"Abhushan"
A Jewellery Based Wearable
Smell Interface to Explore
the Effect of Smell on
Social Interactions

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Abstract

Smell is affecting the way we interact with our environment and with each other, even if we are not aware of it. To explore the effect of smell on social interaction we designed *"Abhushan"* (åbhūshana), a jewellery-based wearable smell interface. In a pre-study, we examined the social acceptability of the wearable with eight users over a duration of two days. Our users reported considering private spaces for social acceptance for such a wearable. Findings from this study led us to design our main experiment where we performed a within-subject experiment with eleven pairs of participants to . The aim of the experiment was to understand the effect of smell on social interactions based task. Exposed to a smell and no smell condition, participants were asked to collaboratively write a story about a standardised visual stimulus.

We analysed the stories, alongside observation and interview data, using a *multi-domain analysis framework* from HCI, psychology and sociology. Our results suggest that people tend to be convinced that smell has no impact on them. However, analyzing the stories along with recorded videos we observed that the quality of communication was more comprehensive with smell. We discuss possible implications of our results, especially in the context of facilitating creative activities and brainstorming with smell.

Überblick

Geruch beeinflusst die Art und Weise, wie wir mit unserer Umwelt und untereinander umgehen, auch wenn wir uns dessen nicht bewusst sind. Um die Wirkung von Gerüchen auf die soziale Interaktion zu untersuchen, haben wir textit "Abhushan" textipa (åbhūshana) entwickelt, eine auf Schmuck basierende, tragbare Geruchsoberfläche. In einer Vorstudie untersuchten wir die soziale Akzeptanz des Wearables bei acht Nutzern über einen Zeitraum von zwei Tagen. Unsere Nutzer gaben an, private Bereiche für die soziale Akzeptanz eines solchen Wearables in Betracht zu ziehen. Die Ergebnisse dieser Studie haben uns dazu veranlasst, unser Hauptexperiment so zu gestalten, dass wir ein themeninternes Experiment mit elf Teilnehmerpaaren durchführen konnten. Das Ziel des Experiments war es, die Auswirkung von Geruch auf die auf sozialen Interaktionen basierende Aufgabe zu verstehen. Die Teilnehmer waren einem Geruch und keiner Geruchsbedingung ausgesetzt und wurden gebeten, gemeinsam eine Geschichte über einen standardisierten visuellen Reiz zu schreiben.

Wir analysierten die Geschichten neben Beobachtungs- und Interviewdaten mit einem textit Multi-Domain Analysis Framework von HCI, psychology and sociology. Unsere Ergebnisse lassen vermuten, dass die Menschen davon überzeugt sind, dass Geruch keine Auswirkungen auf sie hat. Bei der Analyse der Geschichten zusammen mit aufgezeichneten Videos stellten wir jedoch fest, dass die Qualität der Kommunikation mit dem Geruch umfassender war. Wir diskutieren mögliche Auswirkungen unserer Ergebnisse, insbesondere im Zusammenhang mit der Erleichterung kreativer Aktivitäten und dem Brainstorming mit Gerüchen.

Acknowledgements

First of all, I would like to thank all participants who participated in the user studies conducted for this work. Thank your for your constructive feedback.

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Special thanks go to Prof. Marianna Obrist for helping me with her constructive feedback throughout this thesis. Your wisdom of knowledge motivated me to explore in domain of Olfactory interfaces. The collaboration with her influenced my choice for choosing Prof. Obrist as second examiner. Special thanks go to Prof. Jan Borchers for providing me the necessary facilities and feedback on the *Abhushan*.

I would like to thank my parents for all their support. Thank you so much for always having an open ear and encouraging me to keep moving along my path. I would also like to thank my brother & his wife for filling my gap back at home.

Finally, I want to thank my partner Srishti Dang who always had more confidence in me than I had myself. You forecasted every single step of my career in the last four years and although I had trouble believing you back then I must admit you were right all the time. Whenever I have doubts again, I will recall your voice. Among everything I learned from you, the one thing that I value most is that you encouraged me to always think big and to extend my definition of big at every step along the way. Thank you for all your emotional support, it means a lot to me.

Conventions

Throughout this thesis we use the following conventions.

Text conventions

Definitions of technical terms or short excursus are set off in coloured boxes.

> **DEFINITION OF A TERM:**
> This is an empty definition of a term.

Definition:
Definition of a Term

Scenarios are set off in green boxes.

> **EXPLANATION OF A KEYWORD:**
> This is an empty explanation.

Keyword:
Explanation of a Keyword

Examples are set off in blue boxes.

> **EXCERPT FROM REFERENCES:**
> *This is an empty excerpt reference.*

Excerpt:
Excerpt from References

Implementation symbols are written in typewriter font.

```
method()
```

The whole thesis is written in American English. For reasons of politeness, unidentified third persons are described in female form. The first person is written in plural form.

Chapter 1

Introduction

Human-Computer Interaction (HCI) follows the path of integrating technology into peoples everyday physical life. The user experience should become smooth and natural without the user realising that technology is all around them. Out of the five basic human senses shown in Fig. 1.1 - sight, hearing, smell, taste and touch - smell is still at an embryonic stage even if it holds great potential for HCI and influences user behavior significantly [Lynch, 2015].

Smell is least explored in HCI among all the senses.

Figure 1.1: The Human Senses and Sense Organs.

Adding a chemical sense to technology opens up new opportunities for interfaces and the interaction with it [Obrist et al., 2016]. More importantly, smell research promises to deliver a step-change in our understanding for senses of human as interaction paradigms within the field of HCI [Maggioni et al., 2019].

Definition:
Olfactory perception

> **OLFACTORY PERCEPTION:**
> "Olfactory Perception is a process that starts in the nose with the stimulation of olfactory sensory neurons and terminates in higher cerebral centers which, when activated, make us consciously aware of an odor." - [Slotnick and Weiler, 2009]

Smell evokes
memories stronger
and vivid.

Olfactory perception takes an important position in the neurological processing of sensory stimuli as the olfactory bulb is connected to the two brain areas that control emotions and memories. Compared to other modalities, memories evoked by smell give stronger feelings of being brought back in time, are more emotionally loaded, are experienced more vividly, feel more pleasant, and are autobiographically older (ranging back to childhood) [Obrist et al., 2014].

We as humans
always least
understood the
smell.

Smell based communication has been one of the oldest methods of communication and chemical based communications such as scents is of the least understood forms of communication. People are constantly using their sense of smell whenever they involve in a social interaction. Even though we are not very aware of doing so, our brain is responding to the odor [Sullivan et al., 2015]. They are like invisible social magnets that communicates below the level of our consciousness.

1.1 Power of Smell

Humans have five senses however; current technologies are purely vision's dominated over other senses. Among the so-called "five senses", olfactory perception takes an exceptional position in the neurological processing of sensory stimuli. Compared to other modalities, memories

evoked by smell give stronger feelings of being brought back in time, are more emotionally loaded, are experienced more vividly, feel more pleasant, and are autobiographically older (ranging back to childhood) [Obrist et al., 2014].

Smell has a primary connection with our memory and how we feel. When we first smell a new scent, we link it to an event, a person; we link it to the feelings and sensations that we are experiencing at that time. Smell is incredibly powerful in connecting humans to past events and experiences [Larsson et al., 2014]. A growing body of research promotes the use of essential oils and fragrances to support mental well-being. For instance, several studies have shown that scents such as jasmine, lemon or lavender can help reduce anxiety and pain, as well as improve sleep and depression [Kim et al., 2005].

Essential oils helps in supporting well-being.

Other studies show that stress and anxiety can be reduced with the use of essential oils. A group of researchers administrated Heliotropin (a vanilla fragrance) to patients undergoing cancer treatment [Redd et al., 1994]. The results reported that the association of fragrance was associated with 63% less anxiety compared to the placebo effect. These results demonstrates that smell not only plays an important role in evoking emotions but can be a useful in the domain of well-being and medical interventions.

Smell studies have shown a positive impact on reducing anxiety.

1.2   Human Physiology

Olfactory perception takes an important position in the neurological processing of sensory stimuli as the olfactory bulb is connected to the two brain areas: the amygdala and hippocampus, see Fig. 1.2. The entorhinal cortex projects to the amygdala and is involved in emotional and autonomic responses to odor. It also projects to the hippocampus and is involved in motivation and memory. Odor information is easily stored in long-term memory and has strong connections to emotional memory [Phelps, 2004]. This is possibly due to the olfactory system's close anatomical ties to the limbic system and hippocampus, areas of the brain that

Amygdala and Hippocampus play a major role in Olfactory Perception.

have long been known to be involved in emotion and place memory, respectively [Bartoshuk, 1991].
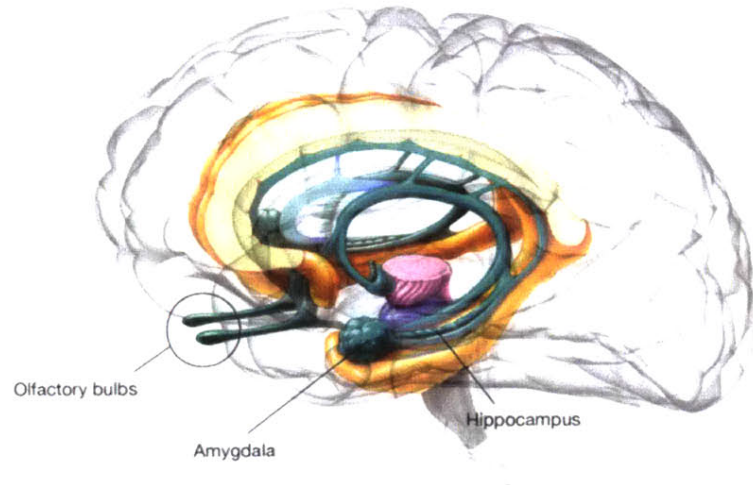
Figure 1.2: Image of a human brain, in color is the structure of the Limbic System. Design by Judith Amores.

Keyword:
Olfactory Bulb

OLFACTORY BULB:
The olfactory bulb is a structure of the vertebrate forebrain involved in olfaction, the perception of odors.

Keyword:
Amygdala

AMYGDALA:
Located deep in the brain's medial temporal lobe, the almond-shaped Amygdala is believed to play a key role in the emotions.

Keyword:
Hippocampus

HIPPOCAMPUS:
The hippocampus is a part of the forebrain, located in the medial temporal lobe. It belongs to the limbic system and plays major roles in long term memory and spatial navigation.

Smell is a very complex and deep sense, very different from the other four senses. The sense of smell differs from the other forms of perception in the direct connection between our olfactory receptors and the limbic system, our emo-

tional center. The sense of smell opens up the cognizance to connect humans to their experiences by adding smell as a layer on top. This layer holds potential to play a role in social interactions of people. One idea is that smell can facilitate the communication and collaboration between people.

Smell facilitate communication & collaboration.

1.3   Social Interactions

> **SOCIAL INTERACTIONS:**
> "Social interactions are the processes by which we act and react to those around us. It is a dynamic, changing sequence of social actions between individuals who modify their actions and reactions due to the actions by their partner." - [Sharp et al., 2019]

Definition:
Social Interactions

People continually update each other about news, changes, and developments on a given project, activity, person, or event. Sherry Turkle (2015) research has shown that when children hear adults talking less, they likewise talk less. This in turn reduces opportunities to learn how to empathize. She argues that while online communication has its place in society, it is time to reclaim conversation, where people put down their phones more often and (re)learn the art and joy of spontaneously talking to each other. Social interaction is central to our everyday lives. Keeping aware of what others are doing and letting others know what you are doing are important aspects of collaboration and socializing.

Researchers argue to consider natural social environment for understanding social interactions.

We further extend this section with the introduction of 4 context scenarios for social interaction based on Rogers et. al. (2019) and what we meant from it.

a) Being Social

Friends and families keep each other posted on what's happening at work, at school, at a restaurant or club, next door, in reality shows, and in the news. Similarly, people who work together keep each other informed about their social

Being social is about for lives and everyday events.

lives and everyday events, as well as what is happening at work, for instance when a project is about to be completed, plans for a new project, problems with meeting deadlines, rumours about closures, and so on.

b) Face to Face Conversations

F2F conversations are about talking to a person and exchanging thoughts.

Talking is something that is effortless and comes naturally to most people. And yet holding a conversation is a highly skilled collaborative achievement, having many of the qualities of a musical ensemble. We aim to understand how natural it is, how comfortable people are when conversing with notion of smell scenario, and the extent to which it is important to follow conversation mechanisms that are found in human conversations.

c) Co-presence

Co-presence is about the situal awareness for an individual.

Co-presence means interaction among people sharing same physical space. It includes physical coordination, periphery awareness & situation awareness. Here we aim to understand how effective smell can be in such scenarios? It is important to consider the coordination and awareness mechanisms already in use by people in face-to-face interactions and then to see how these have been adapted or replaced by the olfactory device.

d) Social Engagement

It refers to participation in activities of a social group (Anderson and Binstock, 2012). The goal of these activities is to analyse how collaboration, coordination, and communication are supported in social group involving multiple people.

Social Engagement talks about how we do engage in a certain task.

The sense of smell opens up the conversance to connect humans to their experiences by adding smell as a layer on top while experiencing. This layer influences social interactions of people and people can use smell to communicate and to collaborate with each other. People are inherently social: we live together, work together, learn together, play together, interact and talk with each other, and socialize [Sharp et al., 2019]. Smell can also facilitate to build up a

certain image of an individual during face-to-face interaction and is able to be store as a unique memory [Choi et al., 2012].

The smell within HCI domain has been explored in the context of designing VR experiences [Ranasinghe et al., 2018], ambient notifications [Maggioni et al., 2018] and, in-car interactions [Wintersberger et al., 2019] which mostly focuses upon one-off applications. The incorporation of smell in the wearable devices such as a necklace has also been explored in the recent years [Amores and Maes, 2017], [Dobbelstein et al., 2017]. Yet, specific examples demonstrating how such rich and unique engagements with the smell in social interactions can be supported through the creation of new design artifacts are sparse.

Social Engagement examples where olfactory devices are used is sparse.

1.4 Human Communication Research

Human Communication Research is a domain from sociology covering empirical work in any area of human communication and human symbolic processes. In this area, researchers works to advance understanding of human symbolic processes with a strong emphasis on theory-driven research, the development of new theoretical models in communication, and the development of innovative methods for observing and measuring communication behavior. It has a broad social-science focus and as important applications in psychology, sociology, linguistics, and anthropology, as well as areas of communication studies Adler et al. [2016].

Human Communication Research develops theories and method understanding the communication.

> **COMMUNICATION BREAKDOWN:**
> A communication breakdown is defined as a failure to exchange information, resulting in a lack of communication.

Keyword: *Communication Breakdown*

We strongly relate with this domain as we wanted to explore the role of smell in social interactions based tasks from human communication lens. This involves understanding the communication patterns, exploring the rea-

Understanding communication patterns.

sons of communication, understanding communication breakdown and effect of relationship between two individuals. It is also focused upon the length of time two people know each other because it directly affects the overall communication and coordination.

1.5 Motivation

In a daily life, people interact with their entire physical environment using all of their senses, however, when it comes to the digital world, our interactions are restricted to an audio-visual experience and limited to the small screens of our computers and smartphones. This makes us explore what role olfactory devices can play in our daily life.

We explored several ways for people to better communicate at a distance, mostly using the sense of sight, touch and sound (Showme++, Tagme, Social Textiles). Over the period for this research we came across an article by Amores & Maes in CHI 2017 on Olfactory Interfaces for Unconscious Influence of Mood and Cognitive Performance. The authors presented the first olfactory computational necklace that can be remotely controlled through a smartphone and can vary the intensity and frequency of the released scent based on bio-metric or contextual data.

The developed prototype completely replaced the traditional jewellery as a worn artefact. Considering this study as a starting lead made us to think about preserving the aesthetic qualities of the jewellery while replacing the jewellery material with smart material for sensors and actuators. Working with smell is challenging as it is highly subjective. We explored multiple application scenario starting from mood regulator, cognitive performance enhancement, smell agent, learning etc. After multiple brain-storming sessions within our team, we resorted to exploring social interactions as potential application area.

More recently electronics have become small enough to be worn directly on the human body. Driven by technological possibilities it seems logical to focus on new practical func-

We are restricted by limited social interactions.

Inspiration for this thesis was Essence project.

Exploring domain for the experiment design.

tionalities. However, such an approach neglects interesting aspects of clothing and accessory like the implications of the proximity to the human body and its rich material and social connotations. Within the field of clothing and accessories, we are especially interested in jewellery, because of the rich personal and social cultural values they traditionally embody. Jewellery not only communicates about our taste, occupation and social status towards others, but also confirms these elements for ourselves, resulting in self-confidence and a sense of belonging. Versteeg et al. [2016a]

Smell can be embedded in clothes, devices and jewellery.

How can smell be meaningfully experienced when integrated with a jewellery? How might rich, emergent and ongoing experiences of social interactions with smell be supported? And what opportunities exist for leveraging smell in designing technology that supports new ways of experiencing the trajectory of communication in the daily life?

Research Questions in this thesis.

To explore these questions and ground our own thinking in this emerging space, we designed *Abhushan*, an interactive olfactory jewellery for people to use in their daily life. We choose jewellery as our wearable device to explore the domain of social interactions because it holds comprehensive personal, social and culture values. It not only communicates about our taste, occupation and social status towards others, but also confirms these elements for ourselves, resulting in self-confidence and a sense of belonging [Tsaknaki et al., 2015].

Formulation for Abhushan and main experiment design.

