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Exploring value dilemmas of brain monitoring technology through speculative design scenarios

Martha Risnes [a], Erik Thorstensen [b], Peyman Mirtaheri [a], Arild Berg [c,*]

[a] Department of Mechanical, Electronic and Chemical Engineering, Faculty of Technology, Art and Design, OsloMet - Oslo Metropolitan University, Oslo, Norway
[b] Department of Natural Sciences, Practical-Aesthetic, Social and Religious Studies, The Faculty of Teacher Education and Languages, Østfold University College, Halden, Norway
[c] Department of Product Design, Faculty of Technology, Art and Design, OsloMet - Oslo Metropolitan University, Oslo, Norway

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ABSTRACT

In the field of brain monitoring, the advancement of more user-friendly wearable and non-invasive devices is introducing new opportunities for application outside the lab and clinical use. Despite the growing importance of responsible innovation, there remains a knowledge gap in addressing the possible impacts of wearable non-invasive brain monitoring technology on mental health and well-being. Addressing this, our main aim was to study the use of speculative design scenarios as a method to describe potential value dilemmas associated with this new technology. Through a qualitative study, we invited participants to engage in discussions regarding three variations of wearable non-invasive brain monitoring technology presented in speculative video scenarios. The study's findings describe how the discussions contribute towards promoting heuristics that can help foster more responsible innovation by identifying norms and value dilemmas through inclusive speculative design practices. This qualitative case study contributes to the literature on responsible innovation by demonstrating how responsible innovation frameworks can benefit from incorporating anticipatory speculative design methods aimed at early identification of potential value dilemmas.

Introduction

In the fast-advancing field of health technologies, it has become increasingly important to consider the impacts and consequences of new and emerging technologies. Consideration is particularly crucial when it comes to the design and development of technologies that have the potential to impact human perspectives on health and well-being, such as wearable non-invasive brain monitoring devices (Coates McCall et al., 2019; Coates McCall & Wexler, 2020; Sample et al., 2020; Wexler & Thibault, 2019).

Advancements in technology, including smaller and more accurate devices, as well as effective data analysis methods, have enabled the use of wearable, non-invasive brain monitoring devices outside the laboratory setting (Pinti et al., 2018), in homes, and for various purposes (Blandford, 2019; Raisamo et al., 2019). At the same time, as technology is advancing the opportunities for collecting data about the brain, new digital services are emerging to improve mental health and well-being (Federal Ministry of Health, 2019; Norwegian Board of Technology, 2020). The work by the Federal Ministry of Health describes how: "New technology can help predict and prevent mental health problems, provide self-help, and make treatment cheaper and easier to access." (Norwegian Board of Technology, 2020). Such developments introduce ethical questions regarding privacy, overconfidence in technology, responsibility, safety, and the philosophical aspects of enhancement and humanity (Drew, 2019; Farah, 2005).

Addressing these ethical challenges involves integrating methods that mitigate possible unwanted impacts and enhance desired impacts into the process of designing new technology, but this process is further complicated by the inherent uncertainties surrounding these impacts, not just in their potential manifestations but also in the way they might be valued in the future (Swierstra & Rip, 2007). Accordingly, these uncertainties are a fundamental design challenge. The notion of designing in this work describes the process of planning and developing all aspects of a technology, including its applications. A notable subset of these challenges arises from what are termed 'soft impacts'. As defined by Swierstra & te Molder (2012), soft impacts are those that are "difficult to value, quantify, and explain causally".

The field of responsible innovation has recognized the importance of

* Corresponding author.
E-mail address: arildber@oslomet.no (A. Berg).

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anticipating and addressing the impacts of technology (Urueña, 2021, 2023). Stilgoe et al. (2013) developed a policy framework for responsible innovation that engages with the uncertain impacts of novel technologies. One of the four dimensions of responsible innovation is anticipatory commitment. Urueña further posits that anticipation, as a dimension of Responsible Innovation, should be applied early on to the problematisation of the processes and purposes of Science, Technology, and Innovation (Urueña, 2023). This approach encompasses evaluating the visions and expectations guiding the direction of Science, Technology, and Innovation. Urueña's review (2023) offers an overview of how anticipation has been employed to address diverse challenges and the methods employed in those applications. Urueña's work sheds light on the different contexts and domains where anticipation plays a significant role, offering insights into its potential benefits and limitations, fragmentation of the field and the problem of reifying futures (2021, 2023).

