SpotlessMind - A Design Probe for Eliciting Attitudes towards Sharing Neurofeedback

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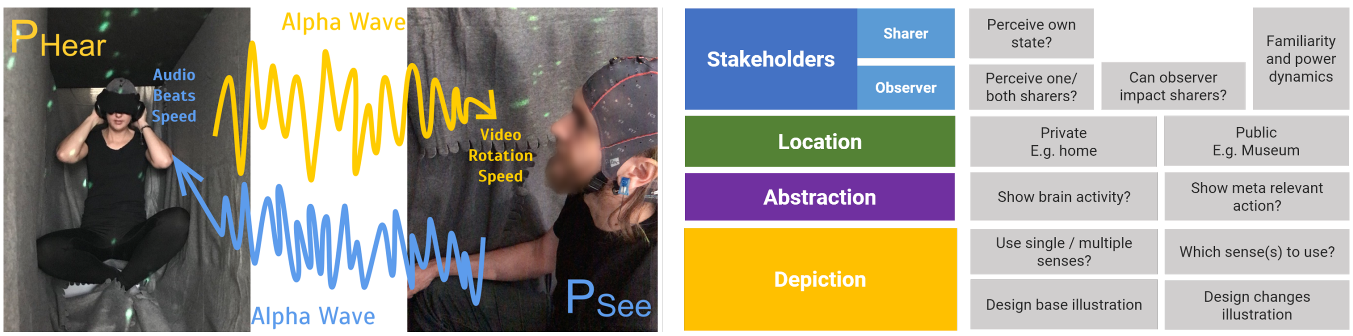

Figure 1: The left figure shows our concept for sharing brain occupancy. P_{hear} hears the brain occupancy of P_{see} , while he sees the brain occupancy of P_{hear} . Bystanders perceive the state of P_{see} and P_{hear} . The right figure consolidates design parameters for creating BCI experiences supporting collaborative sharing of cognitive states.

ABSTRACT

Mutual understanding via sharing and interpreting inner states is socially rewarding. Prior research shows that people find Brain-Computer Interfaces (BCIs) a suitable tool to implicitly communicate their cognitive states. In this paper, we conduct an online survey (N=43) to identify design parameters for systems that implicitly share cognitive states. We achieve this by designing a research probe called *"SpotlessMind"* to artistically share *brain occupancy* with another while considering the bystanders' experience to elicit user responses. Our results show that 98% would like to see the installation. People would use it as a gesture of openness and as a communication mediator. Abstracting visual, auditory, and somatosensory depictions is a good trade-off between understandability and users' privacy protection. Our work supports designing engaging prototypes that promote empathy, cognitive awareness and convergence between individuals.

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CCS CONCEPTS

• **Applied computing** → **Media arts**; • **Human-centered computing**;

KEYWORDS

Brain-Computer Interfaces, Cognitive States, EEG, Collaborative Art, Design Framework, Brain Occupancy, Installation

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1 INTRODUCTION

Empathetic behaviour is socially rewarding as it allows for optimizing reactions and fostering advantageous bonds. However, a prerequisite for empathy is understanding another's state. Therefore, amplifying human cognition to support telepathy is long craved from Sci-Fi movies like "what women want" to research endeavours using Brain-Computer interfaces (BCIs) to sense engagement and interest. Complementarily, implicit communication can offer a safe space to individuals who struggle to express themselves. Thus, brain waves have been used impactfully for artistic communication, sharing states and facilitating mutual understanding. For example, *E.E.G. KISS* visualizes the intimacy of two people while kissing via their brainwaves as "A portrait of our kiss" [18]. While current Brain-Computer Interfaces (BCIs) do not support accurate interpretation of thoughts, it is possible to detect abstract states like engagement and attention (e.g. [16, 26]).

Our work extends this body of literature by presenting an *exploratory elicitation study* to understand the design parameters for systems that share cognitive states implicitly. We achieve this goal by proposing a design concept called *"SpotlessMind"* to share a cognitive state, namely *brain occupancy*. We define *brain occupancy* as a cognitive state referring to how busy the mind is at an instance. We focused on communicating cognitive states because prior research identified a user need to communicate cognitive states more than physiological and emotional states [13].

