c)). The four participants, who selected cinnamon as their favorite scent, crafted a peaceful scenery. For example, P06 created a smiley character with a brown wool scarf and a red heart in the middle of its chest (see Figure 6(a)-1). P06’s aim was to represent the feeling of warmth and coziness felt while smelling cinnamon (quote from the interview: “*I put the happy faces because it was a happy scent basically, and I kind of knew I wanted to make something that reminded me of like a warm hug.*”). P10 created a bright flower with orange, yellow, pink colors to express positive feelings (quote from the interview: “*I’m a gardener. So that’s my hobby. And so that’s my little flower (..) there’s a flower that particular absolutely love. It’s a Delia..and it has those colors*”) (see Figure 6(a)-2). P02 created a smiley character covered with a blanket made of wool as a reminder of “*a lovely hug while wearing a snuggly blanket comparing to week 2 and 3 that felt cold and clinical*”.

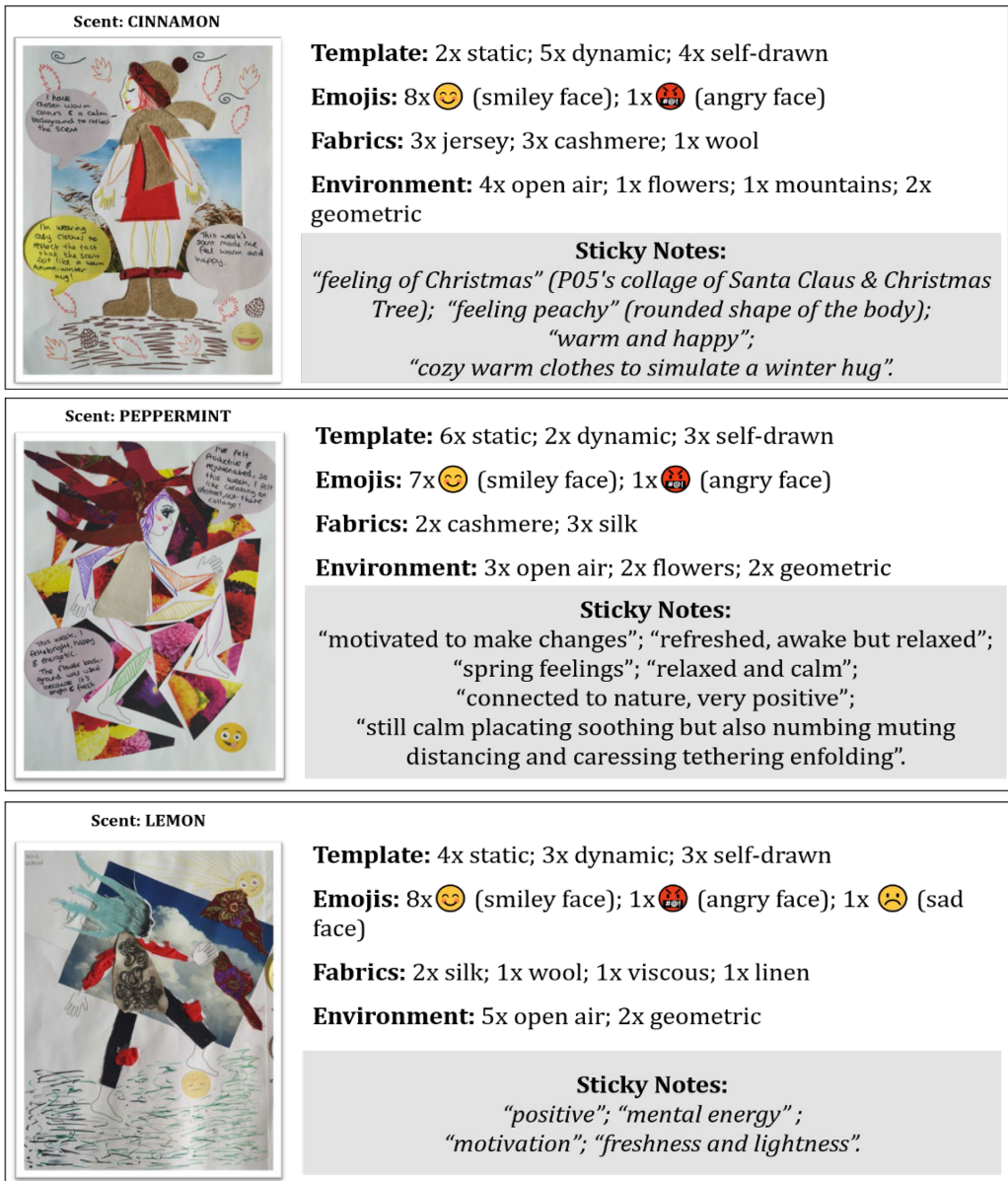


Fig. 7. Overview of the EssBody collages descriptive analysis. In the figure, there is an overview of the templates, emojis, fabrics, environments selected based on each scent. We also reported the comments left on the sticky notes and a picture of one of the collages, as visual examples.

and less comforting.”, as she reported in the interview (see Figure 6(a)-3). P05 made himself fishing because “fishing is my favorite thing basically like my absolute favorite place to be is Sweden and whenever I go there is a place super peaceful and I can just sit off a rock and kind of fish by myself. And it’s like, it’s just the happiest place that I can go basically and when I smell the smell and it made me just feel calm, it’s a similar feeling that I felt when I would go fishing to this place.”, as he reported in the interview (see Figure 6(a)-4).