Anticipation methods have become especially relevant to developing non-invasive brain monitoring technology, as the opportunities to collect data for health purposes and monitoring are envisioned (Cinel et al., 2019, p. 16; Coates McCall & Wexler, 2020). Although the technology might not have yet reached a stage where it dramatically alters perspectives on the brain, potential opportunities and applications for future applications are envisioned in the literature (Balcombe & De Leo, 2022; Blandford, 2019; Cannard et al., 2020). A critical-hermeneutic perspective on the future might be helpful for combating the reifying power of futures, and the purpose is to deconstruct the futures that colonise the present (Urueña, 2023). Hence, to design non-invasive brain monitoring technologies, understanding current values that shape such development is essential to avoid undesirable framings of what non-invasive brain monitoring can contribute to in a design. One approach to doing this could be to analyse the literature envisioning such purposes and framing of non-invasive brain monitoring. However, this approach may not fully capture personal perspectives on the technology. Another strategy involves engaging the public to elaborate on their values, promoting a more democratic technology development process. Nonetheless, this approach comes with challenges, as it requires a comprehensive understanding of the technology's possibilities.

To address this challenge, drawing inspiration from speculative design (Dunne & Raby, 2013; Malpass, 2013) can be beneficial. Speculative design, like anticipation methods, delves into the future by exploring what does not yet exist. Speculative design initially emerged as a critical discourse on the role of product design in reinforcing capitalism (Dunne & Raby, 2013). Speculative design employs various tools, such as satire, rationality, and narrative, to engage in critical debates (Malpass, 2013).

By incorporating elements from speculative design into the anticipation process, participants can be drawn into the discussion more effectively by emphasising certain dilemmas. The approach involves highlighting existing health paradigms while introducing novel technologies that may not be familiar to the participants. This way, the anticipatory approach can be engaging and thought-provoking, encouraging participants to think beyond conventional perspectives. Through such creative and critical engagement, the design process can become more transparent, inclusive, and responsive to diverse values and expectations, which aligns with the goal of Responsible Innovation (Stahl et al., 2021).

To operationalise participants' perspectives into design heuristics, it is crucial to adopt an ontology that acknowledges the mediating role of technology in human-technology relationships, moving away from viewing technology as neutral objects (Verbeek, 2006, 2011). This shift in perspective is essential because it enables us to explore the intricacies of design choices by identifying value dilemmas in an early stage of a project. By recognising and understanding these value dilemmas, it is possible to make informed design choices and design for specific mediations within an iterative co-creative process.

Smits et al. (2022) provide a structured outline of methods, aimed at describing the ways in which technology acts as a mediator within the realm of health technologies. These methods are formulated into actionable design heuristics, which incorporate various design methods and are grounded in existing theories of value change, as demonstrated by the works of Boenink and Kudina (2020) and van de Poel (2013). The concept of "technological mediation" is central to postphenomenology (Verbeek, 2006) and, building on Ihde (1990), scholars in the field use the concept of technological mediation to analyse the complex relations between humans, technology and the world (Adams & Turville, 2018; Kiran et al., 2015; Rosenberger & Verbeek, 2015).

This work contributes to unpacking central aspects of this challenge as we examine a case study on the design of non-invasive brain-monitoring technology for health purposes. A novelty in this study is the application of three variations of the same non-invasive brain-monitoring technology in combination with speculative design scenarios. This article aims to contribute to the empirical work in the field of Responsible Innovation by operationalising anticipation to generate heuristics. The speculative video scenarios are explored as a tool for anticipation to highlight how the technology could be designed to mediate different values of the mind and health, which includes a critical perspective on current healthcare and well-being practices and logic.

The research question guiding this study is:

How can speculative videos help explore potential value dilemmas in different designs of wearable non-invasive brain monitoring technology?