In our design concept (see Figure 1), two participants share their brain occupancy, where the state of the partner is depicted using visual representations for one, and auditory representations for the other. Bystanders perceive the cognitive states of both sharers to create a holistic avant-garde experience. Our concept capitalizes on sharing reciprocity and the power of performances to encourage users to implicitly share their cognitive state. It also embraces the interpretation ambiguity and incorporates it as a design construct.

Our results show that 98% of the participants would like to see the installation and 79% would like to actively try it. They wanted to share their brain occupancy with romantic partners and family as a gesture of openness and as a conversation-starter tool. Figure 1 summarizes some of the design aspects for designing ubiquitous systems to share cognitive states. Our work is a step forward to extending the human senses by amplifying implicit cognitive state sensing. Consequently, it could enhance empathy and support cognitive convergence between people.

2 ENVISIONED USE CASES

We envision that ubiquitous systems supporting communication by controlling multimedia using shared cognitive and psychological states could present a modern form of "telepathic experience". In this paper, we focus on designing a research probe to control media and communicate a cognitive state, namely *brain occupancy*. We define **brain occupancy** as a cognitive state referring to how busy the mind is at an instance. We use brain occupancy as a pseudo cognitive state easily understood by the users for our research probe. Brain occupancy has a balanced association as one could be occupied with problems or exciting topics.

We envision that such probes could support empathy between individuals and elicit a sense of trust and openness. We also envision that two individuals can reach cognitive convergence, i.e. a loop of borrowing from the receiver's state and affecting the sender's state. For example, a meditation instructor can help a trainee achieve a calm state through reflecting on the instructor's state, while the instructor gets to reflect on the changes happening in the trainee's state in real time. Such systems should support implicit (automated) and explicit (user-triggered) state detection, sharing and reciprocity.

3 RELATED WORK

3.1 Depicting Brain Activity

Audio depictions of brain waves have been extensively used in prior work. For example, Wu has shown that the passive EEG signals of two different sleeping states can be converted into musical tones with distinct emotional expressions [29]. Folgieri has enabled the users to consciously play a specific musical note from passive brain signals [10]. It is also found that music and the emotions felt by the listener had a notable influence in the passive brain activity [9, 11]. Similarly, researchers and artists have also developed BCI for conscious and unconscious *visual expressions* and creative insights. For example, "BrainArt" allows users to create drawings using their cerebral rhythms [8]. "PsychicVR" relates the electrical activities of the brain to 3D contents in virtual reality, to help the user increase mindfulness and concentration [3]. Therefore, we use auditory and visual mappings in our design to depict brain occupancy.

3.2 Communicating Cognitive States

BCIs have been used to detect audience's real-time cognitive engagement implicitly. For example, they were used during a performance art to offer guidelines for designing theatre performance [30], in viewing museum exhibitions to design and customize museum experience that tailored to each visitor's taste [1], and while listening to presentations to help presenters improve their performance real-time or post-hoc [15]. Cognitive engagement has also been detected and visualized at work [12] and in learning [5, 6, 17, 20, 27] to give user self-reflections to improve motivation and engagement. Finally, Alpha waves have been used as a monitoring tool for mindfulness meditation training and behavior change activities [25].

3.3 Implicit Communication Using Art

Mutual understanding and state sharing have become a significant topic in art installation and social practice in contemporary art fields. In 1964, Yoko Ono has performed her "Cut Piece" that allows the participants to cut her suit with a pair of scissors wherever they want, as a form of giving and taking [22]. In 1980, Marina Abramović and Ulay's intense "Rest Energy" was performed with complete and total trust. They held an arrow on the weight of their bodies towards Abramović's heart. Their heartbeats were broadcasted from speakers [24]. In 2010, Abramović has reperformed "The Artist Is Present", in which she sat on one side of the table in the museum and the audiences sat opposite to her while maintaining eye contact [23].

The advances in BCI have unbound performance artists' modalities from their body to more private and intimate ones, such as brain activities. In Lisa Park's art installations "Eunoia" and "Eunoia II", she abstracted her inner struggle, transient feelings and thoughts in front of the public as vigorous vibrations of the water pools representing her passive brain waves [19, 28]. Our design contributes to this body of work by merging artistic expression and passive sensing of Alpha waves to explicitly encourage sharing and cognitive convergence with others.

3.4 Research Gap

Prior work shows that people feel calm, relieved, motivated and more confident after sharing their cognitive state with others [13].