The three participants, who selected peppermint as their favorite scent, modeled different scenes. One of them [P07] represented a scenery linked with events that happened throughout the past weeks: a fish in the sea (see Figure 6(b)-1) *“..to symbolize being a small fish in the ocean, surrounded by a bigger fish just like the world. Currently there’s always going to be someone bigger but doesn’t mean they’re better”* as reported in the interview. P04 made an association with past memories where peppermint was a reminder of childhood, a swing, and the after eight chocolates (see Figure 6(b)-2) *“I am a very nostalgic guy and it always brought back memories of childhood”*. P11 used visual metaphors to express the feelings elicited through the peppermint scent (see Figure 6(b)-3): a thumb up as *“it made me feel good and motivated”*, a lightning bolt to *“describe mental clarity and sharpness”*, and a flower to *“describes freshness and lightness felt”*.

The remaining four participants [P01, P03, P08, and P09] selected the lemon scent as their favorite scent. P1 represented a half body human character attached to the ground with an arm raised towards the sky (see Figure 6(c)-1). The sculpture was a metaphor of an *“uplifting feeling that I wanted to get from it. (...) The person being stuck in the ground but there was that sense of being taken up. The spikes are supposed to be metaphors for the things, causing stress, anxiety or discomfort”*, as he stated during the interview. P03 created a positive natural scenery with sun, clouds and birds (see Figure 6(c)-2) because *“it reminds me of a fresh summer day. I put a happy emoji as this is how the scent made me feel. It reminds me also of the good week I have had.”*, as stated on the sticky notes. P08 created a familiar environment, close to his house, mixing nature and urban landscapes (see Figure 6(c)-3) *“I was sort of trying to recreate myself in that kind of natural environment. But also trying to represent that there’s an urban environment as well. Maybe it’s meant to be like the part behind my house that I was mentioning. There’s my residential estate and then I walk on to the park and then it’s all very nature”*, as stated in the interview). P09 associated the scent with a swimming pool and he used the modeling clay to create the layout of a pool, the blue material *“to kind of show the water”*, three emojis *“to sort of show like the feelings that people would have when they are in certain areas of the pool so that it would be like the shallow end which is kind of like it’s all smiles and then this is getting a bit towards the middle and that’s getting towards a deep and then when you get to the deep, you start to feel a bit shocked”* (see Figure 6(c)-4).

In summary, we see a range of different feelings/emotions and memories expressed through the EssFun visual artifacts (see an overview in Figure 6). It is also interesting to note that lots of creations represent human bodily characteristics. We used them as prompts in the interviews to obtain more insights into the effect of scents on the participants’ emotions, memories, and, especially, body image.

4.6.2 Interview Results. Following the above-described analysis approach and iterative coding process applied to the interview transcript, we identified seven main themes (i.e., NVivo nodes): “Activity”, “Scents”, “Feelings/Emotions”, “Memory”, “Scent/Body Awareness”, “Olfactory Wearable Device”, and “Meta Reflection”. “Activity” refers to the EssScent (i.e., Instagram posts), EssBody, and EssFun outcomes, which were used as prompts in our semi-structured interviews (see detailed explanation in Section 4.5.2). The “Meta Reflection” node aimed to gather feedback on the study participation and the use of materials. However, we did not use this node to answer the main research questions. Thus, we were left with five main themes which we ran through queries in NVivo to explore correlations amongst the main themes and sub-themes. In the queries we focused on the main research questions on how the three scents affect participants’ emotions, memories, and body image in a daily life environment. Figure 8 shows an overview of the main findings, which we summarize below, also including findings on the “Olfactory Wearable Devices” theme.