To address this question the work in this study consists of three steps:

1. Designing Fictive Variations: Firstly, we describe the design of three fictive variations of non-invasive brain monitoring devices, drawing from the possibilities identified in the larger discourse on such technology. These variations serve as hypothetical scenarios to stimulate discussion and reflection.
2. Expert Focus Groups: Next, we conduct expert focus groups to delve into the differences in the purpose of non-invasive brain-monitoring technology as portrayed in the three videos. Through these discussions, we aim to gain insights into how varying purposes can shape perceptions and values related to the technology.
3. Conceptualisation of Value Dilemmas and Norms: The discussions from the focus groups lead to the conceptualisation of value dilemmas and norms guided by van de Poel's (2013) bottom-up hierarchy of design requirements, norms, and values. By doing so, we explore how these findings can inform and guide the design process of non-invasive brain monitoring devices. (2013)

Method: a case study of speculative brain-monitoring designs

The anticipatory case presented in this study is based on the utilisation of three videos presented in focus groups. The videos were designed by one of the authors and subsequently shared with specific participants through the facilitation of four focus group sessions.

As a methodological choice, the rationale for speculation was not about forecasting in utopian or dystopian directions. By inviting participants to critique and imagine possibilities, its goal was to describe what present values enabled participants to critique the speculations. Verbeek has described this as moral imagination or anticipating mediations (Verbeek, 2006). Grunwald (2014) emphasises the importance of understanding anticipation in the context of present values and practices, rather than to address future concerns. Similarly, Kudina and Verbeek (2019) argue that values and practices are dynamic; hence, that technology shapes the norms we use to evaluate technology.

We found it helpful to use Yin's explorative case study approach (2017) to design the procedure to guide the empirical work including the focus group discussion. The method section describes the process of making and analysing speculative video scenarios. Furthermore, we describe how we identified possible value dilemmas by inviting participants to discuss the impacts of non-invasive brain-monitoring devices.

Making three speculative design scenarios

We used three variations of purpose of a non-invasive brain-monitoring device to emphasise technology's contextual and relational impact. We were inspired by the ContraVisions used by Mancini et al. (2010). Mancini et al. (2010) describe alternative realities as a technique from science fiction and fantasy, where parallel stories with the same character unfold, based on different choices and actions. We also wanted to explore how the imagined design choices could shape three different user narratives in three videos describing three alternative realities. However, rather than creating contradictory visions, we used the idea of alternative realities to emphasise potential technological mediations through design choices.

The choice of including videos was to help participants comprehend and imagine the variations of the design. The videos used simple animated characters that were easy to reproduce. The style was designed to contrast the positive unharmful way the technology is introduced and the imagined intrusive consequences the technology could have, also referred to as the uncanny (Auger, 2013). We wanted to balance abstract illustrations that left space for participant interpretation with enough detail to make the idea understandable. The different designs in the video drew inspiration from several actual developments to ensure that the speculative designs had a degree of viability (Apple, n.d.; Mendi, n.d.; Tankevirus, n.d.).

Nevertheless, making such videos can be time-consuming, and achieving the other relevant outcomes without speculative video scenarios could be feasible through other methods, such as spoken narratives or stories (Kiran, 2017). Whether videos or spoken narratives are chosen the aim is for the story to be understandable and to engage the participants. Stilgoe et al. (2013) argue that plausibility and timing are essential for success in anticipating methods. Therefore, we used plausible user narratives but tried not to be too stereotypical in describing the technology in a daily context. We created a narrative approach that placed unfamiliar technology in a familiar context – described by Auger (2013) as "the ecological approach".

A review of opportunities for non-invasive brain monitoring (Ferrari & Quaresima, 2012; Teplan, 2002) was conducted before making the speculative videos (Abiri et al., 2019; Adans-Dester et al., 2020; Cinel et al., 2019; Khan et al., 2021; Raisamo et al., 2019). The purpose was to ensure that the functionality of the technology was close to what is possible (Cinel et al., 2019). The limitation of the technology was mainly related to size, ease of real-time monitoring (Khan et al., 2021) and accuracy (Coates McCall & Wexler, 2020).

The speculative part of the work relates to the following questions, based on a technological mediation perspective (Smits et al., 2022):

- How could this technology be designed to mediate different perceptions and actions?
- Can we challenge assumptions about current practices?
- Can we speculate on alternative relations or different purposes?

The goal was to describe contextual factors beyond the science-fictional representation of the technology by using variations of the design.

We wanted to approach these questions based on mediation theory, how a specific technology mediate relationships between human beings and the world (Verbeek, 2008). By creating three speculative videos about technology use, we investigated how technology could be designed to mediate different perceptions of the mind, health, and well-being. Although the technology under discussion is not yet developed, it is possible in this way to study how various conceptualisations of the technology could elicit different reflections on the relationships it mediates. These ideas were realised in three speculative design videos based on brain-monitoring technology, each exploring a different interpretation of availability, agency, and responsibility (Table 1).