However, the design parameters for systems that foster reciprocal disclosure to encourage implicit sharing are under-explored. Such systems should utilize new visualization channels and modalities to communicate cognitive states to support user needs [4, 13, 14]. Closing this gap is important as EEG show potential to unconventionally foster mutual understanding and enhance empathy. Our work reduces the gap and extends prior work (e.g. [13]) by exploring the design space via the proposed design probe.

4 DESIGN CONCEPT

We *designed* a shared experience that enables two users to communicate their brain occupancy in an artistic form, while including bystanders as observers of the experience. We denote here the two users as **sharers** and the bystanders as **observers** .

Each participant can only perceive the brain occupancy of the partner through a single modality. One can only see (P_{see}) while the other can only hear (P_{hear}). During low brain occupancy (i.e. a relaxed state), the users perceive tranquil auditory or visual depictions. The depictions become more dynamic as the occupancy increases. The changes remain in a comfortable range to emphasize the balanced association. We chose an auditory and visual depictions as they are the literature standard for communicating brain waves (e.g. music depictions in [10, 29] and visual depictions in [3, 8]). We eliminated the sensory depiction of one's own state to help the sharer immerse in the partner's state to achieve the primary goal, i.e. mutual empathy and understanding. The installation could be set in a variety of locations including (semi-)public spaces like offices and exhibitions.

We focus here on describing the design setup rather than the technical detection and the mapping of the brain occupancy as we acknowledge they are simplistic in our model. The setup (see Figure 1) is composed of a laptop, two commercial wireless BCI caps, a projector, two noise-cancelling headphones, blindfolds, and black curtains. We created a dark cave using the curtains for the sharers with a viewing window for the observers . Both sharers wear the BCI cap. P_{hear} additionally wears blindfolds and a noise-cancelling headset streaming the occupancy music of the partner. P_{see} watches the occupancy circles of the partner in silence while wearing a noise-cancelling headphone. The observers can hear the music and see the video. We used ambient nature music with overlaid beats that get faster with increased brain occupancy. Complementarily, we used a video of the universe that rotates faster with increased brain occupancy. For a simplified approximation, we mapped high-amplitude alpha waves to low brain occupancy as they are associated with calmness in meditation literature (e.g. [2, 10]). Thus, we used the averaged alpha value as the factor to control the media speed.

5 DESIGN PARAMETERS STUDY

We used our prototype as a probe to jog the participants' imagination and collect design feedback about systems communicating cognitive states. Our goal was to understand 1) how the participants would like to depict brain occupancy, 2) what are the users' sharing patterns of brain occupancy?, and 3) what are the use cases for sharing brain occupancy in various contexts?. We also wanted a preliminary evaluation for our design concept.

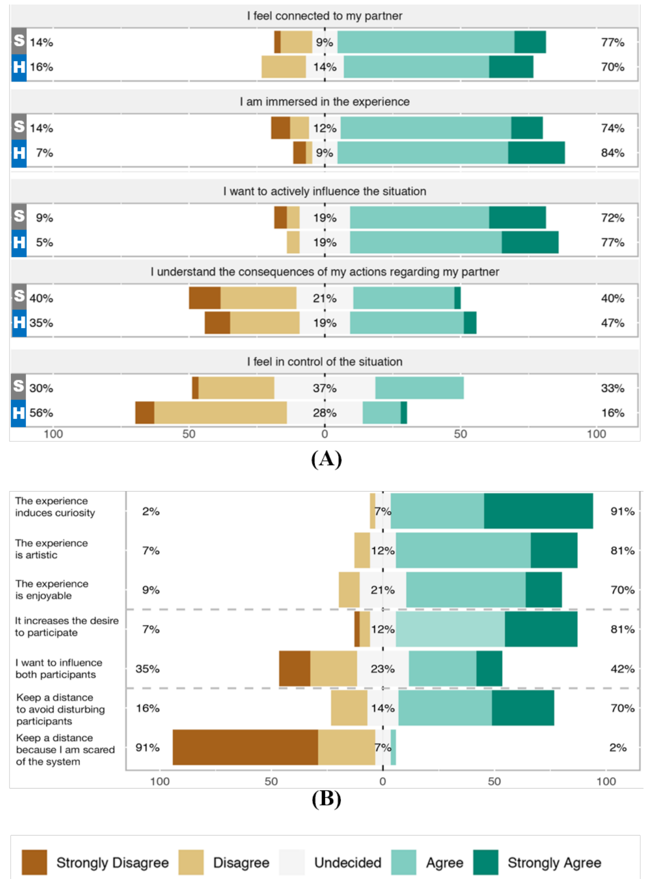

Figure 2: The sharers found our concept immersive and supporting connectedness. (S) denotes P_{see} while (H) denotes P_{hear} (Figure A). The observers were interested to try our concept and found it enjoyable (Figure B).