Concerning the effect of scents on emotions, we analyzed the effect of each scent (“Scents”) on feelings (“Feelings/Emotions”) for each task (“Activity”: “EssScent”, “EssBody”, “EssFun”). We

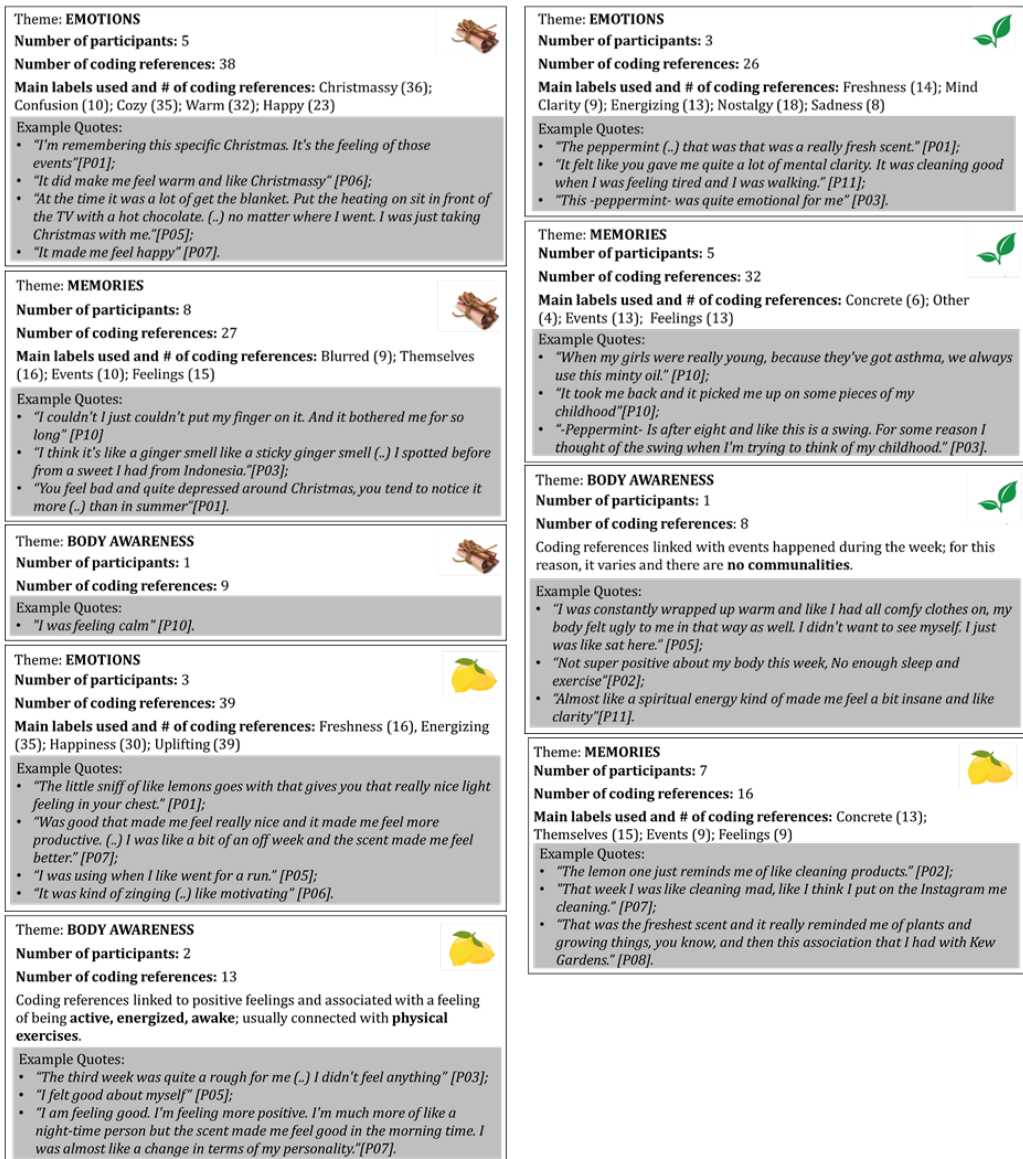


Fig. 8. Results of the interview analysis. We divided the results based on the three scents (cinnamon, peppermint, and lemon) and the three main themes (emotions, memories, and body awareness). We reported the numbers of participants and coding references. We also reported the labels (nodes in NVivo) most frequently used to describe each scent in relation to each theme. Below each coding and frequency references, we provided examples of quotes taken from the interviews.

found that the same scent elicits similar feelings/emotions during different tasks. In Figure 8, we reported the adjectives most used, the number of coding references per task and the total number, the number of participants that used such description, meaningful quotes to show examples of how participants described their own feelings and emotions caused by the scents. For example, while smelling cinnamon scent, participants reported strong feelings of “Christmassy”, “confusion”,

“coziness”, “warmth”, “happiness”. Concerning peppermint scent, the predominant feelings were “freshness”, “mind clarity”, “energizing”, “nostalgia”, “sadness”. Concerning lemon scent, the most shared feelings were “freshness”, “energizing”, “happiness”, “uplifting”. Overall, we can state that all the three scents elicit mainly positive feelings/emotions. There are clear distinctions between cinnamon, peppermint, and lemon. However, there is some overlap between lemon and peppermint. Indeed, both of them elicit a fresh energizing feeling, but lemon also stimulates an uplifting vibe, and peppermint is linked with mind clarity and reflections and memory.