The approach was informed by the *anticipation phase* introduced by Smits et al. (2022). The anticipation phase includes introducing the participant to a prototype or an imaginary version of technology to "acquire an understanding of technology soft mediating impacts on current value framework" (Smits et al., 2022, p. 45).

Each of the three videos generated showcased a variation of the design of a fictional technology called 'Unwind', with each video presenting a different user narrative (see Fig. 1). 'Unwind' was presented as a product that can help avoid a downward spiral by nudging the user toward a healthier brain activity (Fig. 2).

In each video a start-up company introduces a vision of their 'Unwind' product, and one of the three characters. Each scenario is based on wearable, non-invasive monitoring technology that offers a personalised device to help the user snap out of harmful thinking patterns. Each scenario presents one of the three applications of the Unwind technology in a design (Table 1). In video 1, the Unwind technology and app is introduced as a healthcare service tool for use in work with mental health. In video 2, Unwind is sold as a self-help consumer product, aimed at individuals who want to learn about and optimise their

Table 1
describing the different properties of the speculative videos.

	Video 1	Video 2	Video 3
Actions and perceptions	The first scenario used the current framework for healthcare as the context for the speculative design. We started with whether technology should be treated differently to medication or other interventions	The second scenario framed optimisation as well-being. The user is in charge of defining their well-being through self-care	The third scenario framed health as a social responsibility. The goal was to design an informed contract between user and data buyer. The user can choose to share data either as a social responsibility or as a simple information exchange
Value dilemma	Availability	Agency	Responsibility
Dilemma	Availability to more people/digitalisation of mental health care might result in lower quality of health care	Individual's right to define and act on own well-being; economic incentive to manipulate the perception of well-being for collecting data	Need for research data to improve health on a social level; risk to the individual in sharing data
Tools, persuasive elements in the design	Lower cost, information, personalised treatment	Curiosity, gamification, social status	Economic incentives, transparency, information
Challenge/ problem	Mental health	Well-being	Societal health
Actors	Human, app, health team, public services, pharmacy	Human, app, Spotify and other services, colleagues	Human, app, research institutions, private companies
Narratives	Peter, 22 years old and studying in Oslo, has been having trouble sleeping and concentrating. Peter can borrow the Unwind app technology from the pharmacy to: connect to a health team; monitor his medication; and suggest exercises recommended by the health team	Trine, 26 years old and just started a new job, has ambitious career goals. Unwind, in the market for personal health monitoring, helps Trine to concentrate by telling her the best time to take a break and by connecting to other apps, such as Spotify, to select the best music for her work	Trym, 40 years old and loves to exercise, uses motivational training apps, watches and equipment, and logs what he does. The app gives Trym an overview of all his data, and control over what he shares and with whom, whether he contributes to research or earns points
Link video	https://youtu.be/UXeGX7owElw	https://youtu.be/Mk2OZnwxEVM	https://youtu.be/76n_GCwsEqw

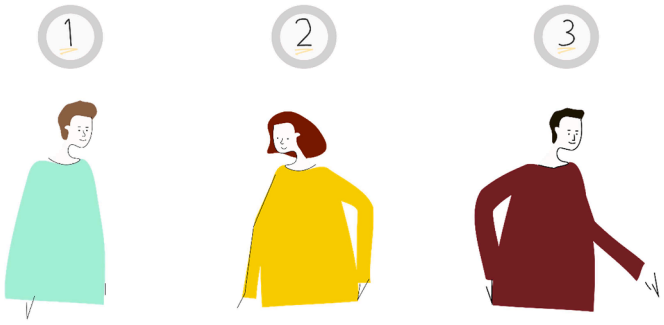

Fig. 1. Three fictive characters for three scenarios: Peter, Trine and Trym.