5.1 Research Method: Online Survey

We instrumented an online survey with a video explaining the concept. The video explained our concept of brain occupancy, the proposed system and showed a short snippet of videography exhibiting the installation by two researchers to jog the participants' imagination. The video lasted for 2 minutes 30 seconds and was accessible throughout the survey.

The survey had three sections: 1) attitudes towards the concept, 2) concrete depictions for brain occupancy using the Aristotelian senses (vision, audition, somatosensation, olfaction, and gustation), and 3) attitudes towards sharing brain occupancy along with use cases for the concept. All Likert items used a 5-point scale (1=strongly disagree, 5=strongly agree). In the first section, we used Likert items to evaluate interest in the system. We requested that participants take on the roles of P_{see} then P_{hear} and asked them questions on how connected, immersed and in control they felt (see Figure 2A for samples). Afterwards, we changed the perspective to the observers asking the questions in Figure 2B to also understand their interest. Finally, we asked whether the observers could influence the experience or not and collected the rationale via an open-ended question. In the second section,we similarly used Likert items to ask about modality preferences to represent the brain waves using each of the Aristotelian senses (see Figure 3 for sample questions). We also asked how they would map increasing brain occupancy to each sense. In the third section, we asked if the participants would share their brain occupancy or not with four groups: romantic partners, family, colleagues, and strangers (see Figure 4) inspired by prior research (e.g.[7, 21]). We collected the rationale and usage scenarios via an open-ended question.

5.2 Procedures

After collecting an electronic consent, we collected demographic data, such as age, gender, nationality, and occupation. We also asked about previous experiences using or working with BCI devices. Afterwards, we asked the participants to watch the video before answering the questions. All questions except for open-ended ones and the demographics were obligatory. All participants were presented the survey questions in the same order.

5.3 Participants and Recruitment

The questionnaire was disseminated over a set of public groups on social media, various mailing lists and personal invitations. Participants were able to enter a lottery to win one of five amazon vouchers, valued at 5 each. 197 participants initially attempted to complete the survey. Data from participants who did not fully complete the survey was excluded from any analysis. Thus, our analyzed sample consisted of 43 participants (1 non-binary, 17 female, 25 male) with an average age of 27 (range: 21-43). The participants' occupations covered faculty positions, different graduate stages, creative work in design and various jobs in technological domains, like software development. 15 participants had tried BCIs before, while 10 had actually worked with them (i.e. developed or conducted research). On average, the participants took approximately 26 minutes to complete the survey.

6 RESULTS

6.1 Attitudes towards the Probe

The majority would like to see the system (98% agreement) and try it (79% agreement). 42% found the representation of the brain occupancy in the video easy to understand, while 35% disagreed and 23% were undecided.

6.1.1 Participants' perception of the sharers. Figure 2A compares the attitude from the perspective of P_{see} and P_{hear}. Both felt connected to their partner (over 70% agreement). They also found the experience immersive and wanted to actively influence it (over 70% agreement). However, they do not feel confident about the consequences of their actions. Thus, they did not feel in control of the setup, especially in the case of P_{hear} (only 16% agreement) as opposed to P_{see} (33% agreement).

6.1.2 Participants' perception of the observers. Figure 2B summarizes the attitudes of the participants as observers . The results show that the majority find the experience artistic (81% agreement) and enjoyable (70% agreement). The majority are also curious about the installation (91%) and want to participate as sharers (81%).

The participants are undecided whether the observers should impact the sharers or not, as 42% of them encouraged active participation of the observers , while 35% discouraged it and 23% are undecided. To understand such results, we conducted a thematic analysis on an open-ended question to explore the perceived influence of the observers on the sharers . We open-coded the answers and two themes emerged. The first is the observers *have no effect* on the experience and should remain passive. They believe that the observers could choose to deliberately physically interact with the sharers to affect them. The second is the observers will always *impact the experience*, even if (s)he remains passive. Participants comment that the familiarity and comfortability around the observers will affect the sharers. For example, **P33** comments "If they know they are being watched; Hawthorne effect[1] might come in"

6.2 Sensory Depictions of Brain Occupancy

Figure 3 summarizes user preferences for senses used to depict brain occupancy. Participants, especially the observers wanted to have multimodal sensory depictions of brain occupancy (81% agreement for observers and 60% for sharers). 63% participants wanted to add somatosensory representations of the brainwaves to the installation while 51% wanted to add olfactory representations. Nevertheless, participants disapproved of the additional gustatory representation of the brainwaves (only 23% found it appropriate).