Concerning the “Memory” theme, as shown in Figure 8, we found that different scents elicit different types and characteristics of memories. Similar to the emotions, in Figure 8 we presented the main labels we used to cluster memories, the number of coding references, the number of participants that used such description, and meaningful quotes. With cinnamon scent, we coded more blurred memories (in terms of the dichotomy “blurred” vs. “concrete”) of past moments (in terms of the dichotomy “long-term” vs. “short term”) about participants (in terms of the dichotomy “themselves” vs. “others”). With peppermint scent, participants reported more concrete memories about others’ events. With lemon, participants reported more concrete memories of themselves about recent events.

Concerning the body image, we found less categorical results. As meaningful effects of scents on body image, we focused on all the quotes in which participants mentioned their own body in terms of energy, physical activities, wellbeing, interest in themselves, bodily sensations. We could extract three different approaches to the body image, shown in Figure 8. With cinnamon, participants reported a general feeling of being calm and peaceful. With peppermint, we did not find major commonalities because each reference to the body image was strictly connected to personal events that happened that week, instead of the scents. With lemon, we found a common sense of being energetic and happy, often linked with a boost for physical exercise.

In summary, based on the data collected and analyzed, we found that each of the three scents can elicit peculiar feelings, emotions, and memories. Indeed, while lemon and peppermint can be sometimes similar, cinnamon is different in terms of how it is perceived and how it makes participants feel. However, concerning the effect of scents on body image, we faced difficulties in finding strong commonalities between participants experiencing the same scent, and even within each single participant’s experience of different scents. We argue that the effects of scents on body image are very subtle and require further investigations, and that the richness of the data we have gathered offers first indications for the latter.

4.6.3 Ideas for Future Olfactory Wearable Technology. In a recent study, it has been found that smell can be a relevant material for designing experiences and future technology [13]. Inspired by this publication, as part of the final interview, we asked the participants the question “If we go beyond the study, what type of scented technology would you most desire to use?”. We wanted to further explore how smell can become part of the designing process to ideate and create future technology through qualitative investigation techniques, and which type of physical implementation people can envision.

Participants described a range of wearable technologies as inspiration for future research and design opportunities around smell and the body. As indicated above, in the codebook there was a main theme labeled “Olfactory Wearable Device” with three sub-themes: “Device”, “Purpose”, and “Scenario”. Each participant was asked not only to think about a technology (i.e., device) but also to explain the reason for suggesting such choice (i.e., purpose), and to describe in which specific events and conditions participants would like to have such device (i.e., scenario), what effect they expect to experience from the release of the scent, and what command should trigger the release

of the scent. Below, we briefly present participants' responses to exemplify the variety of ideas for future scented technology:

- P01: “a scented t-shirt for Zen days and something more manual for when you are anxious like a presentation.. something that really helps you to relax, put you in that separate space for a few minutes like a bracelet or a necklace”;
- P02: “scarf because it's close to you and then it's because I think I do it for me, rather than for someone else (..) something goes over you”;
- P03: “something on the sleeves..or the key ring is fine (..) because when you are outside, everything changes so much so many smells and stuff..will be nice to have that kind of smell with you going outside.”;
- P04: “something small to carry around while working or going for walks (..) it keeps me really focused.”;
- P05: “something that you can control and clip inside your clothes. Only spreads far enough that you notice.”;
- P06: “something like earrings or a watch to have a scent that you want to even be able to tone down or tone up (..) a Fitbit for example that like monitors your heart rate and things like that and you associate a scent.”;
- P07: “a jumper, something cozy and comfortable”;
- P08: “like a handkerchief or something on the key on a key ring that you can just get out and then this sniff whenever you want.”;
- P09: “like a blazer which radiates a nice perfume; it's the basic idea behind wearing perfume..So if it was actually able to give that scent consistently, it would kind of be like re spraying the perfume.”;
- P10: “a t-shirt or a handkerchief”;
- P11: “Like an app or something where you could put into the app how you want to feel (..) And the app can then generate a scent that matches what you wanted to feel. (For example), I hate driving, so it'd be quite handy to be able to use technology to design a scent that was going to help chill me while I was in the car”.

In summary, we gathered insights useful for design thinking and the user centered design process, especially to help in the early stages of understanding users' needs and the ideation stage. In the following section, we discuss our main findings from the field study, highlighting implications for future directions, both from a design and research point of view, and focusing on the main limitations that we have faced.