1.6 Thesis Contributions

HCI researchers advocate that technologies should work as catalysts, they should support human relationships rather than trying to substitute them[Lynch, 2015]. In this thesis, we describe the insights that emerged through the design and development of *Abhushan*. Next, we provide a brief background on features and interactions with the device. Our main study in this paper is focused on understanding the role of smell in social engagement and quality of communication. We evaluate the effect of smell on overall social interactions with a controlled experiment design and

Multi-domain analysis framework derived from HCI, Psychology, Sociology & Human Communication Research.

report our findings. The goal of the experiment was to analyze how collaboration, coordination, and communication are supported in social group involving smell as a cue. The novelty in this work is not the design of *Abhushan* but using a *multi-domain analysis framework* derived from literature of HCI, Psychology, Sociology and Human Communication Research to investigate smell and social interactions, refer Fig. 1.3.
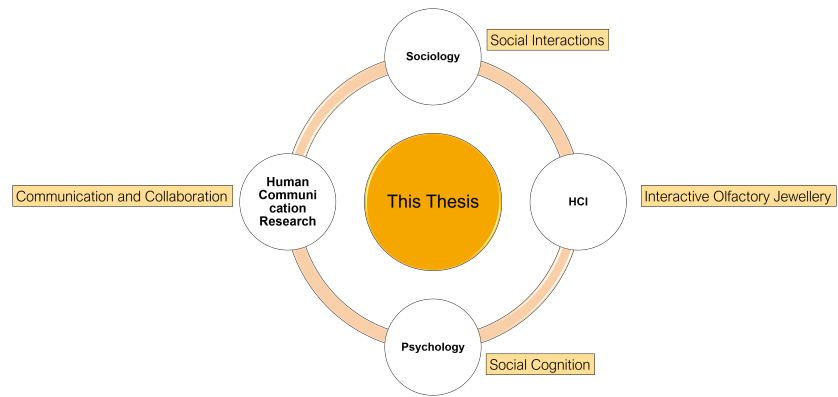
Figure 1.3: An Interdisciplinary Lens: *Multi-domain Analysis Framework* showcased in this thesis.

Synopsis on main
highlights of thesis

Our results provide useful insights suggesting that smell has an important role in the quality of communication of participants. The stories written with smell were more comprehensive and it helped in repairing of communication breakdown. Besides, our data analysis provide interesting information that users do not trust their own sense of smell.

Section outlines for
remainder of this
thesis.

In the remainder of this thesis, we first review related work on the jewellery in combination with smell interfaces and social interactions of humans. Following this, we describe the necklace design, features, implementation and, its interactions. We utilize *Abhushan* in performing a pre-study on social acceptability. The results from this pre-study guide us on designing our main experiment. We then describe our user studies setups, experiment design, tasks, participants, and procedure followed by a discussion about the results. We conclude with an application as a brain-storming

tool, limitations of our work and suggestions for future research directions.

In summary, this thesis makes the following contributions:

- the *Abhushan*, a personalized olfactory based wearable jewellery focusing upon aesthetics, light weight and communication capabilities.

- A study providing insights into the effect of smell during social interactions pivoting the face to face conversations and social engagement during the task.

- A unique and novel analysis framework to understand the role of smell in social interactions from domain of HCI, Human Communication Research, and Psychology.

- Exploring how people judge their own sense of smell v/s how the effect is actually expressed in the data.

- Scenarios that illustrates social acceptance for an olfactory jewellery, it's role in quality of communication and it's key application as a brainstorming tool.

Chapter 2

Related work

The related work in this thesis intersects different dimensions of Jewellery, Smell Interfaces and Social Interactions. We report the literature and research gaps that motivates our research questions. The domain of jewellery have been looked extensively in the HCI field. Similarly, scent has been widely explored in art but the olfactory system has been rarely appreciated in the technological world. Social Interactions have also been looked into HCI but it remains a topic of interest mostly for the psychology and sociology community.

This chapter outlines related works at intersection of Jewellery in HCI & Social Interactions.

2.1 Jewellery in HCI

Jewellery in HCI was used in the context of social interaction and also connecting people with each other. Projects like [Kikin-Gil, 2005] or [Ahde and Mikkonen, 2008] have made an effort to use jewellery as a form factor for helping people to look for friends or others with the same interests. [Kikin-Gil, 2005] especially designed to support emotional communication and group identity by nonverbal communication between group members.

Jewellery in HCI is mostly used for communicating emotions.

Members are able to communicate their emotional state with a jewellery piece to the other group members. [Paka-

nen et al., 2014] on the other hand deals with the usual on-
line communication by changing a bracelet into a 'smart-
watch' as it is able to send text messages over a paired mo-
bile phone.
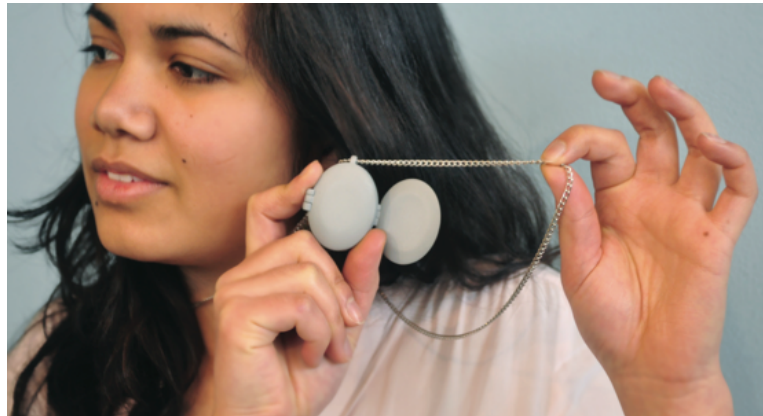
Figure 2.1: A sound locket by K Niemantsverdrie et al. for
individual memory reminiscence.

Marti et al. focused their discussion on sound experiences
using interactive jewellery and fashion jewellery and how
they can be enhanced [Marti et al., 2019]. Versteeg et al.
[Niemantsverdriet and Versteeg, 2016] integrated the emo-
tional layer of memories into a necklace, i.e. people can
record sounds and listen to them again whenever they
feel like it, see Fig. 2.1. In another research by same au-
thor, they presented the Interactive Jewellery Framework
which was derived from adding a digital layer to the phys-
ical object [Versteeg et al., 2016b]. They proposed design
directions that might help achieving the jewellery that is
truly interpreted as jewellery, instead of being perceived as
technology-driven gadgets goal, see Fig. 2.2.

Jewellery artifacts on
experiencing sound
timeline and
framework design by
Versteeg.

> **DESIGN DIRECTIONS FOR INTERACTIVE JEWELLERY:**
> • translating interaction scenarios with traditional jewellery to interactive jewellery.
> • using relatively simple technology with high experiential qualities, instead of using state-of-the-art technology.
> • abstract and more poetic data representation as opposed to concrete and detailed information.
> • data uniquely stored on the jewel. [Versteeg et al., 2016b]

Excerpt:
Design directions for Interactive Jewellery

Fortmann et al. [Fortmann et al., 2016] researched in a lab study on a how a smart digital multi-purpose bracelet should be designed in order to be attractive, functional, easily comprehensible, and easy to manage. As they stated that toady's wearable devices mostly have their focus in functionality but lack in aesthetics as well as comfortable wearing.

Jewellery in form of multi-purpose bracelet by Fortmann.
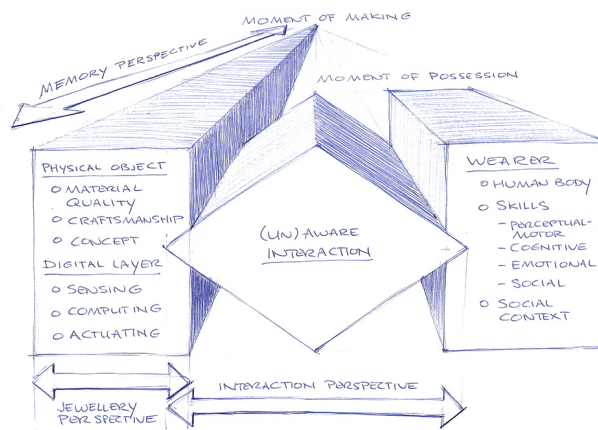
Figure 2.2: Interactive Jewellery Framework: Adding a digital layer basically means adding the possibility to collect data (sense), process these data (compute) and react based on that (actuate). Image by Maarten Versteeg.

A group of researchers consolidated the theoretical grounding and the definition of new forms of design support for deaf women [Marti et al., 2018]. They designed 3D shape-change jewellery fabric modules with different behaviours: kinetic transformations, light patterns and vibrations, refer Fig. 2.3. Their aim dissects from functional needs like am-

3D- Shape changing jewellery with focus on hedonics.

bient awareness and safety, to hedonic needs like aesthetics, curiosity, possibility to express a personal sense of style when accessorizing the body.

Figure 2.3: 3D shape-change fabric modules (left), felt necklace with light patterns (center), regenerated leather necklace with vibration (right). Image by Patrizia Marti.

Importance of
Aesthetics in
Jewellery design.

Above mentioned research projects deal with different ways to enhance humans social interactions by facilitating either online or emotional communication but also supporting single peoples emotions and thoughts. But all of them have an intention of designing a jewellery piece that is aesthetic and pleasing to wear as jewellery made from precious materials like silver. Aesthetics is very important in the area of jewellery as also shown by above research. As mentioned in our introduction smell interfaces in HCI have great potential on social interactions and the following projects show this potential.

2.2 Smell Interfaces

The sense of smell enables to enhance peoples' experiences by adding smell as a layer on top while experiencing. When talking about integrating anything to peoples's life the question of how the form factor can look like is very important to answer. When this device should be able to be integrated permanently aesthetics and comfort of wearing

it are important again. One of the first attempts to incor-
porate smell into an interface goes back in 1950s in project
Sensorama when scents were released during the viewing
of a film, so that the viewer could associate certain smells
with scenes of the movie, see Fig. 2.4 [Heilig, 1962].
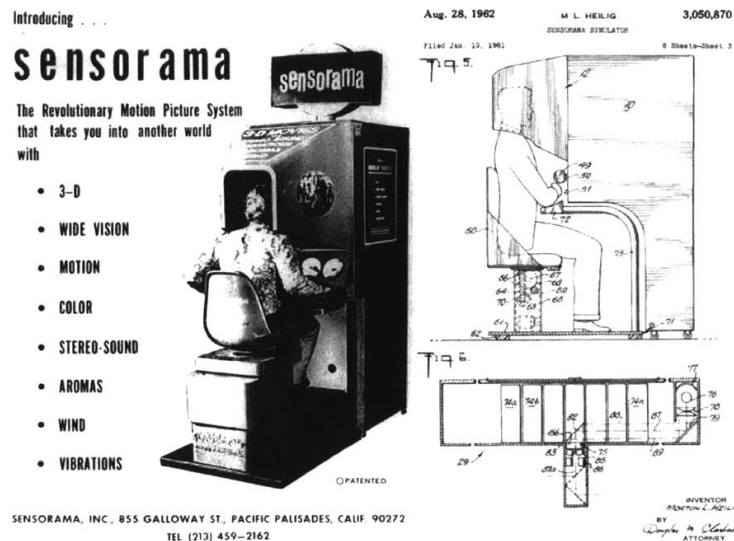
Figure 2.4: Sensorama was one of the first Virtual Reality
systems. It was an immersive, multi-sensory device that
had stereo sound, smel, vibrations on the seat and wind
simulation. Image by Morton Heilig .

In Essence [Amores and Maes, 2017] by Amores et al. put
their focus on using smell as an influence on peoples' mood
and cognitive performance while being asleep or awake.
Essence is an olfactory computational necklace which is re-
motely controlled and changes the intensity and frequency
of the released scent according to the users biometric or
contextual data (Fig. 2.5). The necklace is quite bulky as
it comes in a small glass for the front and a square box for
the back in which electronics for controlling the device are
hidden. In their study user stated that the necklace was
acceptable to wear and did not make them feel uncomfort-
able. i.e. even if their is improvement possible in terms of
design the device can be worn. Another variant of essence
was introduced as BioEssence that was designed to moni-
tor cardio-respiratory information to support mental well-

being. It provided just-in-time release of scents based on
the physiological state of the wearer. However it was not
rigorously tested in controlled situations and real-life sce-
narios.
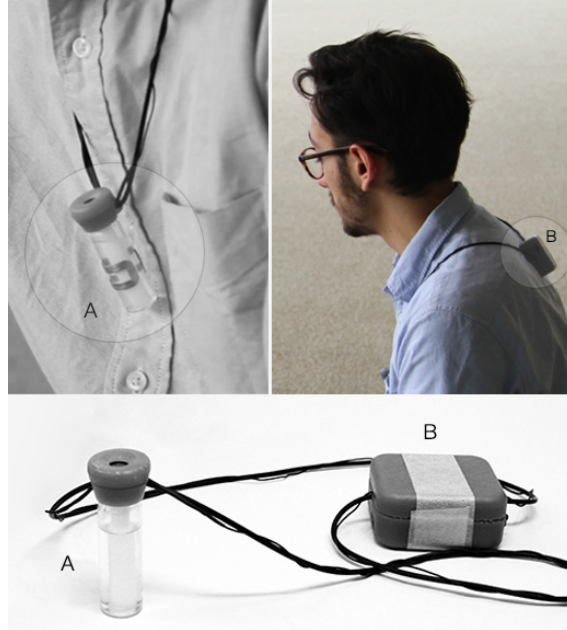
Figure 2.5: The Essence necklace. (A) A 3D printed cover
holds the piezoelectric on top of the cotton stick filter, soak-
ing up the fragrance from the container. Once the fragrance
is depleted, the user can easily unscrew the cap and refill
the container. (B) Back part of the necklace that contains
the micro-controller and the rest of electronics to control the
release of scent. Image by Judith Amores.

Description for
inScent, Clayodor &
Bio-Essence project.

inScent [Dobbelstein et al., 2017], a wearable olfactory de-
vice that evaporates smell to evoke emotions and memories
but also to inform the wearer. Compared to Essence, in-
Scent allows the user to add scents to their mobile applica-
tions. This device was also evaluated but in a public setting.
Users underlined the importance of social acceptance and
the fact that bystanders could also smell the scent and react
to it. Kao et al. moved the sense of smell to another layer
by combining it with tangibility [Kao et al., 2015]. Clay-
odor is a clay-like material that changes its smell accord-
ing to how users change its shape. Their prototype has to
be explored in terms of how tangibility can be mapped to
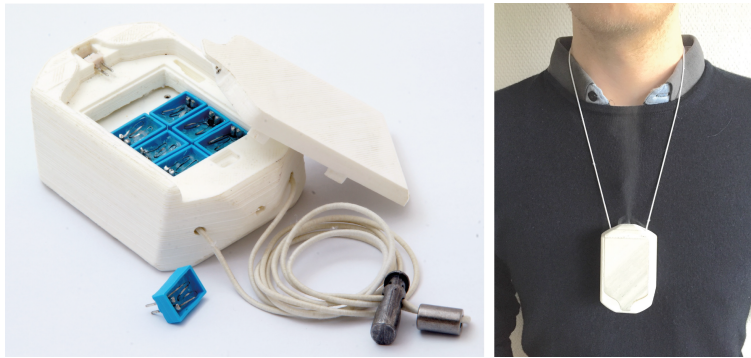
Figure 2.6: Left: The inScent prototype with opened top lid. Up to 8 scent cartridges can be plugged in. Each cartridges contains highly viscous scented liquid soaked into glass fiber to deter leaking. Right: Normally, scent emission is not visible to the eye. Image by David Dobbelstein .

smell and what are the richness and downsides of the interface. The project shows an interesting approach to give the user the power of controlling their smell interface which is important when smell is introduced. The user should be able to choose whether smell is evaporated to support their comfort.

The "Smoke Dress" by artist Anouk Wipprecht [Wipprecht and Casas, 2012] releases a cloud of smoke when it detects a person approaching (Fig. 2.8). This provides a future glimpse where one can see the application of smell in the fashion industry. The sound perfume project [Choi et al., 2012] relates to the fact that sound and smell can unconsciously leads people to create a mental image of another person's personality during a conversation. Using a unique smell can build up a certain image in your opposites head. Therefore, they designed Sound Perfume as a wearable with which they investigated how people can receive the power to manage their impression on others and help people to create their very unique identity.

The Smoke Dress and Sound Perfume project.

clayodor is a project based on malleable material that changes smell based on user manipulation of its shape. This work explores the tangibility of shape changing materials to capture smell, an ephemeral and intangible sensory

Motivations for clayodor project and its limitations.

Figure 2.7: Smoke Dress. Image by Anouk Wipprecht.

input. The design of a proof-of-concept prototype, and discussions on the challenges of navigating smell though form were presented in the paper by Kao et al. [2015]. This work had some limitations as granularity of recognition of clay would the support from system to change each time and subtle differences with individual hands.

Obrist et al. [Obrist et al., 2016] emphasise the lack of knowledge about understanding people's multi-sensory experiences in HCI. Smell is one of these unexplored senses. Exploring what areas can be stimulated by these senses is crucial as a first step to be able to design rich experiences in human computer interaction later on. (refer later to social interactions one area to be explored regarding sense). One example of investigating the senses is by Obrist et al. [Maggioni et al., 2018] in which they investigated the characteristics of the five basic taste experiences (sweet, salty, bitter, sour, and umami) and recommended when to use which taste, e.g. sweet is able to enhance positive experiences.

Characteristics of the five basic taste experiences.