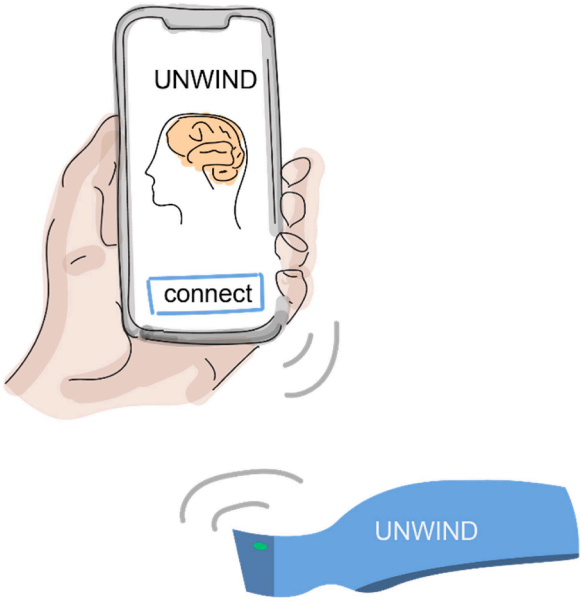

Fig. 2. Unwind technology, app and hardware.

concentration and work pattern. In video 3, the Unwind product includes a service for individuals to share their data with private companies and research.

Focus group procedures

The aforementioned three videos were presented to various participants during a series of focus groups. We were interested in the discussion between participants about the role of emerging technologies, so it was appropriate to use Kvale and Brinkmann's (2009) description of focus groups and discursive interviews to guide our focus group protocol. The use of focus groups was especially relevant as the prime concern is attention to variations in responses rather than consistency (Kvale & Brinkmann, 2009, p. 75).

A total of 10 participants interested in brain monitoring, mental health and technology were recruited as part of an expert engagement study. Five participants came from industries related to ICT development and design, product design, and social work. Five participants were academics working with topics related to technology and design from the disciplinary backgrounds of design, art and design education, universal design and ICT, and humanities. We recruited people from these fields because we wanted participants familiar with some of the challenges related to technology development, as they were more likely to relate to the dilemmas of unintended impacts. The participants were also encouraged to contribute views based on personal perspectives.

Each focus group consisted of two to three participants and was held in the preferred language of either Norwegian or English. The focus groups were recorded and then transcribed before analysis. Because of the Covid pandemic, three of the four focus groups were on Zoom. In the digital focus groups, the number of participants in each group was reduced to improve the dialogue between the participants because getting a good flow in a digital meeting can be challenging with too many participants.

Focus groups were held in autumn 2021 and lasted approximately 1.5 h. There were four focus groups with a total of 10 participants, six male and four female, 25–35 years old. The Norwegian Centre for Research Data (NSD) approved the protocol, and the participants signed written informed consent. The verbal communication was recorded, anonymised and transcribed for further analysis.

To facilitate a dynamic and participatory discussion, the focus group protocol consisted of two parts, drawing from the approaches of Kvale and Brinkmann (2009, p. 75) and Yin 2017, p. (119)). The first part involved the participants watching a video scenario and engaging in open-ended discussions among themselves, with minimal interference from the mediator. This allowed for the exploration of immediate positive or negative reactions to the scenarios. The aim was to elicit new thoughts and encourage reflection, aligning with Yin's emphasis on open-ended questions (2017, p. 119). Building upon this, the second part of the focus group, led by the mediator, encouraged participants to further elaborate on their perspectives and provide in-depth explanations for their evaluations of different scenarios, as suggested by Kvale and Brinkmann (2009, p. 75). The experience of the focus groups was that participants had started to reflect on elaborations in part 1, so part 2 was used to continue their discussions and to expand on some topics.

Analysis

The focus group analysis was informed by Smits et al.'s (2021) value-oriented interviews, which used content analysis. We used a content analysis based on a deductive and inductive approach. To do this, we examined participants' discussions about norms and values. The design scenarios presented to participants were thus based on predetermined values, and we anticipated that they might be discussed. However, we also paid attention to any new dilemmas or conflicts of values that arose from participants' contributions. Thus, it was a combination of a deductive and inductive approach (Dubois & Gadde, 2002, p. 554).

First, we grouped the transcribed focus groups thematically according to the videos. During our initial reading, we identified and highlighted relevant text segments. Our aim was to translate these segments into norms using van de Poel's (2013) approach, which involves constructing a hierarchy of design requirements, norms, and values. This approach allows us to move from abstract values like justice to less abstract norms that interpret these values and, finally, to specific design requirements derived from the norms (Kozlovski, 2022).