5 DISCUSSION

In this article, we present a four-week field study adopting the cultural probes approach. We designed our own *QuintEssence* probe package and ad hoc tasks to complete during the study phase. We focused on how scents impact on daily feelings and emotions, different types of memories, the broad concept of body image (bodily perception and bodily feelings). We engaged with people out of academia or industry, who had no previous experience of research and no knowledge about the theoretical concept of body image perception and multisensory stimulation. We are aware that people often struggle in deeply thinking and verbalizing their own emotions, memories, and especially bodily feelings. For this reason, we argue that our findings can be seen as the first step towards the definition of a research program focused on stepping out of a laboratory environment towards a more complex and unpredictable setting, i.e., daily life, and they might enhance and inspire further research supporting the capturing and sharing of smell-related personal experiences, especially towards the body. Indeed, recently, the role of the body in design is gaining

growing attention (e.g., [85]). We focus on the experiences elicited primarily by the new element we introduced in participants' daily life, i.e., scents, and we explore how this new element affects participants' emotional side, and personal bodily feelings. We did not involve designers at this stage, but we gathered feedback and experiences from the participants with the aim of later inspiring designing opportunities. Indeed, our study can be seen as a first investigation for future collaborations with expert designers to create tangible wearable technologies and meaningful experiences. Here below we discuss the novelty of our approach, the implications of our findings for research as well as design in HCI, the limitations we faced, and possible opportunities for future work.

5.1 Emotional Effects of Scents on Memories

Based on previous literature, we know that scents meaningfully impact on emotions and memory. However, we are also aware that the perception of scents and how they affect people's psychological needs is subjective and can be hardly detected in a daily-life environment. However, using a cultural probes approach we did not aim at finding rigorous and replicable results, but we wanted to *"give participants a voice to interpret and explain their own practices"* [8]. For this reason, in the final interviews we separately coded when people were referring to emotions and memories ("Feelings/emotions" and "Memories"), when the recalling was due to variables rather than the scents per se ("influenced by scents" and "influenced by daily life"), and we also used more detailed description labels (e.g., for emotions "energizing", "uplifting", "calming", for memories "blurred", "about others", "about events"). We analyzed how frequently each of the aforementioned labels is used in relation to each scent.

We found that lemon and peppermint scents present some commonalities in terms of elicited feelings/emotions (e.g., "energizing", "uplifting", "fresh"). In contrast, cinnamon presents different descriptors (e.g., "Christmassy", "cozy", "warm"). These findings are in line with previous research showing that peppermint and lemon are both highly arousing, while cinnamon is less arousing [13]. Concerning the effects of scents on memory, we found similar results. Lemon and peppermint scents present commonalities, such as recalling concrete memories. Cinnamon, on the contrary, has been mainly associated with the recollection of blurred memories. Smell can have a regulating impact on a person's mood and can play an important role in remembering the past. We argue that our findings not only provide rich descriptions of single scents, but also related qualities of scents in combination with daily life events useful for designers to recreate smell-enhanced multisensory experiences in wellbeing research in HCI. A possible next step would be to replicate the field study with more participants, in different countries, with diversified ethnicities, and with more scents, to gather further findings and create categorizations similarly to [60]. Gathering more evidence, designing for scenarios around memory using olfactory technology can therefore build on our field study as a first step to understand actual real-life scenarios.

We also collected tangible outcomes showing emotions and memories linked to a well-defined scent through the EssFun task. This type of outcome can inspire various design opportunities. Indeed, even if the EssFun outcomes are very individual and hardly generalizable, it is still interesting noticing how participants used the modeling clay to show their emotions and memories starting from a scent. Moreover, we provided participants with fabrics, emojis, and colored markers to implement and enrich their outcomes. At the end, each final creation is a multisensory representation of the emotional effect of scents. We argue that our EssFun task, more than the final outcomes themselves, can be of particular interest for artistic purposes, e.g., art installations or workshops to visualize and share the emotional effect of scents. Due to the low cost of the materials and the playfulness of the task, we also envision possible applications with children,

elderly, or people who struggle to share and speak about emotions and feelings (e.g., autism). In summary, since our study is a first investigation of the effect of scents on emotions, memories, and bodily feelings in a real-world environment, future collaborations with expert designers can be envisioned. For example, we envision possible opportunities for collaborations with fashion designers to create tangible wearable outcomes, as well as with user experience designers to create multisensory experiences to enhance wellbeing and behavioral change, and home automation to recreate a better living environment.

5.2 Relationship between Body Image and Smell

While the above section discusses results on the effects of scents on emotions and memories based on both QuintEssence probe package data and interviews, we did not find strong claims concerning the body image, as expected. Indeed, studying body image is very complex and requires considering not only the perception of the body as a whole but all the emotions, memories, and social influences that impact on the creation and the recurring change of this concept. The focus on body image and smell was our research impulse to, for the first time, move away from rigorous laboratory scenarios and land in a daily life environment. We designed the EssBody task as a prompt to gather more information about the effect of scents on body image. Based on the collected results, we found that participants often implicitly addressed their own body image mentioning how energized the scents made them feel, how much they were involved in physical exercises, how much they felt tired and dizzy (“*I was feeling calm*” [P10]; “*I was trying to be quite active as I start running again and I take it [the scented bottle] with me*” [P05]; “*[The lemon scent] wasn’t happy. The third week was quite a rough for me. I couldn’t sleep at all*” [P03]; “*Not super positive about my body this week, no enough sleep and exercise*” [P02]).