A group of researchers [Maggioni et al., 2018] explored the effectiveness of visual, olfactory, and also the combined visual-olfactory notifications in a messenger. The found
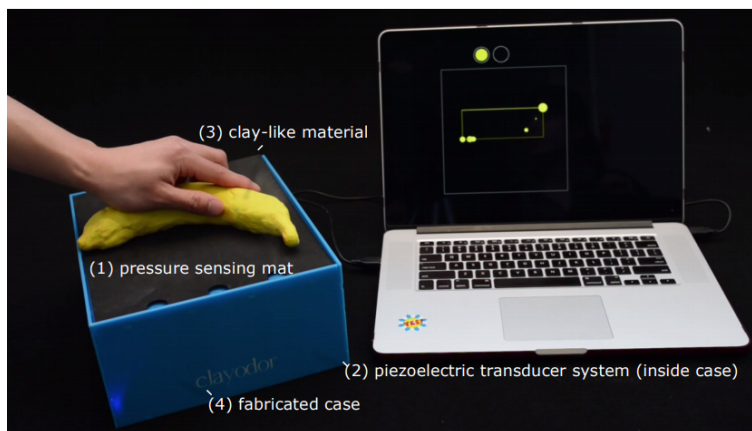
Figure 2.8: clayodor prototype. Image by Cindy Hsin-Liu Kao.

that olfactory and visual notifications improve users' confidence and performance when testing the level of urgency of a message with the same quality. These research projects show the importance of investigating senses but also the sense of smell to utilise it for unique and personal HCI experiences. As mentioned by Obrist et al. [Obrist et al., 2016] we need to explore what senses can be stimulated in which situations and their impact on people's interactions. One are of these is social interactions which is introduced in the following section.

Olfactory and visual notifications improve users' confidence and performance.

2.3   Social Interactions

Morris et al. Morris et al. [2004] present design directions for ubiquitous computing that are able to support social interaction. The focused on a very special user group of elders coping with cognitive decline and their caregivers. The important note from their work is that technologies should work as catalysts, they should support human relationships rather than trying to substitute them.

Ubiquitous computing to support social interactions.

Wallbaum et al. [2015] underline as well as Sharp et al. [2019] the importance of Interpersonal social interaction, building relationships and the communication with others

for every person. More particular they put their focus open
serious ill people that feel the need to communicate with
friends and family. The work presents design concepts and
prototypes To facilitate unobtrusive technologies for com-
munication.

So far the described projects focused on the social human
and guidelines for building technologies that facilitate so-
cial interaction in person or online. Olfactory technologies
open up another area of being social and social interaction.
Therefore, the following projects will introduce some of the
present ideas for olfactory interfaces in combination with
social interactions. Creativity and creative activities can be
enhanced by sensory experiences Gonçalves et al. [2017].
Gonçalves et al. executed a study with 100 students to in-
vestigate the effects of auditory and olfactory support dur-
ing a creative writing task. They found that support in the
form of smell are important for creative working and rec-
ommend to integrate them into environments where cre-
ative writing is undertaken.

Figure 2.9: Map used to trigger the creative writing task
in experiment by Gonçalves et al. Image by Frederica
Gonçalves.

Zemke and Shoemaker [2007] were interested to explore
the effect of the physical environment, i.e. e.g. a room or
lobby, on the interactions between people in this environ-

ment. Their study results point to an ambient scent having a positive effect on the number of social interactions executed by the participants.

Research projects have already been starting to integrate smell interfaces into humans social interaction as the olfactory sense can influence our behaviour significantly. Some in the form factor of a jewellery piece but other factors are possible as the ClayodorKao et al. [2015] or simply putting the sense in the room Zemke and Shoemaker [2007]. Related projects have not studied in detail in the quality of communication and social engagement between human beings. The following sections will introduce quality of communication and social engagement in more detailed manner. This work focused on studying these two aspects and we decided to use a necklace as the form factor to integrate our olfactory interface.

Social Engagement and Quality of Communication

2.4 Related Works at a Glance

This subsection present all research projects discussed in this chapter at a glance. They are analyzed on domain, key features, main contribution, methodology used and the research gap. This systematic analysis is performed to give an overview of the current research gaps and how this thesis aims to touch down some of them. Table 2.1 provides an overview of the research projects.

Analyzing related works in form of a table.

Table 2.1: Related works at a Glance

No.	Project	Domain	Key Features	Main Contribution	Methodology Used	Research Gap
1	Essence	Smell Interface	Mood Change, Cognitive Performance	Olfactory Computational Necklace	User Study	Bulky device, Low Aesthetics
2	Bio Essence	Smell Interface	Cardio-respiratory Information	Trigger multiple scents based on physiology of the wearer	Physiological Sensing	No real-life deployment
3	inScent	Smell Interface	Scent Cartridges, Olfactory Necklace	Application as Mobile Notifications Alert	User Study	Social Acceptance in Private Spaces, Bulky device
4	Sound Locket	Sound based Jewellery	Recorded Audio Fragments for autobiographical memory	Stand-alone single-purpose piece for audio in jewellery	Iterative Design Process	No user-study, longitudinal evaluation
5	Shape Change Necklace	Jewellery	Kinetic Transformation, Lighting & Vibrations	Ambient Awareness for Deaf Population	User Study	Small Sample Size & Limited Sounds
6	I smell Creativity	Smell & Social Interactions	Creative Writing based on Smell, Smell with Sound	Creativity support tools and applications	User Study	Single measure to analyze data - CSI*
7	Interactive Jewellery	Jewellery Framework	First framework for designing jewellery, detailed review of literature	Drawing inspiration from interaction with traditional jewellery	Design Explorations	Framework not evolved, No real life example
8	Scent Room	Smell & Social Interactions	Effect of scent in public places (hotels, lobby etc.)	Inspiring Product based industry to make effective use of smell	User Study	Convenience sample used, reduced intercoder reliability
9	clayodor	Smell Interface	Use of malleable material to produce scent	Proof-of-concept prototype for retrieving different fruit scents	Design Explorations	Capturing the ephemeral though the tangible?
10	Smoke Dress	Smell Interface	Veil of smoke around the wearer to camouflage	First use of smell in fashion dresses - an interactive display	Digital Art	No user study, real life implementation

Chapter 3

Abhushan

We designed Abhushan to explore social interactions surrounding olfactory technologies that can manifest diverse expressions of a person in everyday life. We created a jewellery that might contrast the utilitarian qualities of many everyday social activities to give rise to more open-ended experiences of contemplation, curiosity, and engagement. We aimed to create a design artifact that projected an olfactory jewel piece and which manifested the exploration of social interactions from a formal lens.

Design aim was to showcase utilitarian qualities of many everyday social activities.

3.1 System Description

Abhushan is a necklace that can be worn in everyday life. The wearable is made up of 3D printed form factor i.e. a rose containing the electronic circuits and a Printed Circuit Board (PCB). The PCB contains a microprocessor and a Bluetooth Low Energy (BTLE) module embedding on it. The scent release intensity of the wearable is controlled by a wrist band.

Abhushan consists of 3D printed form factor controllable via a wrist-band.

The wrist band is a 3D printed small container which contains a Arduino Nano Microprocessor with BTLE module. The wireless connection between the wearable and the wrist band is achieved using BTLE. Besides, the *Abhushan*

also provides a simple ON/OFF button functionality for activating scent release located on the 3D printed form factor.

3.2   Implementation

Narrow gap between
tech design and
actual physical
object.

The implementation of the prototype took several design iterations. We tried to keep an aesthetically pleasant and closer to a jewellery design. It was done to assure that our device does not appear to be another technology gadget but a jewellery piece. This resonates with thoughts of Tsaknaki et al. Tsaknaki et al. [2015] who reports that the border is quite narrow between technology design and the actual physical object.

Engaging in a
dialogue with
theoretical, empirical,
and design materials,
for iterative
development.

The development of *Abhushan* consisted of the following. We reviewed theoretical literature, studies, and a range of design works. Similar to Odom's idea of design as a reflective conversation with materials Odom and Duel [2018], we engaged in a dialogue with theoretical, empirical, and design materials, and iterative development and critique of design concepts, to arrive at the final jewellery design. While we explored design ideas related to form, materials, and interaction in parallel, an important early decision was to test different scent generating and delivering methods. These included techniques such as the accelerated vaporization by heating using Kanthal wire (*used in design Fig 1.1*), vaporization by heating using glass fiber cord (*used in design Fig 1.2*) and atomization by ultrasonic waves (*used in design Fig 1.3 & 4*).

3.2.1   Iteration 1

Iteration 1 based on
heating of Kanthal
wire.

In our first iteration, We started using a real necklace (in form of a statement necklace) which provided enough space for integration of an smell module. In this iteration we used accelerated vaporization by heating using the Kanthal for generation of smell. The smell was generated from the scent contained in a 3D printed scent module (small scent container), refer Fig. 3.1.

Figure 3.1: The battery along with the scent container was placed beneath the jewellery as to be hidden. - Iteration 1

This module was located behind the jewellery so has to be hidden, Fig. 3.2. In this iteration we were able to generate the smell but this resulted into an issue of high voltage requirement. Not only this this but we encountered other issues such as time to cool down the heat and bulkiness of the jewellery. This led us to re-think our notions of method of smell generation. Henceforth, concerning about safety issues and wearable being closer to the body, we decided to re-iterate our prototype.

Iteration 1 was discarded because of safety issues.

Figure 3.2: The front look of the jewellery. - Iteration 1

3.2.2 Iteration 2

Iteration 2 based on
heating of heating
glass fiber cord.

In our second iteration, we decided to remove the real necklace so that the overall weight of the wearable decreases. This lead us to 3D print two jewel like pieces with light weight and still stick to the domain of the physical jewellery. We attached the printed jewel pieces with the scent module from iteration one, Fig. 3.3. Now, since we already knew that kanthal wire heating was not an optimal option, we switched to another technique for smell generation.

Figure 3.3: Two 3D printed jewel pieces were connected with the scent container. - Iteration 2

Iteration 2 was
discarded because of
high heating time
and time to soak the
scent.

In this design iteration, we used vaporization by heating the glass fiber cord soaked into the scent module. The glass fiber cord helps in soaking the scent and evaporating it when gets into contact with an heating element. Here, we were able to reduce the bulkiness of the prototype. However we were encountered with a new issue. The issue raised was the time required to soak the scent by fiber cord and then heat it in form of vapours took hefty time. The reason why we call the timing as hefty because when a user turn ON the wearable it should respond within few seconds. However, this was not a case for us as it took around 40-45 seconds to get the smell of the scent. This made us to a brainstorm about odor module integration in the jewellery once again.

3.2.3 Iteration 3

The third iteration of the *Abhushan* nearly took a month to find an optimal smell generation technique for our wearable. In this design iteration, we switched to atomization by ultrasonic waves for the scent generation. Atomization refers to separating something into fine particles. It is a process of breaking bulk liquids into small droplets. An optimal method to achieve this in terms of the electronic engineering are piezoelectric. We used piezoelectric transducers to convert the liquid scent into the smell. Here we used a traditional flask based test tube to store the scent, 3.4.

Iteration 3 based on using piezoelectric transducers.
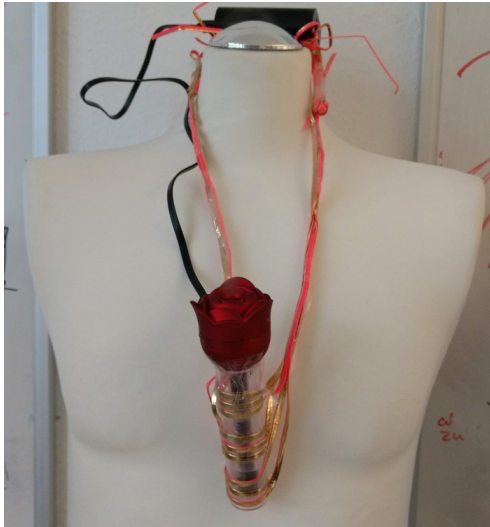
Figure 3.4: Form factor for the jewellery was 3D printed as rose. - Iteration 3

A cotton wick was use to soak the scent. We used a cotton wick from our learnt experiences with glass fibre cord which took much time to release the scent. The piezoelectric transducer was placed on top of the cotton wick. On supplying the electricity, the piezoelectric vibrates and in turn vaporizes the soaked scent of the cotton wick. This design iteration worked for us to resolve the odor module integration into the jewellery as ultrasonic waves were capable of breaking the soaked scent into small particles that look like vapor and was inaudible to the user.

Iteration 3 was considered for further iterations as it provided best scent generation technique for our scenario.

3.3   Final Design

Abhushan final
design used a cotton
wick to soak the
scent.

Abhushan's physical form is comprised of 3D printed form factor, a casing flask to contain the scent, and a cotton wick to soak the scent from the flask. We chose these materials to give the *Abhushan* the weight and feel of an enduring object capable of persisting as one's personal jewellery and that becomes more nuanced through time.

Multiple color beads
were used to
decorate the
jewellery.

The final design of the wearable is enhanced version of the third iteration. We kept the same smell generation technique i.e. vaporization by smell as our last iteration. Here, we focused on creating the wearable more like an jewellery. We added different light weight color beads on the necklace cord to make it look prettier. The necklace is approximately located 6 inches from the nose (enough to reach the nose and not be too noticeable by the user).
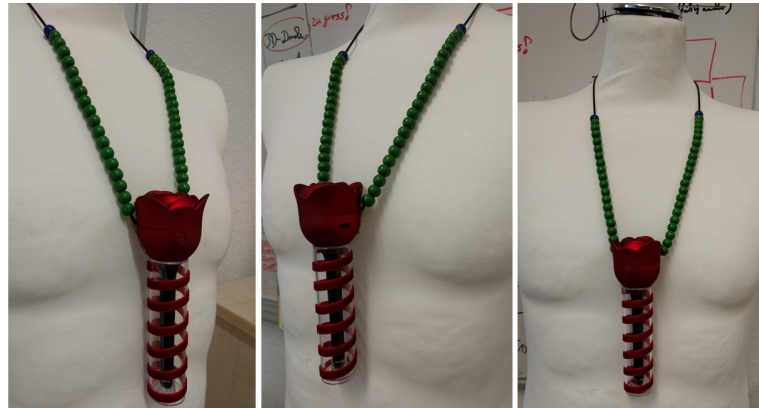
Figure 3.5: The final design of the *Abhushan*. Displayed as left, right and front Camera angle. - Iteration 4

3.3.1   Fabrication

Flask contains the
scent to be
evaporated.

The flask containing the scent was also decorated with red stripes to make it more appealing. The *Abhushan* generates a sense of openness in the design that may subtly invite other domestic things to accumulate in, on, or around it over time, as it settles in as a fixture in one's everyday life.
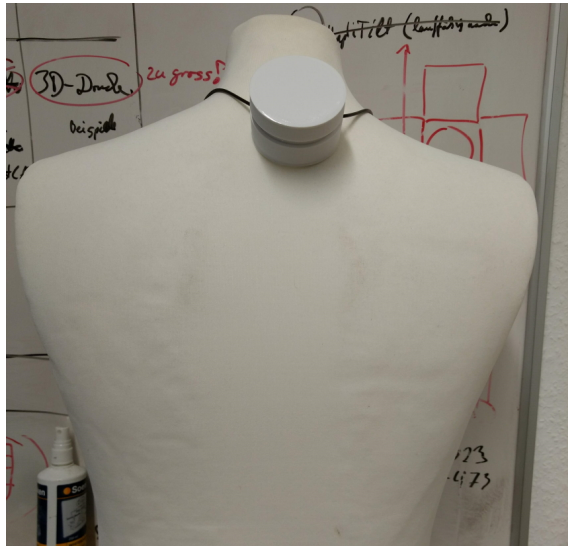
Figure 3.6: The back cover case works as a communication module for the wrist band. It controls the scent intensity signals. .

In this way, *Abhushan*'s minimal, yet rich form and material qualities evoke both the familiar and unfamiliar facets of a jewellery.

3.3.2 Features

Abhushan contains a small scent flask which can hold any scent in liquid form but it can only contain one scent at a time. Once the scent is depleted or change is required, the user can easily refill the flask with the desired scent. For an aesthetically appealing look and a light weight prototype, the battery for the jewellery can be placed inside the rose itself. To endow the *Abhushan* with communication capabilities to be remotely controlled, we used a microprocessor on a PCB that controls the complete system and a Bluetooth Low Energy (BTLE) board that implements the wireless communication with the BTLE enabled *wrist band* at the back of the neck so as to be hidden (Fig. 3.9). Although the prototype is currently working with the wrist band it can be used with any Bluetooth compatible device. For example,

Scent intensity can be controlled using BTLE module.

The jewellery can be customized based on the form factor.

a smart phone can be used to setup automatic frequency for the release of the scent. This makes the jewellery easily portable. Besides, for daily usage & simple functionality of only ON/OFF, the 3D printed cover at the back of the neck (Fig. 3.6) can be easily detached for wearing the necklace without it. The shape of the form factor around the odor module is customizable to any shape that can contain the odor module of 3.5 cm in diameter. An example of same is shown in Fig. 3.7.D with a 'hat'.

Figure 3.7: The series of images numbered from 1 to 4 showing the iterations in the design of *Abhushan* .

3.3.3   Interactions

Scent intensity is regulated by no. of taps on the touch panel of wrist band.