Figure 5A summarizes the proposed depictions for each sense. We identify representations for the baseline denoted as *baseline illustration* and mappings for changing occupancy denoted as *changes illustration*. Participants mostly proposed abstract depictions for the baseline illustration across all the senses. For example, they proposed a heat map that gets denser with higher occupancy and a music visualizer to represent the raw changes in the brain waves using the *vision*. Similarly, they commonly used music and nature sounds like birds to represent a calm state and complex sounds like street traffic and horror movies tones to represent occupancy using the *audition*. *Somatosensation* received the highest number of suggestions in the qualitative comments. Participants frequently combined multiple mappings such as speedy vibration with increasing number of objects generating it to communicate an exaggerated depiction of occupancy. One participant also proposed integrating the feedback mechanism to the environment such as adding the vibrations to door knobs. Examples for specific depictions include mapping occupancy to a prickling feeling. On the other hand, although the majority proposed sweet depictions for *olfaction* and *gustation*, there was a division around its interpretation in relation to the brain occupancy. Participants also proposed using *olfactory* depicts to represent semantic actions rather than occupancy. For example, **P41** proposes "Stench to keep people away or perfume to attract people". Interestingly, gustation was the most discredited sense in the comments in terms of likeability and feasibility.

6.3 Sharing Brain Occupancy

Figure 4 summarizes the participants' preferences in selecting their fellow sharers . As sharers, participants are open about disclosing their occupancy but rather know about the others' occupancy (74%

[1]Dictionary definition: "The alteration of behaviour by the subjects of a study due to their awareness of being observed".

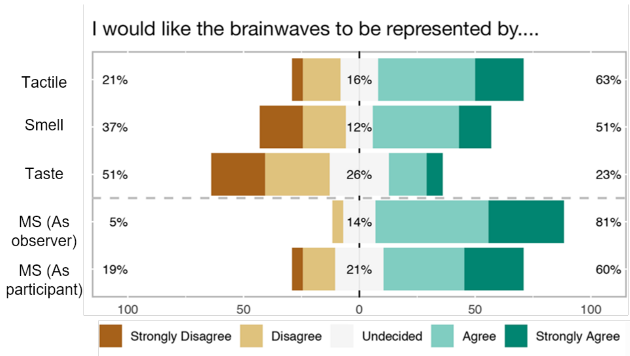

Figure 3: Participants, especially observers wanted multi-modal depictions and appraised additional somatsensory depictions. (MS) denotes multiple senses.

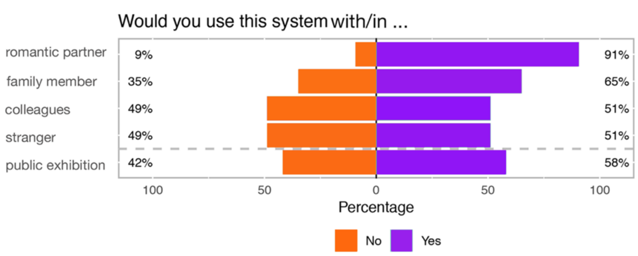

Figure 4: Participants are not apprehensive about sharing the brain occupancy with anyone. However, they prefer to share it with romantic partners and family members.

and 84% agreement respectively). Aligning with previous work [13], 91% agree to share their state with their romantic partners. Despite approving, they are more reluctant to share with family members (65% agreed to share). Only 51% of the participants preferred to share their state with strangers or colleagues. 58% agreed to participate as sharers in the installation if it was in a public exhibition. We conducted thematic analysis using open codes on an open-ended question for each of the four groups to understand: 1) the use cases (summarized in Figure 5B) and 2) the forbidden cases for sharing brain occupancy.

The majority of the participants proposed using the system for fun regardless the sharers ' relation to them. A common use case across the user groups is getting instant feedback about particular inquiries using clear questions like "know their (romantic partner) true opinion about my favorite movie/series although it can show high mind activity out of dislike when I think they like it" **(P14)**. We discuss below special scenarios for each of the groups.