Analyzing the EssFun outcomes, we noticed that most of the artifacts represent human features (i.e., full body, upper body, body traits). Indeed, in line with [12, 13], in which cinnamon has been found to be associated with thick body silhouettes and lemon and peppermint with thin body silhouettes, two out of three participants crafted a rounded body shape inspired by cinnamon (shown in Figure 6(a)-1,3), one out of three represented a thin body silhouette inspired by peppermint (shown in Figure 6(b)-2), and two out of four represented spiky human-like characters inspired by lemon (shown in Figure 6(c)-1,3).

Expanding our results in future workshops could explore further correlations between scents and body silhouettes. Likewise, future field studies with more structured questions and tasks (e.g., direct questions, more interviews throughout the study) could help overcome the difficulty and novelty of sharing insights, thoughts, feelings directly linked with the body. Another possibility for future work could include working with people experienced in mindfulness or meditation or including training for all participants before taking part in the study to be more aware of their own body using such techniques.

5.3 Opportunities for Wearable Olfactory Garments

Asking participants which scented garment or tool they would like to have, we aimed at gathering possible opportunities and applications for future multisensory wearable design. We used the same scenario as in [13]. However, differently from [13], instead of experienced designers, we questioned end users and we focused not only on the description of the garment per se, but also on possible applications and scenarios. We found interesting results that range from small and intimate accessories (e.g., necklaces, earrings, bracelets), to pieces of clothing (e.g., t-shirt, blazer, scarf). We clustered three main themes behind the choices and the goals of the garments: to boost physical activities (“*With the smell [lemon scent], I was almost trying to wake myself up as*

much as I would when I'm about to try and go for a long run" [P05]), to increase self-confidence (*"I wouldn't actually mind like maybe like a blazer or something like that, which radiated kind of like a nice perfumes"* [P09]), to relax and calm down (*"something that really helps you to relax, put you in that separate space for a few minutes like a bracelet or a necklace"* [P01]). Even if we did not ask participants to create any tangible outcome to show their ideal wearable design, we foresee future collaborations with fashion designers to create tangible outcomes starting from the collected end-user perspective.

Within the HCI community there is a growing interest in research and design of similar technologies. Indeed, building on recent research efforts about smell-delivery systems and fashion design, Amores and colleagues developed a series of wearable accessories able to release in a controlled and precise way scents [2], based on biometric or contextual data (e.g., heart rate and respiration [1]). Most recently, Wang et al. designed on-face olfactory wearable interfaces that are lightweight and can be adhered to the skin or attached to face accessories [79]. However, nowadays all the available on-body olfactory technologies have critical limitations (e.g., cumbersomeness, not fashionable, limited number of scents) and they have been created mainly for research purposes. We can envision future opportunities to create smart multisensory tools (e.g., the Google Jacquard program or the Azalea cushion that mediates an embodied co-experience between remote interlocutors via a motion-driven soundscape and audio-driven visuals [38]) with scent delivery in-built systems.

In line with all these recent findings and artifacts, the outcomes from the interviews can be taken and applied by designers as rich inspirations to create tangible garments and, more broadly, meaningful experiences. In fact, we argue that starting from our data and reflections upon the data, it could be insightful to develop structured descriptions of fictional characters to inform designers and practitioners about the possible experiences that people feel and face when exposed to scents in everyday life. For example, the creation of experience characters can be relevant to focus on how scents impact a person's daily life, what reactions can be expected from the introduction of scents in field environments, and what technology can be designed to activate emotions, memories, and body awareness. This knowledge can be applied in several environments with different goals: from leisure purposes (e.g., creating multisensory installations in public space, using multisensory stimulation to engage people) to clinical purposes (e.g., using multisensory stimulations to help people recovering from low-mood and depression). As proposed by [59], the creation of experience characters can be relevant to focus on how scents impact on a person's daily life, what reactions can be expected from the introduction of scents in field environments, and what technology can be designed to activate emotions, memories, and body awareness.

5.4 Methodological Variation and Participants' Comments

As previously explained, the cultural probes approach does not involve a predefined list of materials and tasks. It can change according to the aim of the study and the target users. In our case, we designed our *QuintEssence* probe package in order to explore the effect of scents on emotions, memories, and body image in daily scenarios. Our variation is based on previous literature [31, 32, 42], and at the same time the addition of new elements, such as the creation of ad hoc tasks. We ran the study between November 2020 and January 2021 (last interview), during the second UK national lockdown. While designing the package, we had to face ethical concerns related to the spread of the COVID-19 virus. For this reason, we included hand sanitizer in the probe package, and we attached labels reminding participants to wash their hands and stay safe. Moreover, due to the pandemic, we had to schedule the in-depth interviews via the Zoom platform, instead of in person.