As mentioned *Abhushan* can be remotely controlled through the wrist band using the Bluetooth module embedded inside (Fig. 3.10). The wrist band can vary the intensity of the released scent. A single tap on the touch panel of the wrist band corresponds to the low intensity, two taps for medium and three taps for high. Any successive tap will lead the cycle back to low intensity.
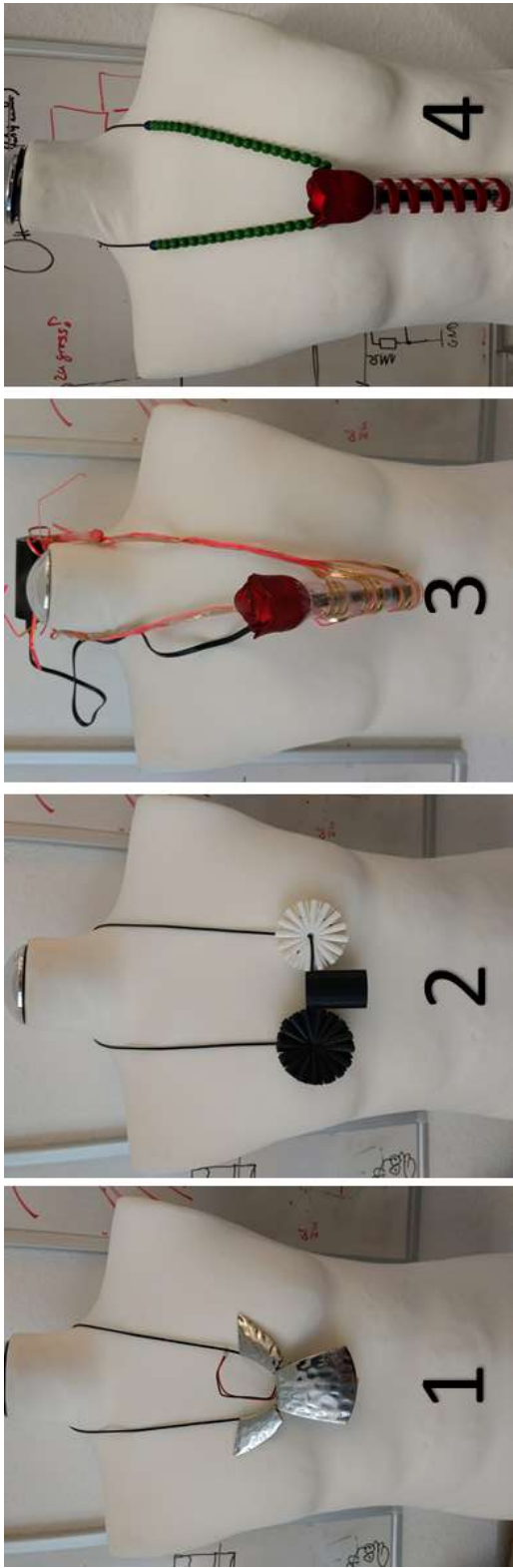
Figure 3.8: The series of images numbered from 1 to 4 showing the iterations in the design of *Abhushan* .
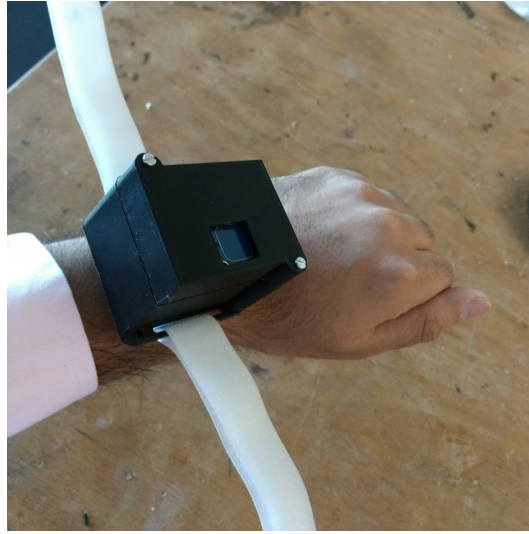
Figure 3.9: The wrist band for communication with the *Abhushan*. The case is 3D printed and contains a touch sensor.
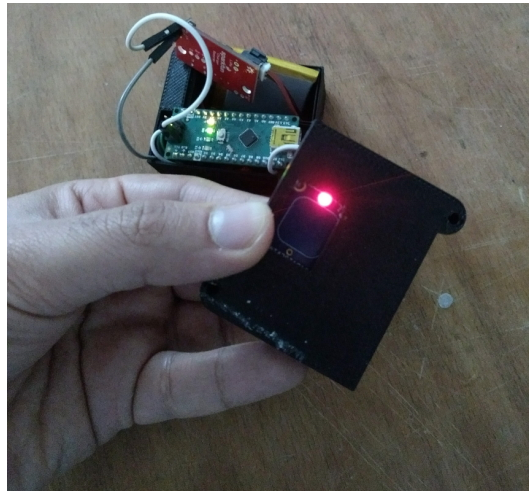
Figure 3.10: Wrist band connected with the Abhushan. The red LED blinks when the touch sensor is activated.

Scent is released in
form of fine mist.

Besides, *Abhushan* has an ON/OFF button located on the wrapping of the odor module, i.e. rose in our case. The rose contains an encapsulated piezoelectric transducer that controls the release of the scent. Therefore, *Abhushan* transforms the scent from the small bottle into fine mist, dis-

tributing the scent in the close environment.

3.4   Pilot Study on Social Acceptability

After having successfully built the prototype of the wearable, the next challenge was to investigate the application of the prototype and its effects on the user in a real-life setting. The primary goal of this pilot study was to find out how participants felt while wearing the device in both public and private spaces. It was further evaluated whether the jewellery would be socially acceptable?

Pre-study was focused on understanding social acceptance for the *Abhushan*.

In order to achieve above goal, a qualitative user study was conducted. Section 3.4.1 includes an overview of the participants. Section 3.4.2 shows an overview of the study design. The data analysis and results of the study are shown in section 3.4.3.

3.4.1   Participants

In the study, 8 participants (4 male, 4 female) from the student population of RWTH Aachen University were recruited. All participants were not using strong-smelling perfume or scented deodorants during the procedure. The group were aged between 22 to 32 years (mean=26.33, sd=2.02).

3.4.2   Procedure

Before the study was conducted, the participants were asked whether they had problems with their sense of smell, e.g. allergic reactions. Afterwards, an information sheet describing functionalities and features of *Abhushan* was handed out and the participants were further asked to sign a consent form. Subsequently, we asked the participants to wore the wearable for 2 days at their preferred timings in both public and private spaces. They were given 5 different

Participants wore the *Abhushan* for 2 days at their preferred timings.

scents to use with the device namely Lemon, Peppermint, Jasmine, Lavender and Anti- Smoking scent.

3.4.3   Measures

We used experience sampling method to gather feedback about the wearable from our participants. A Google form was created which includes open ended questions about their experience with the *Abhushan* and it's social acceptability. The questions included in the Google form is available in Annexure 3. The same questionnaire was sent to participants at the end of each day around 9 pm. This made us collect data for 2 days and long term experience with the device for the participants.

3.4.4   Data Analysis & Results

We used Qualitative data analysis technique by [Lazar et al., 2017] to come up with our results. The text files were carefully reviewed for completeness. Subsequently, transcriptions were analyzed using a grounded theory approach [Charmaz and Belgrave, 2007]. Afterwards, a first initial coding phase was performed and were revised with second coding. Subsequently, an axial coding approach based on over 50 initial codes was performed. NVivo, software from QRS International, was used to manage and perform the qualitative data analysis [Bazeley and Jackson, 2013]. The results of the study are presented in the following paragraphs.

Socially Acceptability of the jewellery

Most of the participants emphasized that they would like to use the *Abhushan* in their private spaces. They mostly used it while doing meditation, learning, watching a movie and before going to the bed. Their experience regarding social acceptance of the device was a mix of different scenarios. P2 (28, M) wrote that "*I showed this to my 3-4 friends and they*

were intrigued that what I was wearing. They wanted to know more. Then I showed them the prototype, they liked it. Then we started talking about jewellery and boys. It was a vague discussion but this device was topic of discussion." P3 (32, F) wore a red dress suit to match with the color of the rose and wrote that "*My friends at work liked it and told me I was looking pretty. This was not usual. You can say that it was socially accepting.*"

Some snippets from the participants.

Figure 3.11: *P7* added an Instagram picture of her with the *Abhushan*. This picture received 60 likes and welcoming comments.

P1 (26, F) reported an interesting finding when she clicked a picture of herself to upload on the Instagram - a social media platform (See Figure: 3.11). It is important to note here that people did like her picture with the device and served the purpose of the actual physical jewel piece. She also added that it was her best moment with the *Abhushan* as it was a part of her day story and was appreciated by the friends and followers.

A participants added a picture of her on Instagram with the *Abhushan*.

P8 (22, M) gave us a cultural perspective of jewellery and men. According to him, "I liked the fact that it is on my

body and kind of jewellery. In my country people do wear jewels including men. I wish to take this to my country and show people there this nice device. For me who wears jewellery this is nice and I would feel something missing without it." However, we also came across different scenarios where our users did not liked it using in public spaces. P4 wrote that "*I would not like to be the first person to wear this; people would be curious and I would be obliged to explain them what I am wearing. I wouldn't wear it just not to have people keep asking me what it is..*"

Covering other Smells

Since every person had a different perception of smell with different preferences and associations, individualization became essential. Our participants provided detailed inside when they used the device as a deodorant/perfume. P7 (52, F) described her experience as "*I live in an urban like city. There are many beggars around on the streets. I saw this really dirty looking homeless individual start walking down the aisle. I could smell his body odour as pathetic, then I turned ON the device and it was kind of relief as I remember the scent was lemon.*" It was accompanied by P6 (31, M) who reported that, "*It works like deodorant for me, emitting scent after Gym, bicycling, before a party or even after stressful day. Without would be you need to carry your deodorant or perfume every time.*"

Covering smell of other people as an application.

Alternative to an Aromatherapy Device

Aromatherapy is a pseudoscience based on the usage of aromatic materials, including essential oils, and other aroma compounds, with claims for improving psychological or physical well-being. P6 (31, M) reported us "*It was as close to an aromatherapy device and I liked that part. I usually put deodorants but this was more natural.*" P7 (52, F) who was previously used to aromas and scents find it as an alternative to an aromatherapy device which are currently rolling in the market.

Participants found it close to an aromatherapy device.

Chapter 4

Main Experiment

The main focus of this thesis was to understand role of smell in social interactions. The challenge was how to design an experiment which can examine the role of smell. Referencing from psychological studies helped us in formulating this goal. We incorporated Human Communication Research, HCI, Psychology and Sociology to design an experiment which can tap into the domain of Social Interactions. From HCI perspective, we used the prototype necklace *Abhushan* without the wrist band controller.

Understanding the effect of smell in social interactions based task.

Human Communication Research domain helped us to look into the unexplored potential of smell in the communication quality between two people. Similarly, Psychology and Sociology domains tapped into the human aspect of the social interactions such as emotions, understanding the complexity of the problem space and steps in order to come out of it.

Tapping into emotions and communication quality.

We conducted a within-subjects experiment to investigate if olfactory cues from *Abhushan* can affect peoples' social interaction quality. We also focused on their social cognition so as to understand how they accomplish the task. Since writing is part of everyday routine of our sample, the activity in this experiment involved writing a short story using collaborative text editor as the writing environment. We chose collaborative text editor because the participants were familiar with it.

Within-subjects study for collaborative story writing.

4.1   Participants

The study involved 22 participants (10 female, 12 male), from the institution's population, aged between 20 and 32 years old (M = 25.6; SD = 0.94). They were recruited through the university mailing list and were asked to choose a time slot for the experiment. They were given an option to participate in the experiment with their friend by choosing the same time slot. For those who did not availed this option, a random partner was assigned to them. Additionally, they were asked not to use any perfume/deodorant on the day of the experiment. An email was sent as a reminder before the day of the experiment to not use any perfume/deodorant.

4.2   Conditions

The story writing task was conducted under two different conditions: Neutral Environment (no smell) and Smell Environment.

No Smell Condition. This condition was the baseline condition with no smell was provided for the story writing.

Smell Condition. In this condition, the participants wore the *Abhushan* and the smell was remotely controlled by the authors. After every 3 minutes for a 15 minutes duration of the task, peppermint smell was released. The duration of the released smell was 10 seconds and intensity was kept uniform for all the participants. The peppermint smell was released every 3 minutes for a 15 minutes duration of the task i.e. at 0th, 3rd, 6th, 9th and 12th minute.

4.3 Task

> **THEMATIC APPERCEPTION TEST:**
> Thematic Apperception Test, also known as TAT is a test in which participants tend to interpret or describe ambiguous situations based on their motivations by writing stories. It was developed by [Murray, 1943].

Keyword:
Thematic Apperception Test

In the narratives (story) participants write about ambiguous pictures of people shown, reveal their underlying motives, and the way they see the social world. The task was performed in pairs of two participants in two sessions. In each session they were instructed to write a story about a "TAT Image" shown on a big screen. The included TAT images were 01, 02, 3BM, 04, 06BM, 07BM, 08BM, 010, 12M and 13MF. The choice of the TAT image was based on the manual by [Weiner and Greene, 2017]. Sessions were executed with one of the conditions - Smell or No Smell. The conditions were counter-balanced throughout the experiment to balance known and unknown confounds and to avoid biases of the the order of condition and groups. Overall, six groups were introduced to smell in their first session and seven groups in their second session. For example, pair P1 was introduced to smell in the first session followed by no-smell in the second session and pair P7 was introduced as vice-versa.

Sessions were randomized and counter-balanced.

The task was performed in pair of 2 participants in 2 sessions. In each session they had to write a story about a "TAT Image" shown on the big screen. Thematic Apperception Test, also known as TAT is a test in which subjects tend to interpret or describe ambiguous situations based on their motivations in the form stories [Murray, 1943].

Task was conducted in a pair in both the sessions.

A break of 10 minutes was provided between each session. The difference in the sessions was the conditions - Neutral or Smell Environment. The conditions were randomized throughout the experiment. For example, Pair one was introduced to smell environment in first session followed by neutral environment in second session and Pair seven was introduced as vice-versa. It was done to to balance

Two conditions - Smell & No Smell.

Figure 4.1: Two users while performing the task.

known and unknown confounds in order to make control and treatment groups as balanced as possible.

4.4 Procedure

Keyword:
IPIP BIG5 Scales

> **IPIP BIG5 SCALES:**
> International Personality Item Pool (IPIP) scales an individual on (1) Extraversion, (2) Agreeableness, (3) Conscientiousness, (4) Emotional Stability, or (5) Intellect/Imagination) and its direction of scoring can be (+ or -). [Donnellan et al., 2006]

Participants
personality traits
were recorded using
BIG5 IPIP test.

All participants were naive to the experimental conditions. Everyone reported having a normal olfactory acuity. The experiment was conducted in a silent room equipped with computers on desks and a clock. When participants entered the room, they signed the consent form and the authorization to participate. An additional consent was taken from participants regarding video recording their sessions. Debriefing about instructions for the each session, including pre-questionnaire and tasks took over 15 minutes. First, participants were requested to fill the Short Personality Test based on mini-IPIP BIG5 scales by [Donnellan et al., 2006]. The test completion took around five minutes for every pair

of participants. After filling the personality test, we introduced the *Abhushan* to participants.

We demonstrated them how the device works and made them familiar with it's functioning. We played a small game with the participants as in asking them to turn ON the device whenever they hear a beep sound. It was done to make them familiar with the device and remove it novelty. The game lasted for five minutes and we shifted to the main experiment. Both the participants were asked to wore the *Abhushan* if the task condition was smell environment and not to wore anything for neutral environment. The condition was not told to them before the start of the session.

> An initial game was played with participants to remove the device novelty & make them familiar with *Abhushan*.

4.4.1 Sessions

In first session, participants were sitting aside each other and can saw what the other person was writing on the monitor. The resolution and zoom level of the screen showing a "TAT Image" was adjusted according to the participants preference. They were instructed to use their own imagination and creativity to come up with a story. The task required them to think-aloud about the image and resonate their thoughts through conversation to come up with a single story. Both participants were asked to write the story simultaneously in parallel on two computers. Participants were given 15 minutes as a time limit to have conversation and complete the writing task.

> The required task was to collaboratively write a story based on a TAT image.

Once writing task was completed in first session, they were asked to fill the IOWA Communication Record. The filling of IOWA took around eight minutes for all the participants and the first session finished with it. After finishing first session, a break of ten minutes was provided to the participants. In second session, the same procedure was followed with or without *Abhushan* based on whether first session was with smell environment or neutral environment. Lastly, we interviewed them regarding overall feedback of the experiment.