6.3.1 G1: Sharing with romantic partners. A recurrent use case was sharing as a romantic gesture to show intimacy, particularly on a sexual level: "I do BDSM[2], so I already share a lot of mind-states, that would be another experience" **(P6)**. Others proposed to capitalize on the existing intimacy to deliberately relax a partner using the installation, implying convergence. They also proposed using it as a conversation starter to inspire follow-up discussions: "Connecting both partners and allowing them an intimate discussion afterwards" **(P24)**. However, they raise a concern about the negative implications of misunderstandings implying a shallow relationship.

6.3.2 G2: Sharing with family members. Participants proposed using the prototype to better understand kids or paralyzed personnel. Like G1, communication mediation to understand a member's perspective about a controversial topic was recurrent. **P33** explains "before having a serious conversation; to prepare for the worst". They considered sharing as a gesture of trust and openness. However, others found it undermining for family bonds as they should naturally understand each other. They were also concerned about the system's technical complexity and comfortability for daily use.

6.3.3 G3: Sharing with colleagues. Privacy concerns are the paramount theme because as **P13** says "professionally what matters is what they say not what they think/feel". Additionally, the participants highlighted their lack of interest in their colleagues' state: "The sharing of the mind state with this system is too abstract for sharing actual information; so no use for productivity; but at the same time too intimate to share it with colleagues" **(P24)**. Although some participants proposed using the installation to mediate communication conflicts, others find it inappropriate and artsy.

6.3.4 G4: Sharing with strangers. Privacy concerns and generic fear of sharing are the dominant theme. However, some argue that sharing heightens the experience authenticity. For example, **P37** says "Strangers are easier to communicate with on a more intimate level; if you know you are not likely to meet this person later in your life". Interestingly, participants link the magnitude of their influence on the experience with their closeness to the other sharers . For example, **P36** says that sharing with strangers can be more "chaotic", while **P30** thinks that sharing with someone I know would have higher influence. Despite their reservation, participants were open to share within scientific experiments.

6.3.5 Sharing in a public exhibition. Naturally, participants are concerned about privacy infringements in an exhibition setup. **P24** explains "because of the observers I would decline. I do not wish for my erratic thoughts to be visible or audible to strangers; even if they cannot be deciphered directly; one can still see how active my thoughts are". Some participants would only share with familiar sharers in the exhibition setup. This is surprising as the observers could still perceive the system output. However, they are primarily interested in novel experiences. They appraise the setup as an interactive artistic experience that resembles a performance: "Experiences made in galleries or museums tend to need a spectacle/wow-factor nowadays. This project would serve this gap quite well" **(P39)**. However, some participants believe the exhibition setup would reduce the immersion.

6.3.6 Forbidden sharing scenarios. Aligning with prior work [13], participants refused to share because of: privacy and lack of trust, fear of rejection and judgment, considerations to others and lack of reason to share. They particularly feared judgment in cases of: 1) concrete depictions, 2) power imbalance with the other sharer and 3) judgmental observers within their social circles. **P23** explains "depends on the representation and how it's associated with my

[2]Bondage, Domination, Sadism and Masochism

Sense	Base illustration	Change depicting occupied mind
Vision	Colors, signal waves, sea waves	Increasing color variety, saturation, luminance, speed (pulsating visuals)
Audition	Music, music beats, heart beats, stories, nature sounds (birds(= calm & complex (traffic) = occupied mind	Increasing: frequency, intensity, speed
Somatose nsation	Rigidity, vibration, thermal feedback, pressure number of stimulating objects, moistness	Harder objects, faster vibrations, higher temperature & pressure, more stimuli, unclear mapping for moistness
Olfaction	Synthetic scents, sweet scents, perfumes, Floral/natural: calm, spicy / citrus: occupied mind	Increasing intensity and types
Gustation	Sweet, sour / salty, bitter / spicy: occupied / negative states, personalized flavours	Increasing intensity

(A)

User group / location	Use cases	Concerns
Romantic partner	Romantic gestures, augment sex, relax a partner, conversation starter	Misinterpretation ➔ signal shallow relationship
Family	Gesture of trust & openness, communication mediator, understand: kids + paralyzed members	Undermine natural bond, make them worried in negative valence states, technical complexity, comfortability
Colleagues	Communication mediator Generally not preferable	Privacy, lack of interest, lack of benefits, not appropriate for work
Strangers	Higher authenticity, scientific experiments	Privacy, generic fear, influence related to closeness w/ sharer
Public exhibition	Novel experience (Interactive artistic wow)	Privacy violations because of observers, reduce immersion