To gather participants' feedback about our methodology, at the end of the interviews, we asked them comments about the overall study design, the content of *QuintEssence*, and the use of Instagram. We gathered positive feedback about the overall study design (*"Everything was perfect, such as everything is really easy to understand. So I really enjoyed it."* [P03]). Participants reported a general feeling of enjoyment and engagement, despite the length of the study (*"I did enjoy it, to be honest. One it was something different; two taking time out to smell something gets you to relax"* [P10]). None of them described the study as too long or unclear. All the tasks were clearly understood and successfully completed (*"It was all quite easy to understand, and it's all quite nicely done"* [P06]). Participants also stated that the provided materials were adequate to express themselves. Participants found the use of Instagram innovative and engaging (*"Really good and I liked it. It was kind of integrated into something that I do daily anyway"* [P05]; *"It was I think the best way to do it straightforward. Everybody knows how to use Instagram."* [P06], *"I thought it was actually really good way of sharing."* [P02]), as well as carrying around the scented bottles (*"it [carrying around the bottles] was fine, because of the key ring thing. It made it really handy I just had it attached to my car keys. So, it was really it was like, I didn't even have to think about it"* (P04); *"the physical design of it [scented bottle] was funny"* [P02]). The main complaints were about the use of the incense sticks (*"the ash kept falling outside of the cup. I was a bit annoying when I had to clean up"* [P03]; *"the cinnamon one, I actually just preferred smelling it [the bottle] rather than using the incense stick"* [P05]) and the intentional lack of clear instructions about how many times participants were required to post updates on Instagram (*"The things that I was unsure about, I think, was the things that I ended up checking with you like the kind of post content and frequency. It wasn't entirely clear you know how often I had to post."* [P01]).

Based on our own and participants' experiences, we therefore argue that the design of our field study and our variation of the cultural probes package, provide guidelines for further reiterations of our ad-hoc designed tasks and selected materials. Even if the primary aim of this article is not to focus on the methodological contribution, we envision further studies to explore the methodology itself engaging the field in qualitative work outside controlled laboratory settings.

5.5 Limitations

Although we discussed several implications of our work as described in the above paragraphs, we also need to acknowledge some limitations of the field study.

Firstly, the limited sample size. Only 11 participants fully completed our study. We are aware that it is not enough to state generalizable findings. However, this number is in line with previous literature that adopted qualitative methods. For example, in [6], the authors recruited 16 participants, in [85], the authors recruited five participants, in [31], the authors recruited five couples.

Secondly, the topic of body image is a very complex topic which requires more effort to be explored, especially in the daily life environment. Indeed, we are not used to talking and expressing our body image concerns, unless in relation to other events that directly involve the body, such as doing physical activities or dressing [70]. Our study is a first attempt to study how scents impact body image in a daily environment considering all the facts and events that might influence and affect the final perception. We did not find clear results on this relationship based on the data collected through the *QuintEssence* probe package and the final interviews. We argue that such lack of clarity can be due to the tasks, not explicitly involving and addressing the body, and the fact that the only information-sharing between the participants and the researcher (i.e., final in-depth interview) was at the very end of the study as a recollection of memories about the past month.

Thirdly, as briefly addressed in Section 5.4, we ran the study during the second national lockdown in the UK. Our results have been affected by the COVID -19 pandemic and its consequences (e.g., lockdown, social distancing, and loneliness). Similarly, we found a strong influence of Christmas since most of the participants completed the study closer to or during the Christmas holidays. For this reason, we found connections and links between the study's outcomes and generally the Christmas theme, especially when smelling cinnamon. The combination of COVID -19 lockdown and Christmas caused frequent nostalgic and sad feelings and memories, and a general search for warm and soft experiences, often explicated into the need of "warm hugs" ("*it [the EssFun outcome] was like a hug, in a sense.*" [P06]) and "social interaction" ("*At the moment we've been locked down you cannot like see people and you can't hug anyone and everything like that.*" [P01]). Future iterations of the study should, therefore, center on a different period of the year, far from Christmas, and out of long-lasting emergencies such as national lockdowns.