> After Session one, ICR was recorded.
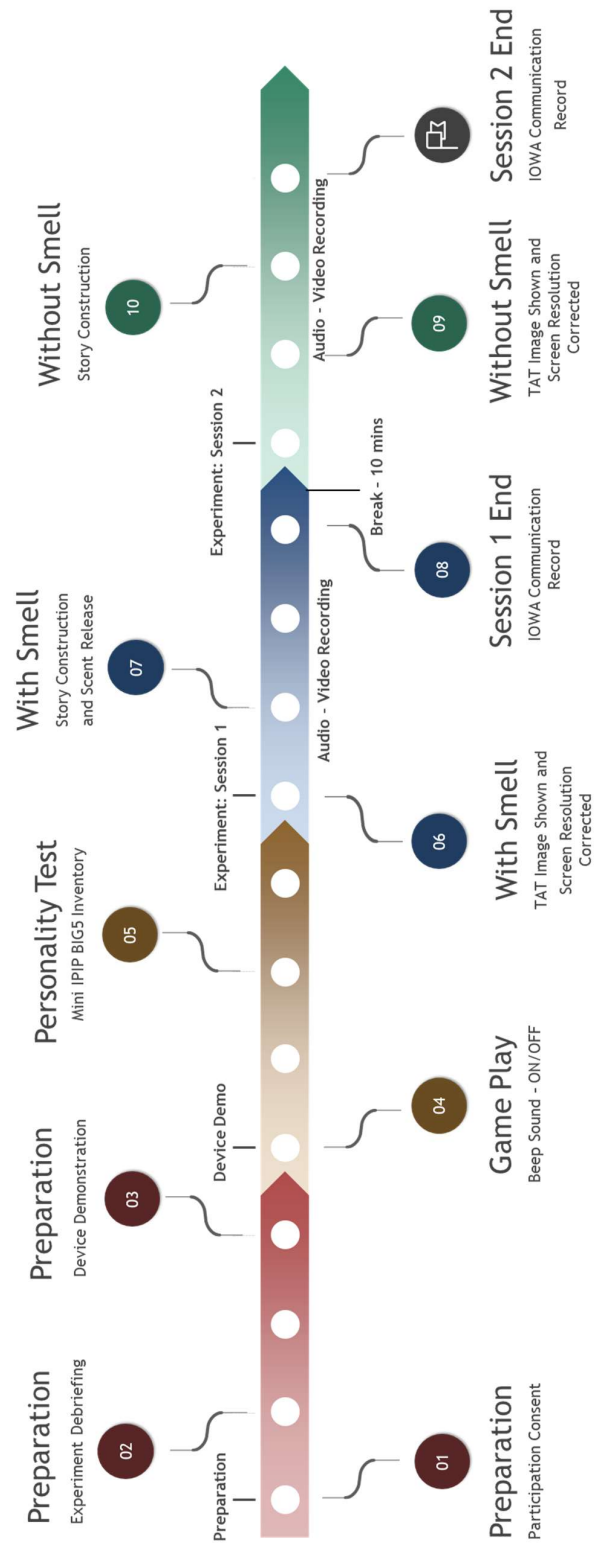
Figure 4.2: Timeline of the Experiment. Sessions were randomized and counterbalanced across all the participants.

4.5 Measures Used

We triangulated the data from various domains of social interactions to understand the role of smell. The following section describes the measures we used to analyze our data.

4.5.1 IOWA Communication Record

To measure the quality of communication, we used IOWA Communication Record (ICR) by Duck et al. [Duck et al., 1991]. The Iowa Communication Record (ICR) is a structured self-report form on which respondents record their recollection of conversations. Its primary purpose is to include communication variables as an explicit focus of measurement. ICR combines some of the measures of quantitative aspects of interaction with some direct measures of communication elements of the interaction [Baxter and Wilmot, 1986] and measures of qualitative aspects of the interaction. Some of the scales examining quality of communication were Relaxed-Strained, Attentive-Poor Listening and, Guarded-Open.

Scales of ICR:
Relaxed-Strained,
Attentive-Poor
Listening and,
Guarded-Open, etc.

A measure such as the ICR which is clearly focused on communication factors in daily life not only offers a handy way of replicating and extending previous descriptive work but its use can be grounded theoretically.

> **COMMUNICATION BREAKDOWN:**
> A communication breakdown is defined as a failure to exchange information, resulting in a lack of communication. [Dictionary, 2008]

Definition:
*Communication
Breakdown*

In addition, it also focuses upon conflicts during conversation and communication breakdowns. Besides, it also focus upon nature of relationship among the pair of the participants for quality of communication.

Nonetheless, ICR primary benefits will undoubtedly be found in its ready attention to those communicative be-

Hypothesis: No
difference in overall
quality of
communication in
smell and no-smell
conditions.

haviors and conversational geographies that will help us to map out more clearly the ways in which conversation and communication in everyday life should be theoretically understood in context of smell. We hypothesize that there is no difference in overall quality of communication in smell and no-smell conditions.

4.5.2   SCORS - Global

SCORS-G was used
for coding the
narrative material.

To measure the narratives accounts, we used SCORS - G Method. The Social Cognition and Object Relations Scale Global (SCORS - G) rating system is one of the most commonly used measures to code object-relational content via narrative material [Stein and Slavin-Mulford, 2017]. It is one of the measures that has a strong theoretical foundation and displays the capacity to assess sophisticated underlying constructs, specifically dimensions of narration.

SCORS-G uses TAT
images for encoding
the narrative
accounts.

SCORS - G has flexibility of being applied to other theoretical communities, that is, anyone who has an interest in using narrative data to study underlying intrapersonal/interpersonal processes.It uses TAT pictures for the narratives. It comprises of eight dimensions, which are scored using a seven-point Likert scale, where lower scores are indicative of more pathological aspects of object representations and higher scores are suggestive of more mature and adaptive functioning.

The three
dimensions of
SCORS-G are AFF,
COM & SC.

We only used 3 dimensions for this method that focuses upon the social interactions. The three dimensions are Complexity of Representations of People (COM), Affective Quality of Representations (AFF) and Understanding of Social Causality (SC). Two authors along with a external psychologist rated the stories based on these dimensions. The rating by each individual took three-four rounds for themselves and were done strictly in accordance with [Stein and Slavin-Mulford, 2017]. Finally, an inter-coder reliability analysis was performed on the ratings. We hypothesize that there is no difference for COM, AFF and USC scores in smell and no-smell conditions.

Complexity of Representations of People (COM)

> **COMPLEXITY OF REPRESENTATIONS OF PEOPLE:**
> COM is based on ability to understand and distinguish between individual feelings.

Definition: Complexity of Representations of People

Complexity of mental representations of self and others is a central dimension of personality structure and interpersonal functioning. Lower scores are suggestive of a more limited understanding of TAT images and higher scores are representative of a more mature and complex understanding of TAT images. Here, psychological mindedness related is focused on two components. The first component is the presence, degree, and differentiation of internal states. The second component assesses is relational boundaries. This can be defined as the extent to which people are described as enmeshed/fused versus differentiated, nuanced, and complex.

SCORS-G focuses on psychological mindedness.

1	egocentric, or sometimes confuses thoughts, feelings, or attributes of the self and others;
3	tends to describe people's personalities and internal states in minimally elaborated, relatively simplistic ways, or splits representations into good and bad;
5	representations of the self and others are stereotypical or conventional, able to integrate both good and bad characteristics of self and others, has awareness of impact on others;
7	psychologically minded, insight into self and others, differentiated and shows considerable complexity.

Table 4.1: Complexity of Representations of People (COM) Score Guidelines.

Affective quality of representations (AFF)

Affective representation is a non-transparent, non-sensory form of evaluative representation, whereby a felt valenced attitude represents the object of the experience as minimally good or bad, and one experiences that evaluative

standing as having the power to causally motivate the rel-
evant attitude. It describes what the person expects from
relationships and how s/he tends to experience significant
others and describe significant relationships). Specifically,
this is scored by assessing the emotion explicitly described
in the narrative as well as how the person experiences other
people, usually in response to the evoked interpersonal
event.

AFFECTIVE QUALITY OF REPRESENTATIONS:
AFF captures the emotional lens with which we view our
world.

1	malevolent, abusive, caustic;
3	largely negative or unpleasant, but not abusive;
4	where affective quality is absent, bland, or limited;
5	mixed, neither primarily positive nor primarily neg-ative (needs to have some positive to be scored 5);
7	generally positive expectations of relationships (but not pollyannaish), a favorable and affirmative view of relationships.

Table 4.2: Affective quality of representations (AFF) Score
Guidelines.

Lower scores indicate that a person views her environment
in a malevolent way and higher scores in a cooperative way.
The extent to which a person focuses on the positive and/or
painful determines how high or low someone scores (i.e.,
degree of spoilage). Often, prompting the individual to
provide information regarding feeling states can help dif-
ferentiate between a 2 and a 3 or between a 6 and a 7.

Understanding of social causality (SC)

Social causality is defined as a social process that produces
a change in some dependent variable. It reflects a social
mechanism rather than a physical one. One can think of
this variable as capturing how a person gets from point A
to B, C, and D in addition to the depth of how people are
understood and described during this process/interaction.

Shorter narratives (word length) are generally rated lower on the variable, but not exclusively. At the same time, longer narratives tend to be rated higher, but not exclusively, especially when narratives are disorganized.

UNDERSTANDING OF SOCIAL CAUSALITY: SC assesses the extent to which the user understands human behavior.	Definition: *Understanding of social causality*

1	narrative accounts of interpersonal experiences are confused, distorted, extremely sparse, or difficult to follow, limited awareness and coherence;
2	where subject describes interpersonal events as if they just happen, with little sense of why people behave the way they do (i.e., a logical rather than illogical stories that seem to lack any causal understanding);
3	understands people in relatively simple, but sensible ways, or describes interpersonal events in ways that largely make sense but may have a few gaps or incongruities;
5	tends to provide straightforward narrative accounts of interpersonal events in which people's actions result from the way they experience or interpret situations;
7	tends to provide particularly coherent narrative accounts of interpersonal events, and to understand people very well, understands the impact of their behavior on others and others behavior on them.

Table 4.3: Understanding of social causality (SC) Score Guidelines.

Of note, there are high correlations between SC and Complexity of Representations (COM). Both target aspects of cognition and both capture the complexity to which characters are described and impacted by one another. However, there are several important differences. First, SC captures more of the organization of the narrative, as well as logic and reasoning, than COM. Specifically, SC focuses most on how narratives and, more generally, people and interactions are constructed and understood.

There exist a slight difference between SC & COM in terms of logic inheritance.

4.5.3 Audio-Video Recording

Video raises a series of questions and problems that may not necessarily arise using more traditional materials and

methods. It forms the basis to more applied studies and interventions, including communication skills training, the design of new technology, and methods for evaluation and assessment.

Definition:
Ethnomethodology

> **ETHNOMETHODOLOGY:**
> Ethnomethodology is a method of sociological analysis that examines how individuals use everyday conversation to construct a common-sense view of the world. - [Garfinkel, 1974]

Ethnomethodology and conversation analysis for the recorded videos.

We used the analysis pattern by Christian et al. reported in their book *"Video in Qualitative research: Analysing social interactions in everyday life"* to analyze the videos [Heath et al., 2010]. Their approach draws on analytic developments within sociology, namely ethnomethodology and conversation analysis. We transcribed the videos as a critical resource in analysis to become more familiar with the data and to develop preliminary observations and insights *(see Fig. 4)*. We explore the ways in which social interaction can provide the resources to examine how participants themselves orient to and accomplish social actions.

Play a video 20-30 times before you gain a sense of delineate features of participant's conduct.

When reviewing data, a video recording of social interaction, its extraordinary detail and complexity soon become apparent. We start with every fragment and play and replay the fragment a significant number of times, perhaps 20 or 30 times, before we can begin to gain a sense of the action and delineate features of the participants' conduct. For any action in the video, we asked ourselves the question 'Why that now?' by interrogating the ways in which it might attend to prior conduct or how it might be treated by the other person in the pair.

Excerpt:
*Context and
Sequence of Actions*

> **CONTEXT AND SEQUENCE OF ACTIONS:**
> *"A speaker's action is context shaped in that its contribution to an on-going sequence of actions cannot be adequately understood without reference to the context – including, especially, the immediately preceding configuration of actions – in which it participates... [Heritage and Maynard, 2006]"*

Transcribing and mapping the participants' conduct in this way enables the researcher to begin to determine the position of particular actions to explore their potential relationship to preceding, concurrent and subsequent conduct, both vocal and visible, of all the participants. It also provides a way of discovering aspects of the action that might otherwise pass unnoticed and to document observations and insights.

Transcribing and mapping participants conduct is vital in social interactions.

> **CONVERSATION AND OBSERVING IT'S EFFECT:**
> *"Even if no quantitative evidence can be mustered for a linkage between that practice of talking and that resultant 'effect', the treatment of the linkage as relevant – by the parties on that occasion, on which it was manifested – remains... And no number of other episodes that developed differently will undo the fact that in these cases it went the way it did,with that exhibited understanding..."* [Schegloff, 1993].

Excerpt:
Conversation and observing it's effect

The potential relations in an experiment can be unpacked through careful attention to the sequential organization that informs their social behavior during the task. Users collection of practices, sequences or phenomena were valuable to compare and contrast their characteristics on different occasions in different circumstances.

User sequence behaviour can provide deep insights about the interaction.

Personality

We used International Personality Item Pool (IPIP) BIG5 scales to understand the personality type of the user. The IPIP test is based on Extraversion, Agreeableness, Conscientiousness, Emotional Stability, and Intellect/Imagination [Donnellan et al., 2006]. It's direction of scoring can be positive or negative leading to personality trait as introvert or extrovert.

IPIP Big5 scale was used to examine the personality traits.

Chapter 5

Evaluation

To inquire the impact of smell on participants social inter-
actions, we triangulated different data sources, such as be-
havioural data, users' verbal accounts during task execu-
tion, self-reports using psychometric scales and data from
our exit interviews.

5.1 Normal Distribution?

Are our samples normally distributed?

The Shapiro-Wilk test did not show a normal distribu-
tion for IOWA scores as well as for COM, AFF and SC
scores. This was re-established by Kolmogorov-Smirnov
Test. Therefore, non-parametric tests were conducted for
both the measures.

Samples were not
normally distributed.
Non-paramtric tests
were performed.

5.2 Inter-Coder Reliability

How confident are we with our ratings?

The ultimate goal of reliability control is to ensure that dif-
ferent people code the same text in the same way. To ensure

A near perfect agreement was observed among 3 coders for SCORS-G score.

this we ran the inter-coder reliability measures on our data. Cohen's kappa was run to determine if there was agreement between all the coders for the rated stories. There was a near-perfect agreement among all the 3 coders, κ = .900, (95% CI, .643 to .937), p < .0005 for the COM dimension. For AFF, the agreement was again near-perfect with κ = .964, (95% CI, .717 to .943), p < .0005. Similarly for SC, the agreement was near-perfect with κ = .902, (95% CI, .618 to .927), p < .0005.

5.3   Effect on Social Engagement

COM Measure

Did smell leads to better Complexity of Representations of People (COM)?

COM was found to be significant in smell condition.

The scores in smell condition (mean = 4.34, 95% CI 2 to 6.5) were rated higher compared to the neutral condition (mean = 3.84, 95% 1.5 to 6.5). The Kruskal-Wallis test showed that there was a statistically significant difference in COM scores between the two conditions $H(1) = 4.24$, $p = .039$. Mann-Whitney tests were used to follow up this finding. A correction was applied and so all effects are reported at a 0.05 level of significance.

COM results were followed up with exit interviews analysis.

Triangulating the results with semi-structured interviews and video recordings allow us to support this result and observation. From the recorded videos, it was observed that after the release of the scent the participants were more attentive towards the shown TAT image. *"Scent was helpful as a brain booster as it redirected me to look into some complex/hidden parts of the image."* - P16. During the task, we observed that after every scent release participants took turns in their story focusing upon different objects in the image. P9 reported that *"The scent release worked as a short break for me to close my eyes and rethink about the story & how can I understand what feelings are associated with the characters? "*

AFF Measure

Did smell leads to better Affective quality of representations (AFF)?

Using descriptive statistics, the scores in smell condition (mean = 4.12, 95% CI 1 to 6) were rated lower compared to the neutral condition (mean = 4.09, 95% CI 1 to 6). A Kruskal-Wallis test shows there is no significant difference in two conditions $H(1) = 4.37$, $p = 0.509$. From the video recordings analysis we found that in both the conditions, the participants try to push themselves into the shown image in order to understand the evoked interpersonal relationship among the characters. During exit interviews, when we asked for emotions elicited during the task, participants were of neutral view. P20 reported that "*I could not find myself in a position where the shown image evoked any emotions in me that may influence my story.*" P15 reported that "*For both the conditions, the emotions elicited in the stories were nearly similar. I couldn't see any affect of the smell.*"

AFF was not found to be significant between smell and no smell condition.

SC Measure

Did smell leads to better Understanding of Social Causality (SC)?

The scores for SC were rated higher for smell condition (mean = 4.53, 95% CI, 2 to 7) compared to the neutral condition (mean = 3.54, 95% CI, 1 to 7). Here, using Kruskal-Wallis test showed that there is a significant difference between the 2 conditions $H(1) = 4.66$, $p = 0.031$. This implies that the experience and interpretation of the image shown is more comprehensive and detailed in smell condition. From video recordings it was clear that users were able to better understand and interpret all main characters in the shown image after scent release.

USC was found to be significant between smell and no smell condition.

In Fig 4, we can observe that when the scent was released P12 stopped the writing and shifted her focus to the image. This shift in focus helped her to re-frame the story considering all the characters and elements presented. A

00:05:32

Scent Released.

Takes turn in conversation to look into hidden elements of the image.

00:06:53

P12: "It's simple, we should be done in 10 minutes."

P12: "There is some other part of the story to look at as well".