(B)

Figure 5: Visual, audio and somatosensory depictions are recommended (Table A). Participants want to share for fun and to get an answer for specific questions (Table B).

social image to people. A bunch of lights and ambiguous sound sure but themed images that could show stuff that could be misunderstood and attributed to me not so sure". They also found the system inappropriate with partners like bosses and bullies as **P13** says "they (bullies) will know better how to push my buttons". We also had two new reasons: 1) faking social cues during interactions such as hiding boredom in a party, 2) high cognitive load situations like exams and presentations as the prototype would be distracting.

7 REFLECTIONS AND LESSONS LEARNT

Share to prove closeness and mediate communication
Participants want to share their brain occupancy with romantic partners and family members. They share to strengthen the bonds as a sign of openness and trust, and to show emotional and/or sexual intimacy. Additionally, such systems can act as a communication mediator and a conversation starter to encourage empathetic behaviours. However, concrete interpretations like assigning opinions to topics based on the system output may result in discord and hinder communication due to the limited accuracy of BCIs . Additionally, considering the power dynamics between the sharers is important to interpret sharing behaviours. For example, in contrast to prior work [13], users would not share their cognitive state with superiors to avoid deliberate manipulation.

Respect and utilize observers' experience
Designers should understand the prior relationship between the sharers and the observers to consider the impact of familiarity and comfortability on accepting the experience. They should also introduce inherent constraints or explicit interaction opportunities to cue the relationship. It is worth noting that not all sharers define their relationship with the observers as "sharing" although observers can perceive their state.

Use abstract visual, audio and somatosensory depictions
Visual, auditory, and somatosensory representations are the most viable depictions for brain occupancy. Somatosensorics were particularly versatile. Olfactory and gustatory depictions are more susceptible to causing discord. Abstract depictions are favourable and increasing speed is the commonly proposed mapping to an occupied mind. Surreal representations provide room for interpretation reducing misunderstandings and fear of use while focusing on the empathetic side of the experience. However, concrete representations cause privacy alerts.

Checklist for sharing cognitive states
We propose a framework to think about BCI experiences supporting cognitive communication (see Figure 1). It is based on the survey data and incorporates our experience while building the prototype. We focus on *four* design parameters:

Stakeholders We consider the sharers and the observers in this model. Designers shall consider whether the sharers can perceive their own cognitive state or not. They also should decide on the presence or absence of observers after considering the familiarity and power dynamics. In case of presence, one should design the interactions between sharers and observers . Additionally, they should decide whether the observers can perceive all sharers simultaneously or can focus on a single sharer . Figure 5B summarizes common relationships between sharers and respective beneficial use cases.

Location The experience location affects the depiction of the information. Possible venues are private (e.g. home), semi-public (e.g. offices) and public (e.g. museums and exhibitions).

Abstraction The prototype could represent either the cognitive state (e.g. engagement percentage) vs. the derived meta action based on the state (e.g. do not disturb).

Depiction This refers to how the information is communicated. Designers shall consider if they will enable multimodal depictions and select the target sense(s). Additionally, they should select a base illustration for representing the state (e.g. music) and another for depicting the change (e.g. speed). Figure 5A summarizes possible base and change illustrations based on the chosen sense.

8 CONCLUSION

BCIs are showing potential as an unconventional way to foster mutual understanding and implicitly control artistic media experiences. In this paper, we propose a design concept named *"SpotlessMind"*, an interactive installation for dual sharing of a cognitive state, namely brain occupancy, while involving bystanders. Our results show that the prototype evokes the interest of the public. We use our concept as a probe to understand design parameters for building systems for mutual sharing of cognitive states (see Figure 1 and 5). We also propose concrete multi-sensory media for depicting brain occupancy. Our findings show that designing the observers experience crucially affects the sharers . Additionally, abstracting visual, auditory and somatosensory depictions is a good trade-off between understandability and protecting the privacy. We envision creating similar systems in the future to support individuals to reach states of cognitive equilibrium by symbiotically reflecting on another's state. This can foster intimacy and could be used in training contexts (e.g. psychiatrists helping anxiety patients).

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