6 CONCLUSION

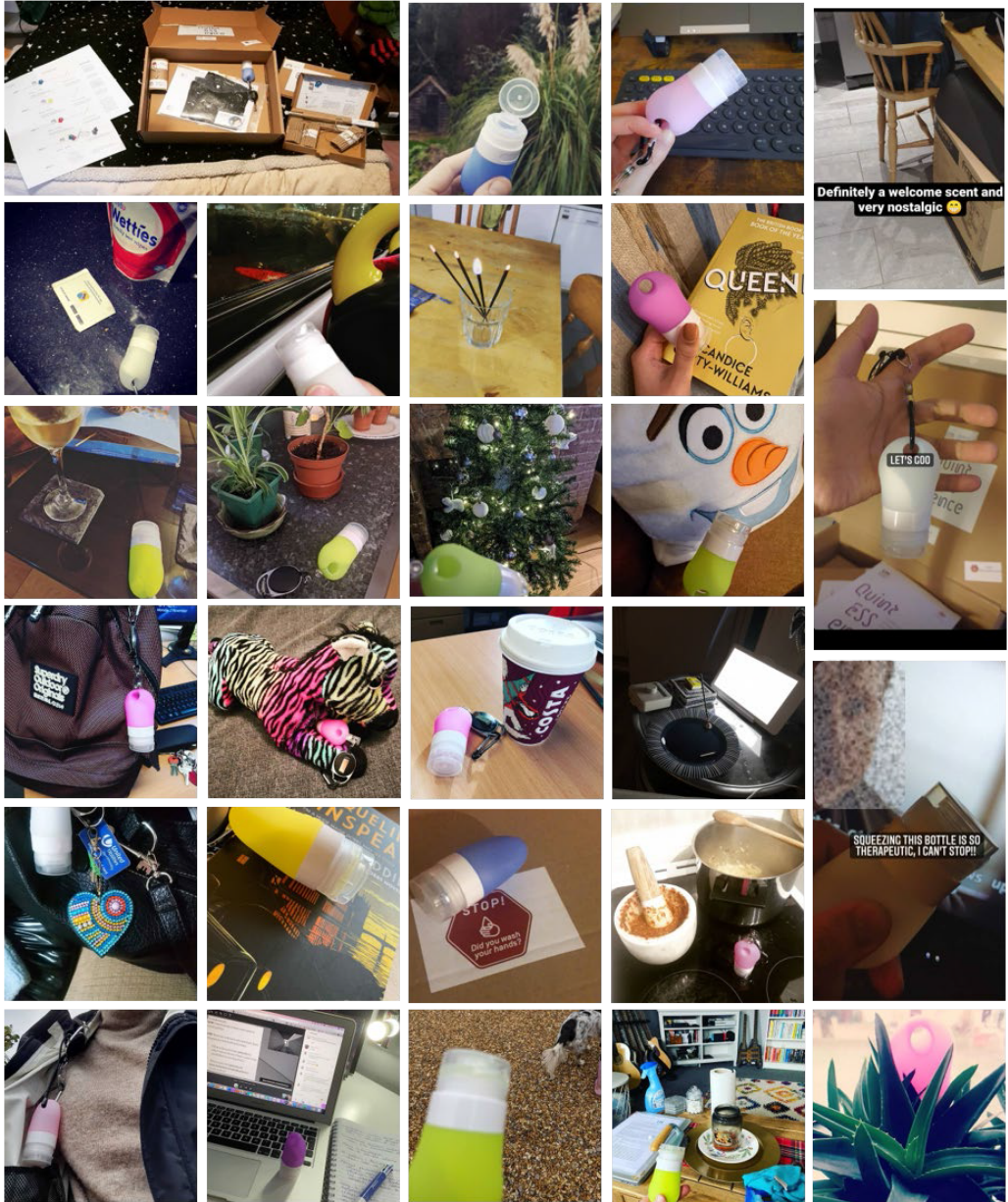
It is long known that smell is a powerful sensory modality that affects emotions and memories. Recently, we started to unlock its effect on body image as well. In this article, we described our four-week field study and the design of *QuintEssence*, a variation of the cultural probes approach to encourage people to be more aware of the effect of smell on emotions, its peculiarity to recall memories and affect body image. We presented the findings based on the *QuintEssence* outcomes and the final one to one in-depth interview. We discussed the emotional effect of different scents and the opportunities for recalling past experiences through scents. Moreover, as our main novel contribution, we explored the role of scents on affecting the complex topic of body image perception in everyday life environments. Our findings provide guidance for designing smell enhanced experiences in HCI. We extracted not only personal approaches to the use of scents in daily life, but also common features for each scent shared by all participants. For instance, cinnamon scent led to feelings of warmth and coziness, and recalling of personal blurred memories, peppermint scent was mainly associated with fresh, calm, and nostalgic sensations, lemon scent was often associated with positivity and energy, and positive and active bodily feelings). We argue that this research enriches existing knowledge on smell in HCI and future design applications.

SUPPLEMENTARY MATERIAL

This supplementary material contains:

- (1) **EssScent outcomes:** a selection of some of the pictures taken by participants during their four-week study and published on Instagram.
- (2) **EssBody outcomes:** a collection of collages made by the participants at the end of each week. At the end of the 4-week period, each participant did three body collages (one per scent condition). They were provided with several materials: two types of body silhouette (static vs dynamic), body parts (i.e., abstract, rounded, spiky shapes), 9 fabric swatches, 10 pictures showing different environments, a pencil case with scissors, glue, 16 colour markers, sticky notes, emoji stickers.
- (3) **EssFun outcomes:** a collection of handcrafted outcomes made by the participants during week 4. They were asked to create a representation of how the participants' favorite scent made them feel. Participants were provided with several materials: unscented modeling clay, 9 fabric swatches, emoji stickers, sticky notes.

S.1 Selection of Pictures Taken from the Participants and Published on Instagram



S.2 Collages Made by Participants During the Weekends, Grouped by Scent Condition

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S.3 EssFun Outcomes Made by Participants During the Fourth Week



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