P9: "May be you should also look into the broken ring of the lady. It signifies the emotions behind the image."
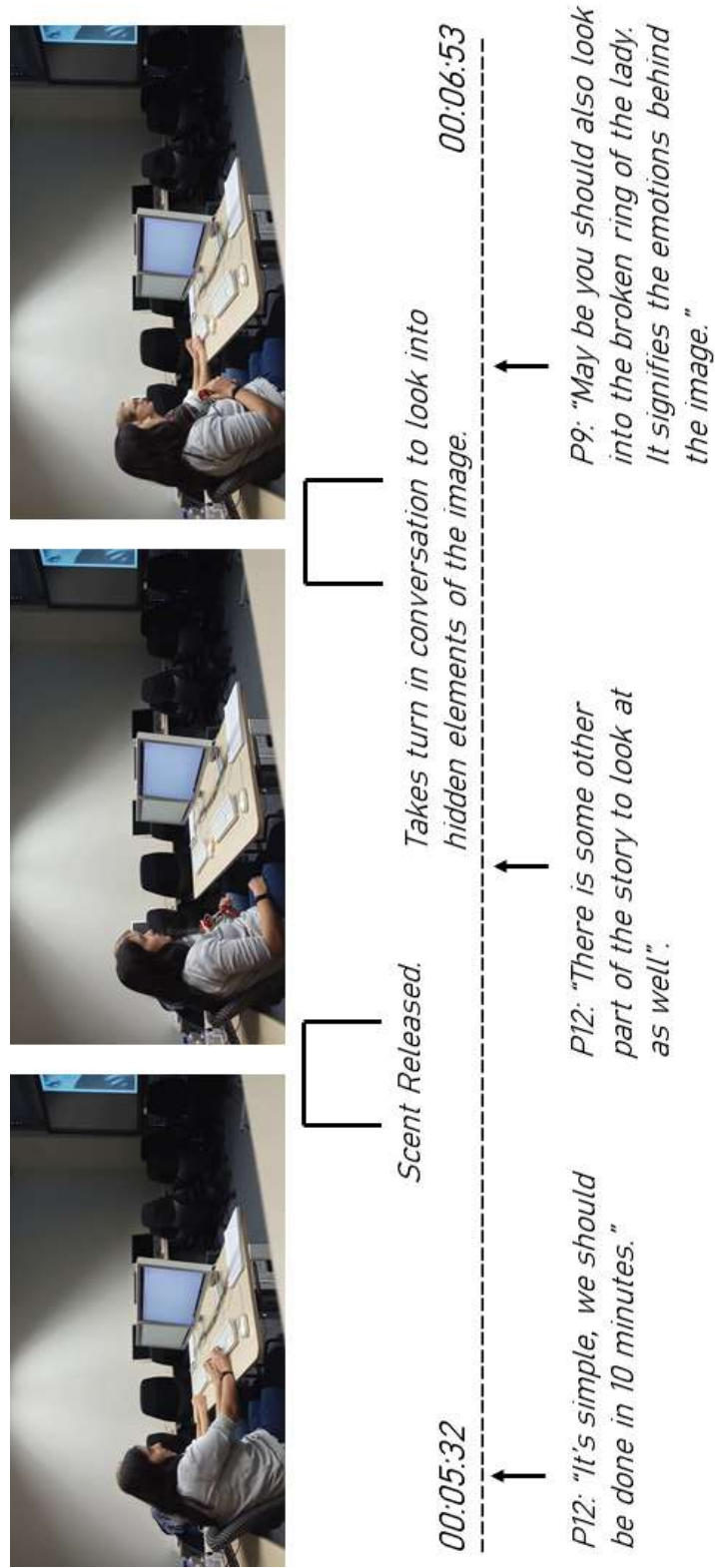
Figure 5.1: The above image represents the video transcription for P9-P10 while performing the experiment showing P9 getting more attentive after scent release.

similar trend was observed for P9, P3 and P17 when they closed their eyes during scent release and were able to connect different characters presented in the image to amalgamate them in a single story. During exit interview when we asked about flow and details of the story, P11 told us *"It was very sudden and magical after scent release that I could look for non-vital elements in the image that somehow relates to the characters"*. Similary, P18 reports that *"Scent made me meditate for a while and focus on connecting the story using different dots which we wrote it together."*

USC results were followed up by videos analysis and exit interviews.

5.4 Effect on Quality of Communication

The smell did play an significant role in enhancing the overall quality of communication on certain parameters. Our results using Kruskal-Wallis test indicates that users were significantly more relaxed $H(1) = 7.728$, $p = 0.005$ with a mean score of 1.54 in smell environment compared to 2.40 in neutral environment. They were more open $H(1) = 8.677$, $p = 0.003$ with a mean score of 7.81 in smell environment compared to 6.27 in neutral environment. In addition more in-depth $H(1) = 8.976$, $p = 0.003$ with a mean score of 3.68 in smell environment compared to 5.04 in neutral environment.

Parameters: Relaxed, open and in-depth were found to be significant in the smell condition.

Finally, they were more attentive $H(1) = 6.01$, $p = 0.014$ with a mean score of 1.95 in smell environment compared to 2.90 in neutral environment. However, we did not found any significant difference for parameters such as smooth/difficult, informal/formal, Free with communication breakdowns/ Laden with communication breakdowns and Free of Conflict/Laden with Conflict between 2 conditions.

Parameters: Smooth, Informal and communication breakdown were not found to be significant in the smell condition.

The significant difference in the parameters was triangulated by the video recordings and exit interviews as well. From analysing video recordings it was observed that scent environment lead to more attentiveness and in-depth observation towards the task. P5 also stated while writing the story after the scent release told her partner that he was more vigilant towards the task to which P6 replied in affir-

00:02:39

Scent Released.

Waves his hand to inform partner about a common character in the image.

00:03:54

Both participants stopped conversation after first 2 minutes & are in phase of communication breakdown.

P9: "Oh! Scent is releasing now. I should better enjoy this compared to the task, because anyway it is beyond my scope!"

P9: "Wait a moment, look at the horse in the picture, it relates to all the characters in the image as everyone is painted behind the horse."

Figure 5.2: The above image represents the video transcription for P11-P12 while performing the experiment showing the communication breakdown and how to elevate from it after scent release.

mative citing P5 to the flow of the story construction depicting the same. In exit interview, P14 reported that *"I felt relaxed when scent was released and it gave me a sense of belonging towards the experiment"*. Similar to this, P22 commented that *"I found scent environment to be helpful in being open to talk as when scent was released we talked about the smell, shared our thoughts and even talked our experience with the same smell."*

The results were followed up with data fromt the exit interviews.

For parameters which were not significant, it was observed from the video analysis that participants enjoyed the overall experiment in both the conditions which resonates with smooth and informal parameters. It was concluded based on the transcription of the videos which shows conversations like *"It's an interesting task! I haven't participated in something like this before"* and *"Our story is really funny! No one would believe that the girl in the picture returned home after partying for whole night. We made it real crazy."* When asked about conflicts in thoughts during the task, all the participants told us that they do had conflicts regarding story construction but it do not relate with the 2 conditions. It was followed up by videos analysis which do reveals the same.

Videos analysis provided insights for the parameters which were insignificant.

Interestingly, when we asked about role of smell in surpassing with communication breakdown during exit interviews, 17 of 22 participants did not find any role of smell in helping with it which matches with their scores reported for ICR. However, from videos analysis and transcription, it was clear that smell did helped the participants to overcome from communication breakdown. It was observed for 7 participants that when they struggled to continue with the story, scent release helped them in correcting this breakdown. They were able to come up with ideas to continue the story which were found absent in the neutral environment. Fig. 5 provides a glimpse that what participants reported and what they perceived was actually different!

There exist a contradiction in the video analysis and the subjective rating by participants. Do humans don't trust their sense of smell?

5.5 Increased Output

Did Olfactory Cues Lead to Increased Output?

Regarding the stories written, the results shows that in the

smell environment participants wrote an average of 170.6 words compared to 173.3 words in the neutral environment. A Kolmogorov-Smirnov test did not show a normal distribution of words written in each condition and, therefore, non parametric tests were conducted. A Kruskal-Wallis test, showed that there was no statistical significant difference between the words written by the participants' between the 2 conditions $H(1) = 20.45$, $p = 0.002$. From our understanding it could be related to the overall duration of the experiment which was same in both the conditions.

5.6   Nature of Relationship

Did nature of relationship among the pair of the participants affected the quality of communication?

Participants were asked to report in ICR if they already knew their partner. They needed to classify the partner as stranger/acquaintance/friend or best friend and length of time they knew their partner. Table 1 shows the relationship between 2 partners.

	Nature of Relationship	Length of time partner known
P1-P2	Strangers	N/A
P3-P4	Friends	2 years
P5-P6	Best Friends	1 year and 2 months
P7-P8	Friend	1 year and 10 months
P9-P10	Friend	3 years
P11-P12	Strangers	N/A
P13-P14	Strangers	N/A
P15-P16	Acquaintance	5 months
P17-P18	Friends	2 years and 1 month
P19-P20	Strangers	N/A
P21-P22	Acquaintance	3 months

Table 5.1: Relationship between pair of the participants in the experiment.

A chi-square test of independence was performed to examine the relation between different parameters of ICR and

participants relationship status in both the smell & neutral condition. On analysing our data, it was observed that participants who classified themselves as best friends or friends were more informal compared to acquaintance and strangers χ^2 (21) = 17.992, p = 0.003. Besides, we did not find any other significant co-relation between relationship status and other ICR parameters. However, it is worth to note that participants rated high for informal parameter in both the smell & neutral environment. Therefore, effect of nature of relationship on quality of communication is same across the environments.

The relationship type best friends or friends were more informal compared to acquaintance or strangers.

5.7   Personality Traits

Did personality type played a role in quality of communication?

The mini IPIP Big 5 test results shows that there were 11 participants who fall in category of Extrovert personality and 11 in Introvert personality. A chi-square test of independence was performed to examine the relation between personality type and parameters of ICR in both the smell & neutral condition. The relation between these variables was not significant, χ^2 (21) = 16.04, p =.360. Therefore, there is no statistically significant association between participants personality and ICR parameters. Hence, we can be further sure that it is the effect of smell that influenced some of the ICR parameters which lead to better quality of communication.

There was no statistical difference for the personality type in smell vs. no smell condition.

Chapter 6

Discussion & Limitations

Developing approaches and strategies to design everyday technologies that express representations of olfactory jewellery that meaningfully evolve and change over time presents important opportunities and issues for the HCI community. Through a critical reflection on our experiences, we highlight insights into how they could be better grappled with in HCI research and practice.

6.1 Tools for Working with Smell as a Design Material

Our idea for smell enhanced jewellery was inspired from Essence [Amores and Maes, 2017]. Our initial decision to understand scent delivery mechanism critically informed our design approach and, ultimately our final design. Through iterative explorations we focused on aesthetics and light weight for the *Abhushan*. This proved crucial to gaining a better grasp on how to conceptually and practically deal with the electronics and final look of the jewellery. However, early design iterations were incredibly crude on a visual and tactile level. They were typically constrained by the electronic equipment size.

The early design iterations with smell in the designed jewellery were crude.

The prototype design can be easily replicated .

Ultimately, these efforts were worthwhile as they catalyzed our development of a form factor based interaction design (the rose & beads) that became a defining element of *Abhushan.* With tools like a 3D printer, an ultrasonic transducer and a micro-controller the complete wearable can be easily designed.

6.2   Social Acceptance for an Olfactory Jewellery

The pre-study was designed to understand the social acceptance for *Abhushan.*

Social acceptance can be defined as understanding the differences and diversity in population because most people attempt to look and act like others do in order to fit in the society [DeWall and Bushman, 2011]. Integration of a jewellery with an odor module was a new experience for our participants. We were interested in understanding whether this would be socially acceptable among them. When we asked this question in the exit interviews, participants responses vary largely. It was reported that if they wore it in public places such as university or a public park, bystanders would certainly ask about it or even be curious to wore it once.

Participants provided insightful suggestions for potential application areas for the *Abhushan.*

The male population gave us engrossing insight that they would be interested in wearing jewellery if it signifies object that relate to men such as hat, football, cricket bat or even neutral classified object as a tree. However, the salient observation was that participants showed an urge to use *Abhushan* in the private spaces. They told us that they can use *Abhushan* while meditating, learning or even watching a movie to enrich their experience. Therefore, we can takeaway from these observations that it would be an useful tool for people in their private space compared to public spaces.

6.3 Making use of Abhushan for Social Engagement

Prior HCI research has shown how social engagement is a concept of utmost importance, not only for informing the design and implementation of interfaces, but also for making it capable of adapting to users [Morrow-Howell and Gehlert, 2012][Zemke and Shoemaker, 2007]. We explored with *Abhushan* how to make use of it in a social engagement task. When participants wrote their stories for the TAT images in smell environment, the results showed that they were better able to understand complex representation of the images.

Participants were better able to understand complex representation of the images in the smell condition.

In addition, the stories were better in understanding the social causality compared to the neutral condition. This was triangulated by video recordings and exit interviews. Triangulating the data helped us to arrive at a decisive conclusion along with the statistical significance. This gave us an impression that attentional and emotional involvement were apparent with the smell. The video recordings were essential to incorporate expressive non-verbal behaviour by participants which closely link with the social engagement. It is worthy to note that engagement defined here is two folded relating to the task of coming up with a single story and comprehending the TAT image.

Engagement defined here is two folded relating to the task of coming up with a single story and comprehending the TAT image.

The personality descriptions of the characters were enriched, psychological mindedness was evident, characters were clearly differentiated and described in nuanced way which lead to higher ratings on COM scale. Similarly, for SC scale the stories were detailed, comprehensive, coherent as well as organized. We found the stories were written in a more fluid fashion (*i.e.* there was less jumping from one topic to the next). However, for AFF scale, in both the environments the emotions of some characters presented in the stories were not discussed. Some characters were overtly expressed and provocative that dilute the emotions of other characters and do not shed light on them.

For AFF, some characters presented in the stories were not discussed and some were overtly expressed

6.4   Enhancing the Quality of Communication

It was clear form ICR data analysis that smell has positive effect in enriching the quality of communication.

This study also examined the difference in quality of communication between smell and neutral environment. For parameters from ICR such as relaxed, in-depth, open and attentive it was clear and evident from the data that smell environment was helpful in enriching the quality of communication. This gives us an important insight about application of *Abhushan* in tasks related to creative writing. For parameters such as smooth, informal and conflicts no significant effect of smell was observed.

However, smell does not help in resolving the conflicts during social interactions.

It guides ourselves that smell does not help in resolving conflicts or making the conversation smooth to which we believe is more subjective. However, the parameter informal was found to be significant when we focus on the nature of relationship between the participants as friends or best friends. It was *in-situ* and resonates which previous research by Duck et al. [Duck et al., 1991]. It becomes important to discuss one key observation in which what participants ratings differs with the video observations. The parameter "Free with communication breakdown" was not found significant towards the smell environment.

The difference in the human perception can be understood by the perception-action theory from psychology.

However, video recordings revealed a different picture. We point out that what participants reported differs from what they perceive. It can be understood by perception-action theory in psychology by Gibson [Gibson, 2014] which states that people perceive their environment and events within it in terms of their ability to act. The smell helped participants to re-organize their thoughts and look more attentively into the TAT image which resulted in resolving the communication breakdown.

From sociology literature, providing cues about a task does help in recovery.

Another angle from which this can be looked at is what helps in recovering from this.From sociology research [Wright and Randall, 1978], it has been observed that providing cues about task, shifting focus to an object other than the task or a sudden alert can help in the recovery. The smell release from *Abhushan* embarks the last two mentioned observation where with scent focus is shifted as a

sudden olfactory alert.

It is interesting to see that how the stories picked apart the details of the content rather than how much users judge it valuable or not. People don't trust their own sense of smell however when we look at the objective data we can observe that how good they are with smell. Humans are rational as they trust their eyes and ears more than their nose so that's where bias come from where they need to rate it. It is an interesting problem space where we always say it is not just what people say but what they do.

> Humans are rational as they trust their eyes and ears more than their nose.

6.5   Application as a Brainstorming Tool

There are multiple applications presented in the past literature for the olfactory jewellery. The diverse range of applications include well-being, Immersive Environments, Learning and, Cognitive Performance [Amores and Maes, 2017] applying to *Abhushan* as well. However with this research on social interactions, we propose another yet important application for *Abhushan* as a Brainstorming tool.

> Smell has been explored before extensively in domain of well-being.

The generation of different ideas is crucial in essence of the brainstorming and indeed a difficult task. Now, being evident from the results it can be noted that *Abhushan* can be a helpful tool for same. *Abhushan* gives an alert in form of smell cues which helps in being more attentive, understanding the complexity of the question and connecting multiple dots to arrive at a conclusion. It can also release a specific scent to help retrieve the learned facts during brainstorming by releasing the same scent again.

> *Abhushan* helps in being more attentive and focused while performing a collaborative task.

People can trigger scent in a creative and collaborative process and that might change the way they think about a problem. Hence, it's helpful in problem solving as well where we are currently very limited in way what kind of props and tools we use in brain storming. One can think beyond the *Abhushan* to integrate the smell in mobile phones, smart watches or even in the white board with different scent being delivered in order to a renewed to solve the problem. Overall, effect of smell on communication and

> *Abhushan* is merely a form factor, jewellery makes it personal.

collaboration or even smell for creative thinking is a key
nugget.

6.6   Limitations

The device can
contain only one
scent at a time.

Despite intensive research on the development of olfactory
devices, there is still a lack of small and wearable device
suitable in daily life. In this paper, the aim was to under-
stand how would people use a olfactory jewellery during
social interactions. The prototype has some potential limi-
tations as the refilling need and limit of one scent at a time.

This study also does
not look the results
from human sensory
perception
perspective.

Although, the refilling need depends on the size of the scent
bottle but it is important to take this into account for future
designs of olfactory jewellery. Besides, we did not focus on
how human sensory perception works that can reflect accu-
rately to the users' modified social cognition and even ar-
gument concretely for social interactions. In addition, sens-
ing the chemo signals could have provided meaningful in-
sights in understanding physical and emotional state of the
participants.

Chapter 7

Summary and future work

In synopsis, this paper demonstrates development of an olfactory jewellery *'Abhushan'* and it's role in examining the social interactions. Moreover, this work combines concepts from HCI, Sociology, Psychology and Human Communication Research to study the effect of smell on quality of communication and engagement in a task. The triangulation of data from psychometric scales, participants verbal accounts and video recordings helped us to report our result with higher internal validity. It offers new possibilities for sensing capabilities and use of scent in the field of HCI. Furthermore, the participants enjoyed the experiment and were excited by this novel way to perceive the information. The user has complete control over the secreted chemical signal that can trigger stronger social response between participants. The modular and portable design of the hardware allows for personalized form factor which covers users' individual motivations to wear the jewellery as in matching with the dress, portable on body substitute of the deodorant and during the meditation etc.

The *multi-domain analysis framework* to analyze social interactions is a contribution of this thesis.

Abhushan can be customized by changing it's form factor.

7.1   Future work

Future work involves
reducing the overall
electronics and
more-fashioned
design.

Incorporation of a
sweat sensor, use
with VR/AR module
are further directions.

The results of the experiment encourages us to find potential applications of *Abhushan* in the future work. We focus on improved, more-fashioned design of the wearable and reducing the overall electronic components. In addition, enhancing the sensing capabilities with sweat sensor by Gao et al. [2016] can provide an application in the field of well-being. With the evolution of wearable computing, VR & AR and enhances in machine learning, the smell will significantly enhance the sense of immersion. Technologies developed in the future will very possibly be able to overcome the challenges of current hardware and will reach sensing capabilities similar to the human olfactory system. Altogether, olfactory wearable devices remains a multifaceted and exciting topic which holds great potential in designing of novel approaches in HCI.

Appendix A

IOWA Communication Record

This appendix provides the IOWA Communication Record used in the study to examine the quality of communication in scent vs no scent condition. The responses of ICR was analyzed and were presented in the results section.

APPENDIX
Iowa Communication Record

Your I.D: _____

Age: _____

Sex: M or F (circle one)

1. Date of Interaction: _____ _____
   mo.   day

2. Time of Interaction: _____ AM or PM
   hour   (circle one)

3. Length of Interaction: _____ _____
   hour   min

4. Description of Interactional Partner:

   _____ _____ M or F (circle one)
   Initials   Age

5. Length of time you have known partner in years and months:

   _____ _____
   year   mo.

6. How would you describe the nature of your relationship? (circle one)

1	2	3
Stranger	Acquaintance	Friend

4	5	6	
Best Friend	Lover	Relative	Other _____

7. What type of communication? (circle one)

1	2	3
Face-to-Face	Long-Distance Telephone	Local Telephone

8. Would you consider the interaction public or private?
   (circle one and state place)

1	2	_____
Public	Private	Where

9. Were others present? Yes or No

10. What was the role of talk? Indicate the extent to which you agree with
    the following:

This was talk just for talk's sake.

1	2	3	4	5	6	7	8	9

Strong   Strong
Agreement   Disagreement

Main purpose of talk was to accomplish some task. (Such as gaining information to complete a project, or solve a problem.)

1	2	3	4	5	6	7	8	9

Strong   Strong
Agreement   Disagreement

Main purpose of talk was to facilitate some social objective. (Such as talk surrounding sports activity or party.)

1	2	3	4	5	6	7	8	9

Strong   Strong
Agreement   Disagreement

Main purpose of talk was to facilitate the relationship. (Such as talk to become better acquainted or resolve differences.)

1	2	3	4	5	6	7	8	9

Strong   Strong
Agreement   Disagreement

11. Describe the main topic of talk:

_____

12. Were there other topics: Yes or No

   If yes, indicate the number of topics you think were addressed in the talk:

_____

13. What were you doing *right before* the conversation occurred?
    (circle one or more)

working	eating	driving	study

childcare	housework	watching TV	reading

listening   talking to   _____
to music   someone else   other

14. Were you involved in any activities *during* the conversation?
    Yes or No

   If yes, please indicate which of the above:

_____

15. What did you do *after* the conversation (as above)?

16. Was the interaction *planned* or *unplanned*? (circle one)

17. If planned, indicate the extent to which you were looking forward to the meeting:

1	2	3	4	5	6	7	8	9

Looking Forward to Meeting   Dreading Meeting

18. Who initiated the talk? (circle one)

    You   Partner   Seemed Mutual   Accidental   Not Clear

19. Who seemed to control the conversation; for example, who decided topics of talk?

    You   Partner   Seemed Mutual   Accidental   Not Clear

20. Who made moves to end the conversation?

    You   Partner   Seemed Mutual   Accidental   Not Clear

21. Describe the quality of communication:

1	2	3	4	5	6	7	8	9

Relaxed   Strained

1	2	3	4	5	6	7	8	9

Impersonal   Personal

1	2	3	4	5	6	7	8	9

Attentive   Poor Listening

1	2	3	4	5	6	7	8	9

Formal   Informal

1	2	3	4	5	6	7	8	9

In-depth   Superficial

1	2	3	4	5	6	7	8	9

Smooth   Difficult

1	2	3	4	5	6	7	8	9

Guarded   Open

1	2	3	4	5	6	7	8	9

Great Deal of
Understanding

Great Deal of
Misunderstanding

1	2	3	4	5	6	7	8	9

Free of
Communication
Breakdowns

Laden With
Communication
Breakdowns

1	2	3	4	5	6	7	8	9

Free of Conflict

Laden With Conflict

22. Indicate the extent to which you think the talk was interesting:

1	2	3	4	5	6	7	8	9

Interesting

Boring

23. Indicate the extent to which you came away satisfied with the interaction:

1	2	3	4	5	6	7	8	9

Satisfied

Not Satisfied

24. How valuable was this conversation to you for your life right now?

1	2	3	4	5	6	7	8	9

Extremely
Important

Not Important
at All

25. How valuable was this conversation for your future?

1	2	3	4	5	6	7	8	9

Extremely
Important

Not Important
at All

26. Indicate the extent to which this talk resulted in a change of your attitude:

-3	-2	-1	0	+1	+2	+3

Negative Change

No Change

Positive Change

27. Indicate the extent to which this talk resulted in a change of your behavior:

-3	-2	-1	0	+1	+2	+3

Stopped Behavior

No Change

Increased Behavior

Describe behavior change:_____

---

28. Indicate the extent to which this talk changed your *thinking* or *ideas*?

0	1	2	3	4	5	6	7	8	9

No Change   Great Change

Describe change in thinking/ideas:_____

---

29. Indicate the extent to which this talk resulted in a change of your feelings:

-3	-2	-1	0	+1	+2	+3

Negative   No Change   Positive

Describe change in feelings:_____

---

30. Indicate the extent to which this talk resulted in a change of your relationship:

-3	-2	-1	0	+1	+2	+3

Much More Distant   No Change   Much More Close

---

31. Indicate the extent to which this talk changed your attraction toward partner:

-3	-2	-1	0	+1	+2	+3

Greatly Decreased   Greatly Increased
Attraction   No Change   Attraction

---

32. On an average day how many people do you talk to?

_____

---

33. Out of the total amount of time you spend conversing per week, what percentage of that time do you think is spent talking with this person?
_____%

Appendix B

SCORS - Global

This appendix provides the Social Cognition and Object Relations Scale (SCORS) used in the study to measure the narratives accounts and social engagement in scent vs no scent condition. The stories were coded in accordance wih SCORS and was validated using intra-coder reliability with a near perfect match.

SOCIAL COGNITION AND OBJECT RELATIONS SCALE - GLOBAL RATING METHOD

Complexity of representation of people: 1 = is egocentric, or sometimes confuses thoughts, feelings, or attributes of the self and others; 3 = tends to describe people's personalities and internal states in minimally elaborated, relatively simplistic ways, or splits representations into good and bad; 5 = representations of the self and others are stereotypical or conventional, is able to integrate both good and bad characteristics of self and others, has awareness of impact on others; 7 = is psychologically minded, insight into self and others, differentiated and shows considerable complexity

1   2   3   4   5   6   7

Affective quality of representations: (i.e., what the person expects from relationships, and how s/he tends to experience significant others and describe significant relationships): 1 = malevolent, abusive, caustic; 3 = largely negative or unpleasant, but not abusive; 5 = mixed, neither primarily positive nor primarily negative, (needs to have some positive to be scored 5); 7 = generally positive expectations of relationships (but not pollyannaish), a favorable and affirmative view of relationships **Note: where affective quality is absent, bland, or limited, code 4**

1   2   3   4   5   6   7

Emotional investment in relationships: 1 = tends to focus primarily on his/her own needs in relationships, has tumultuous relationships, or has few if any relationships; 3 = somewhat shallow relationships, or only **alludes to others**; 5 = demonstrates conventional sentiments of friendship, caring, love, and empathy; 7 = tends to have deep, committed relationships with mutual sharing, emotional intimacy, interdependence, and respect, positive connectedness and appreciation of others   **Note: where only one character is described and no relationship is depicted, code 2**

1   2   3   4   5   6   7

Emotional investment in values and moral standards: 1 = behaves in selfish, inconsiderate, self-indulgent or aggressive ways without any sense of remorse or guilt; 3 = shows signs of *some* internalization of standards (e.g., avoids doing "bad" things because knows will be punished for them, thinks in relatively childlike ways about right and wrong, etc.), or is morally harsh and rigid toward self or others; 5 = is invested in moral values and tries to live up to them; 7 = thinks about moral questions in a way that combines abstract thought, a willingness to challenge or question convention, and genuine compassion and thoughtfulness in actions (i.e., not just intellectualized) **Note: where no moral concerns are raised in a particular story, code 4**

1   2   3   4   5   6   7

Understanding of social causality: 1 = narrative accounts of interpersonal experiences are confused, distorted, extremely sparse, or difficult to follow, limited awareness and coherence; 3 = understands people in relatively simple, but sensible ways, or describes interpersonal events in ways that largely make sense but may have a few gaps or incongruities; 5 = tends to provide straightforward narrative accounts of interpersonal events in which people's actions result from the way they experience or interpret situations; 7 = tends to provide particularly coherent narrative accounts of interpersonal events, and to understand people very well, understands the impact of their behavior on others and others behavior on them.   **Note: where subject describes interpersonal events as if they just happen, with little sense of why people behave the way they do (i.e., alogical rather than illogical stories that seem to lack any causal understanding), code 2**

1   2   3   4   5   6   7

Experience and management of aggressive impulses: 1 = physically assaultive, destructive, sadistic, or in poor control of aggression, impulsive; 3 = angry, passive-aggressive, denigrating, or physically abusive to self (or fails to protect self from abuse); 5 = avoids dealing with anger by denying it, defending against it, or avoiding confrontations; 7 = can express anger and aggression and assert self appropriately **Note: if no anger content in the story, code 4**

1   2   3   4   5   6   7

Self-esteem: 1 = views self as loathsome, evil, rotten, contaminating, or globally bad; 3 = has low self-esteem (e.g., feels inadequate, inferior, self-critical, etc.) or is unrealistically grandiose; 5 = displays a range of positive and negative feelings toward the self; 7 = tends to have realistically positive feelings about him/herself
Note: needs to have some positive to be scored a 5 or above

1   2   3   4   5   6   7

Identity and coherence of self: 1 = fragmented sense of self, has multiple personalities; 3 = views of , or feelings about, the self fluctuate widely and unpredictably; unstable sense of self; 5 = identity and self-definition are not a major concern or preoccupation; 7 = feels like an integrated person with long-term ambitions and goals
Note: ambiguity about a goal is still considered a goal and may be scored in the higher range

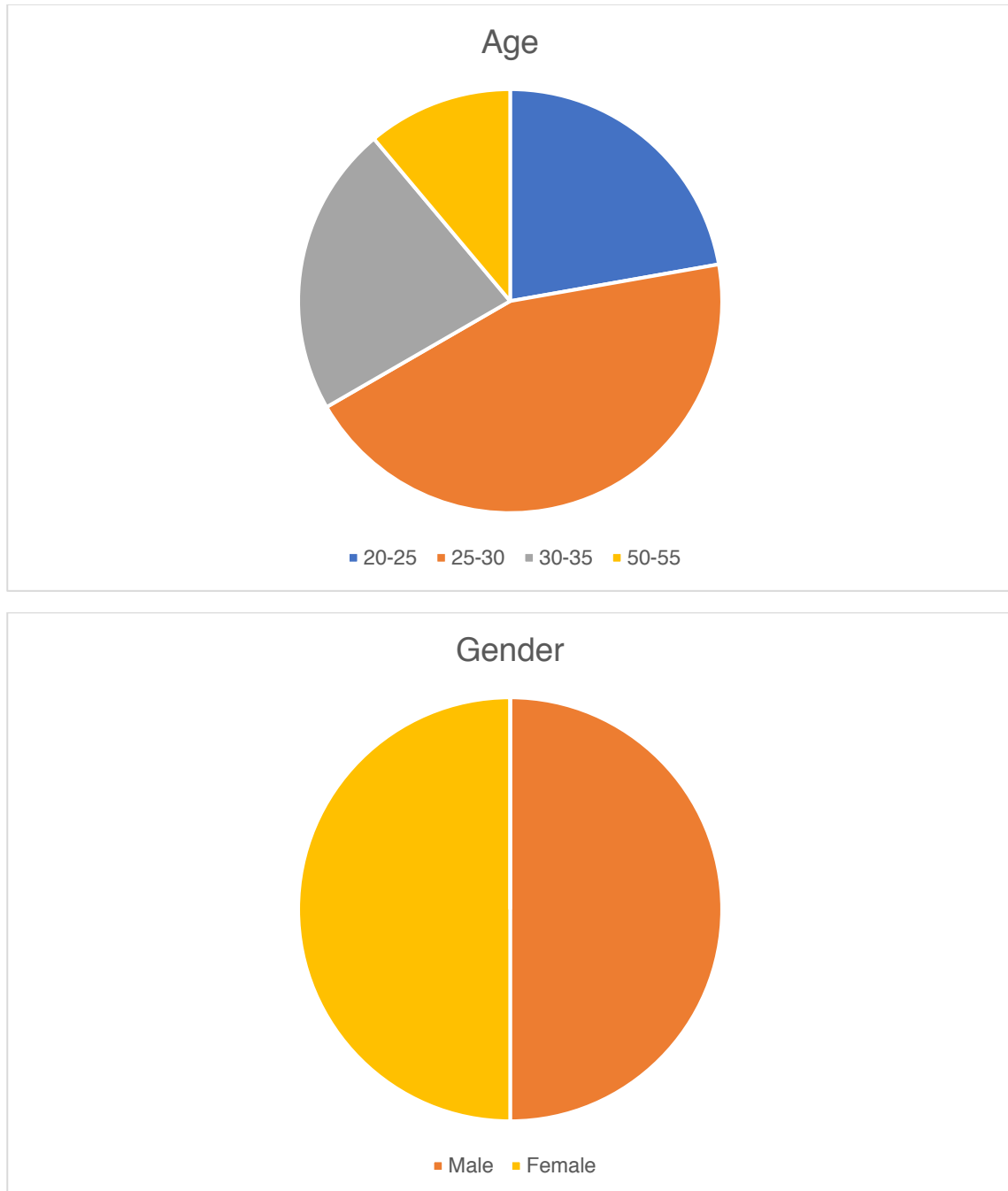1   2   3   4   5   6   7

Appendix C

Pre-Study Responses on Social Acceptability

This appendix provides the responses of the participants of pre-study on social acceptability for the *Abhushan*.

Pre-Study Data:

Demographics:

Total number of participants = 8

Participant #1

Age: 26, Gender: Female, No. of days device used: 2

Q. What do you like about the design of the artefact?

Day 1: Rose as an entity, *Innovative Jewel Piece, Beads giving jewellery look*

Day 2: People talking about it, Instagram likes by friends

Q. What do you dislike about the design of the artefact?

Day 1: The back side (electronics & power source) makes me feel that something is there.

Day 2: The cloudy thing of scent, it should be subtle!

Q. Please comment upon socially acceptability of the jewellery with smell as your real experiences with *Abhushan* today.

Day 1: I was mostly at home as it was Sunday. I just talked to my boyfriend and showed him this over the video call, he told me it looks *supernatural* like a movie!

Day 2: I wore it in the university. All of my friends asked me about this. *Everyone wanted to try this*. I think it was socially acceptable.

Q. Did you perceive the scent emitted by the device today?

Day 1: Yes, I added the lemon scent.

Day 2: Yes, Jasmine! It was calm.

Q. At what time during the day did you wear the device?

Day 1: Around 12 in the noon to 6 in the evening.

Day 2: It was there with me whole day! I would say 9 am to 4 pm approx…

Q. Did you encounter any odour nuisance? If yes, please explain

Day 1: No

Day 2: No

Q. Did you receive any comments/reactions about the emitted scents by the people around you?

Day 1: No

Day 2: Yes, I was with my friends. I remember one of my friends telling me this is *scary*! But when he tried himself, he liked it. Another friend told me she liked my body odour because of scent.

Q. Did you feel comfortable in wearing the device today?

Day 1: Both Yes and No. In first hour, I wanted to remove it. But eventually by time it was ok.

Day 2: Somehow, I felt *comfortable now*. Maybe I wear jewellery all the time that's why it was easy.

Q. Did you feel about losing the device or breaking it?

Day 1: Yes, I was very careful as it was given to me so it was my responsibility.

Day 2: Yes, I kinda felt this as my jewellery which I will always take care of.

Q. Describe any special moment with the device.

Day 1: Exploring the device and showing off to my boyfriend.

Day 2: Making a small video with this to upload on Instagram. It became <mark>a part of my Instagram story.</mark>

Q. Describe a typical day with *Abhushan* and without it.

Day 1: Something to <mark>play</mark> with it, like a new toy!

Day 2: I wanted it to show off to my friends so It was important. But, may be not everyday but on some occasions only.

Participant #2

Age: 28, Gender: Male, No. of days device used: 2

Q. What do you like about the design of the artefact?

Day 1: <mark>Hat shape gives a nice look for jewellery for men!</mark>

Day 2: It's easy to use.

Q. What do you dislike about the design of the artefact?

Day 1: I don't wear jewellery. So, I simply don't like anything on my body.

Day 2: It's bit <mark>heavy</mark> when scent bottle is full.

Q. Please comment upon socially acceptability of the jewellery with smell as your real

experiences with *Abhushan* today.

Day 1: I showed this to my 3-4 friends and they were <mark>intrigued</mark> that what I was wearing. They wanted to know more. Then I showed them the prototype, they <mark>liked</mark> it. Then we started talking about <mark>jewellery and boys</mark>. It was a vague discussion but this device was topic of discussion.

Day 2: I live with my parents. I showed them and somehow <mark>my mom liked it on me</mark>. She asked me as if I have bought a new device with scents to lie to her for not taking bath.

Q. Did you perceive the scent emitted by the device today?

Day 1: Yes. I tried many of them: Lemon, Jasmine, Vanilla, Mint. They all were nice.

Day 2: Yes

Q. At what time during the day did you wear the device?

Day 1: 1 – 3 pm and 5 – 7 pm

Day 2: 10 am – 2 pm

Q. Did you encounter any odour nuisance? If yes, please explain

Day 1: Yes, when I mixed lemon and vanilla. It smells bad.

Day 2: No

Q. Did you receive any comments/reactions about the emitted scents by the people around you?

Day 1: Everyone knew that it was ==something new==! Everybody asked me to show how it works. One of my friends told me the good part is the emitted scent is ==restricted to my vicinity==.

Day 2: My dad asked me how much aware I was when scent is emitted. I think I was aware all the time as I have the controller with me, so when I turn off it is gone.

Q. Did you feel comfortable in wearing the device today?

Day 1: No. Not a fan of jewelry.

Day 2: Little bit. But I won't wear it for long just for some occasions.

Q. Did you feel about losing the device or breaking it?

Day 1: No.

Day 2: No. I knew when it was on my body and when I removed it.

Q. Describe any special moment with the device.

Day 1: Intensity of scent when turned to medium was nice. ==I could smell as if I put perfume==.

Day 2: ==For around an hour, I totally forgot I was wearing== something when I was working.

Q. Describe a typical day with *Abhushan* and without it.

Day 1: Get up in morning, wear it for 15 mins with some good smell and later in night repeat before sleeping.

Day 2: It's just a portable ==on body substitute of the deodorant==.

Participant #3

Age: 32, Gender: Female, No. of days device used: 2

Q. What do you like about the design of the artefact?

Day 1: I love roses! It made me feel I am ==carrying a rose that someone gifted me.== It's nice.

Day 2: Emitted scent is soothing and make me feel calm when I need.

Q. What do you dislike about the design of the artefact?

Day 1: ==I need to wear something red so that It matches with my dress==. Maybe a blue color.

Day 2: I think for testing it is okay!

Q. Please comment upon socially acceptability of the jewellery with smell as your real experiences with *Abhushan* today.

Day 1: I wore a red dress to suit with this device. My friends at work liked it and told <mark>me I was looking pretty</mark>. This was not usual. You can say that it was socially accepting.

Day 2: This was weird. I was wearing this when I went to church. People were okay unless device emitted the scent. Maybe <mark>I disturbed their prayers. So, it was not socially good to have in religious place.</mark>

Q. Did you perceive the scent emitted by the device today?

Day 1: Yes.

Day 2: Yes

Q. At what time during the day did you wear the device?

Day 1: Normal working hours, 9 to 5

Day 2: 4 pm – 9 pm

Q. Did you encounter any odour nuisance? If yes, please explain

Day 1: No

Day 2: Yes, when I was around in BodyShop. They had room freshener <mark>which got mixed with my jasmine smell.</mark>

Q. Did you receive any comments/reactions about the emitted scents by the people around you?

Day 1: Scents are scents. People like the rose thing. It was very new to them.

Day 2: Yes, in church an old guy was whispering <mark>what a lady</mark>. But I don't mind.

Q. Did you feel comfortable in wearing the device today?

Day 1: Yes, it's like any long jewellery.

Day 2: Yes.

Q. Did you feel about losing the device or breaking it?

Day 1: Yes. Jewellery is something which is precious and important for me.

Day 2: Same as last day.

Q. Describe any special moment with the device.

Day 1: I tried to use Abhushan in a project academic meeting. I was very tired and was not able to come up with thoughts. My supervisor asked me for feedback, I had no idea! I was just seeing the wall. Then my supervisor asked me what I am wearing, the conversation folded in respect to the device. I showed her how it works with 3-4 puffs of Jasmine scent. This <mark>was kind of booster and I was more involved in the meeting.</mark>

Day 2: I used the lavender smell to make me sleep. This was <mark>relaxing</mark>.

Q. Describe a typical day with *Abhushan* and without it.

Day 1: I would wear it ==based on my dress choice==. However, if I have like a sunflower, a tree or other variants I may get use to it. Without it also okay, as this is new and not highly adopted.

Day 2: When you want to relax and meditate, it's nice to have.

Participant #4

Age: 21, Gender: Female, No. of days device used: 2

Q. What do you like about the design of the artefact?

Day 1: I really like the design; it ==is similar to a jewellery indeed.==

Day 2: It is ==very small== considering that it is a prototype.

Q. What do you dislike about the design of the artefact?

Day 1: It should be incorporated into some kind of jewelry.

Day 2: Needs to be lighter when added weight of the scent.

Q. Please comment upon socially acceptability of the jewellery with smell as your real experiences with *Abhushan* today.

Day 1: ==I would not like to be the first person to wear this; people would be curious and I would be obliged to explain them what I am wearing==. So, I wore it in my apartment.

Day 2: I tried to wear this in university. All the day was ok, I explained to people what this is. However, I ==removed it during meals==; there, I would rather like to smell my food.

Q. Did you perceive the scent emitted by the device today?

Day 1: Yes, even after scent is gone. I perceived it. My nose is very sensitive, I guess.

Day 2: Yes

Q. At what time during the day did you wear the device?

Day 1: In night for 3 hours.

Day 2: 11 am to 8 pm

Q. Did you encounter any odour nuisance? If yes, please explain

Day 1: Yes, I felt if ==I also emit allergens, an allergic person standing right beside you might smell this and immediately collapse.==

Day 2: No

Q. Did you receive any comments/reactions about the emitted scents by the people around you?

Day 1==: One friend told me that If someone besides me does not smell good, I can cover his smell.==

Day 2: If everybody possesses a device like this, I could imagine that it might stressful.

Q. Did you feel comfortable in wearing the device today?

Day 1: Yes, but for first few hours only.

Day 2: Yes, maybe I was habitual for wearing it for long.

Q. Did you feel about losing the device or breaking it?

Day 1: No.

Day 2: Maybe No because I get it how it works, so can make another one if this broke out.

Q. Describe any special moment with the device.

Day 1: I could imagine that it has an effect on your mood, that it lets you feel good, it might improve your concentration or that it just can be fun; Anyway, you can improve your mood with scents.

Day 2: If you adapt to a scent, it might happen that you will not perceive the scent properly although it has an effect as I had Jasmine throughout the day.

Q. Describe a typical day with *Abhushan* and without it.

Day 1: I would use it in my office when working, when trying to concentrate, when trying to relax, when meditating or when there is other bad smell around.

Day 2: I wouldn't wear it just not to have people keep asking me what it is.

Participant #5

Age: 26, Gender: Male, No. of days device used: 2

Q. What do you like about the design of the artefact?

Day 1: Hat thing! Size and functional design.

Day 2: It can give you any smell that you want.

Q. What do you dislike about the design of the artefact?

Day 1: It should be incorporated into some kind of jewelry.

Day 2: I am not use to wearing the jewelry so it would be nice if I could somehow hide it.

Q. Please comment upon socially acceptability of the jewellery with smell as your real experiences with *Abhushan* today.

Day 1: I won't mind as long as there are enough people around me, e.g. at University If you are outside, nobody will care!

Day 2: I did not had problem explaining to people what this device does. It's just that people do accept it but only when they know what it is actually other than just a hat!

Q. Did you perceive the scent emitted by the device today?

Day 1: Yes

Day 2: Yes

Q. At what time during the day did you wear the device?

Day 1: Few hours in morning.

Day 2: Random Text - Deleted

Q. Did you encounter any odour nuisance? If yes, please explain

Day 1: Yes, I don't know if this is the scent of my personal wearable or from somebody else.

Day 2: No today

Q. Did you receive any comments/reactions about the emitted scents by the people around you?

Day 1: My girlfriend told me that she would like to wear it if she knew she was going into an environment with an inherently bad smell.

Day 2: It depends upon the intensity. If my intensity is too high, people around me get disturbed so they eventually ask me to put it off.

Q. Did you feel comfortable in wearing the device today?

Day 1: No, I did not like it wearing it for longer. For 1 hour it is ok.

Day 2: I did not expect this but yes! Many times I completely forgot it was there, except for some times when the scent suddenly became more noticeable and strong.

Q. Did you feel about losing the device or breaking it?

Day 1: No

Day 2: No

Q. Describe any special moment with the device.

Day 1: My friend just came after Gym to meet me without taking shower, he was not smelling good. Suddenly her girlfriend came at our house, I tried to cover his smell and we started talked about the device.

Day 2: Random Text - Deleted

Q. Describe a typical day with *Abhushan* and without it.

Day 1: It is something new to try it out but not for too long.

Day 2: Random Text – Deleted

Participant #6

Age: 31, Gender: Male, No. of days device used: 2

Q. What do you like about the design of the artefact?

Day 1: Somehow it looks like a necklace, which is good.

Day 2: It's handy and portable device exactly like any jewel piece.

Q. What do you dislike about the design of the artefact?

Day 1: It is kind of big for me. I feel it lot on my body.

Day 2: The controller is too big to handle sometimes.

Q. Please comment upon socially acceptability of the jewellery with smell as your real experiences with *Abhushan* today.

Day 1: In restaurants with their own theme it was problematic. People kind of didn't like me smelling lemon. It also interferes with the food.

Day 2: It did not go more than my personal bubble space. I was in public areas most of the time and people just look at you. However, no one bothers.

Q. Did you perceive the scent emitted by the device today?

Day 1: Yes, with mint.

Day 2: Yes

Q. At what time during the day did you wear the device?

Day 1: Mostly afternoon

Day 2: After workhours with different scents it was relaxing.

Q. Did you encounter any odour nuisance? If yes, please explain

Day 1: No but when I inhaled it, It was!

Day 2: Yes, since I smoke often and it was there on my body, I didn't like it when both smell got mixed.

Q. Did you receive any comments/reactions about the emitted scents by the people around you?

Day 1: My friend told me that I was smoking less on this day as I tried anti-smoking scent. I think cloudy thing makes me feel I am smoking and the smell is closest to cigarette.

Day 2: No

Q. Did you feel comfortable in wearing the device today?

Day 1: I was having urge to use many times since I wanted to know more about it.

Day 2: I asked at my workplace if there is anyone allergic to scents. Everyone was okay! So, I wore in on that day and it was okay.

Q. Did you feel about losing the device or breaking it?

Day 1: Yeah, I thought I might break the back part.

Day 2: Not this time.

Q. Describe any special moment with the device.

Day 1: My senses stricken when I used it while writing code. I was ==more attentive and focused on my work.==

Day 2: It was as ==close to an aromatherapy device== and I liked that part. I usually put deodrants but this was more natural.

Q. Describe a typical day with *Abhushan* and without it.

Day 1: I liked it so I would wear it sometimes not all of course just to try out, without is also okay ==does not make much difference to me==.

Day 2: It ==works like deodorant for me==, emitting scent after Gym, bicycling, before a party or even after stressful day. Without would be you need to carry your deodorant or perfume every time.

Participant #7

Age: 52, Gender: Female, No. of days device used: 2

Q. What do you like about the design of the artefact?

Day 1: Oh boy! This is trendy and looks good.

Day 2: I need not to carry my perfume and wear my jewellery, ==this rose does it all==. Reminds me of the rose my husband gave me some 20 years ago.

Q. What do you dislike about the design of the artefact?

Day 1: It's near to my chest, that is a ==long jewellery==. But that's ok sometimes I wear it.

Day 2: ==Tangles around my chest== sometimes.

Q. Please comment upon socially acceptability of the jewellery with smell as your real experiences with *Abhushan* today.

Day 1: I wear it when I met my girlfriends. We discussed about it that how technology is changed. I tell you for ==older people it is really good as they always like aromas and scents==. So, I think it was socially acceptable.

Day 2: I was sitting near the pond in public garden with wearing this. Many people came to me asking about it, when I started smell. It was good to meet new people but they didn't like it in first glance. May be because many of them were men and they don't wear it.

Q. Did you perceive the scent emitted by the device today?

Day 1: Yes, all the time.

Day 2: Yes, ofcourse.

Q. At what time during the day did you wear the device?

Day 1: During Yoga in morning, for meditation in evening and when I was cooking the food.

Day 2: When I was sitting alone in park, during my reading time and before bed. It was Sunday so I was mostly at home. This is like <mark>you normally do not wear jewellery when you are at home.</mark>

Q. Did you encounter any odour nuisance? If yes, please explain

Day 1: No, in fact I liked that I can smell so many scents.

Day 2: No.

Q. Did you receive any comments/reactions about the emitted scents by the people around you?

Day 1: Everyone asked me what's that, did you tried to make some new jewellery. It was fun showing everyone.

Day 2: Yes, in park. One person told me it is <mark>magic science</mark>*. But while talking to them and scent coming out, they focused on scent only not my saying.*

Q. Did you feel comfortable in wearing the device today?

Day 1: Yes, for yoga and meditation mostly.

Day 2: Yes, early morning and before going to bed was good.

Q. Did you feel about losing the device or breaking it?

Day 1: No.

Day 2: No.

Q. Describe any special moment with the device.

Day 1: Usually I put air freshener in my room. This <mark>device worked as an alternative</mark>*. The nice smell was there ventilation system was on.*

Day 2: <mark>Watching a movie with this on</mark> *and having lavender smell was best experience. It enhanced my experience.*

Q. Describe a typical day with *Abhushan* and without it.

<mark>*Day 1*</mark>*: I had a colleague fart in my office before he left. Everyone in the office was looking here and there about the same. Then I saw that guy I acted like I didn't felt anything to make him feel nothing happened, but inside I smell really bad. After he left, I sprayed the whole room down with air freshener. I think Abhushan would had been a good choice there.*

<mark>*Day 2*</mark>*: I live in an urban like. There are many beggars around on the streets. I saw this really dirty looking homeless individual start walking down the aisle. I could smell his body odour as pathetic, then I turned ON the device and it was kind of relief as I remember the scent was lemon.*

Participant #8

Age: 22, Gender: Male, No. of days device used: 2

Q. What do you like about the design of the artefact?

Day 1: I like the design as in it is easy to wear and looks like big jewellery that man can also wear.

Day 2: <mark>Hat looks classy</mark>! Gives me a manly look.

Q. What do you dislike about the design of the artefact?

Day 1: The surrounding box on my neck is not so good idea.

Day 2: The weight is sometimes heavy when bottle is full.

Q. Please comment upon socially acceptability of the jewellery with smell as your real experiences with *Abhushan* today.

Day 1: I think smell is related with <mark>moral identity</mark>! And certainly, such moral imputations bear upon the processes of human interaction. I am from Africa, I recently started living in this student dormitory, whenever I go to dormitory parties nobody would talk to me & avoid me. On same day, you gave me this device with vanilla scent. I wore this all day inclusive of the party. For first time, 2 students talked to me asking how do you smell nice? It's kind of good impression for them with <mark>my surrounding odour not body odour</mark>.

Day 2: I talked to some new people today as in what they think of such a jewellery. They told me that they would only use it for some occasion.

Q. Did you perceive the scent emitted by the device today?

Day 1: Yes.

Day 2: Yes.

Q. At what time during the day did you wear the device?

Day 1: I wore it mostly in home during late afternoon till night.

Day 2: For 3 hours only in evening around 6 pm.

Q. Did you encounter any odour nuisance? If yes, please explain

Day 1: No.

Day 2: No.

Q. Did you receive any comments/reactions about the emitted scents by the people around you?

Day 1: Yes. People who approached me in the party wanted to know more about. They said it's a cool device.

Day 2: *Random Text – Deleted*

Q. Did you feel comfortable in wearing the device today?

Day 1: Yes, it was overall a new experience for me.

Day 2: Yes I felt habitual with it now.

Q. Did you feel about losing the device or breaking it?

Day 1: No.

Day 2: Yes, it got fallen today, I thought I broke it. But it is working fine.

Q. Describe any special moment with the device.

Day 1: Party moment was special as wrote above.

Day 2: I had some rotten vegetables in my refrigerator, I took them off in dustbin in the kitchen. It was smelling very bad so I turned on the hat and it gave me sense of relief.

Q. Describe a typical day with *Abhushan* and without it.

Day 1: I liked the fact that it is on my body and kind of jewellery. In my country people do wear jewels including men. I wish to take this to my country and show people there this nice device. For me who wears jewellery this is nice and I would feel something missing without it.

Day 2: Random Text – Deleted

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