Van de Poel's (2013) pyramid can be used in top-down or bottom-up processes, i.e. one can move from values through norm specifications to user requirements in a case or one can map user requirements and look for more general norms and values. As van de Poel comments, it is common to work in both directions in a practical case since inputs can be of different types in real-world settings. He uses "for the sake of relations" to move up one level in the hierarchy, i.e. one can have the requirement "the stove alarm triggers after 30 min" for the sake of "the stove should not cause fire"; and "the stove should not cause fire" for the sake of "safety". Specifications are not deduced from the values, but rather add content relevant for the context. Values are then the justification of norms, in a similar way as norms are justifications of design requirements.

Drawing inspiration from this approach, we thematically grouped the highlighted quotations to create subthemes representing the participants' expressed norms. Lastly, the subthemes were thematically organized into value dilemmas rather than solely focusing on values, as

suggested by van de Poel, as this approach better reflected the nuanced discussions that emerged within the focus groups. Especially as the different norms from the focus group often resulted in conflicting conceptualisations of values. This methodological choice not only provides depth to the ethical landscape of the technology in question but also encourages a more dynamic discussion, recognising that real-world scenarios often present complex situations where multiple values may conflict. By framing the discourse in terms of dilemmas, we can capture the nuances and tensions inherent in these intersections, offering a richer foundation for informed decision-making.

Findings

The aim of this study was to investigate how the design of speculative video scenarios could uncover potential value dilemmas in the development of wearable non-invasive brain monitoring technology. Accordingly, to achieve this objective, we invited 10 participants to participate in four focus groups where they discussed three speculative video scenarios that were based on the same technology. The discussions from the focus group resulted in the conceptualisation of value dilemmas, design principles and norms, guided by van de Poel's (2013) bottom-up hierarchy of design requirements, norms, and values.

Video 1

In the first video, we follow the narrative of Peter who is portrayed as facing difficulties with sleep and concentration. Through the video, we observe that Peter can access the 'Unwind' app and technology from a pharmacy after consultation with a team of health professionals. This technology connects him to a medical team and helps monitor his medication, progress and exercises at home all supported by the Unwind algorithms.

Fig. 3 shows a timeline from the videoes, including design elements to prompt discussions. *Medication* was the design element that prompted the most discussion regarding holistic health. Discussion included views on plausibility and whether the medication solution was a mechanical direction for improving mental health issues, see quotation Fig. 3. A holistic perspective on health in connection with the health team was seen as a considerable contrast to technology monitoring medications.

Video 2

In the second video, we get to know 'Unwind' from the perspective of personal health monitoring. The story in Fig. 4 is about Trine. The 'Unwind' app, helps Trine in her daily routine. It tells her the best times to take a break and works well with other apps, to make sure she gets stuff done and reaches her productivity goals. The second scenario was the one most focus group participants immediately found favourable. It was also the most familiar one because of the resemblance to other tracking technologies. Negative and positive experiences with such technology were discussed in all the focus groups. Perhaps brain monitoring used to quantify and optimise work made this scenario the one with the lowest health risk, and many of the participants expressed a curiosity about understanding these issues better:

> *"I had definitely bought it and tested it out, and if I had received the answers I had envisioned in advance, I might have continued to use it. If I got some facts that might have been harder to digest, I might have dismissed the result."*

In all the focus groups, this curiosity was contrasted with whether one needs something outside oneself to understand yourself better or whether there is too much risk in sharing the information with companies because the data could be used for different purposes on a more societal level.

There was also scepticism about whether one needed to use technology or an app to know how one is working. Some participants questioned whether we are too dependent on technology to regulate ourselves. One participant's reflection exemplified this sentiment:

> *"At the same time, one can listen to the body's signals. I should actually know when am I effective, and when am I not effective. Should I just give up and go home? Maybe one loses the ability to sense it a little too, with so many external cues" (FG4)*

Video 3

In the third video, the narrative revolves around Trym in Fig. 5. Using various motivational training tools, including apps, wearables, such as Unwind, Trym diligently tracks his activities. The app provides Trym with a comprehensive view of all his data, giving him the choice to share specifics, either to aid research or to earn rewards.

The scenario presented in video three elicited a wide range of participant reactions. One participant expressed a positive view, stating, "This one makes me feel better than the other ones because it gives me more agency to choose to do that." (FG2). However, another participant held a contrasting perspective, stating, "Video number three, I would never use. Providing data to private actors is out of the question." (FG1). The diverse responses to video three highlight the complexity of the

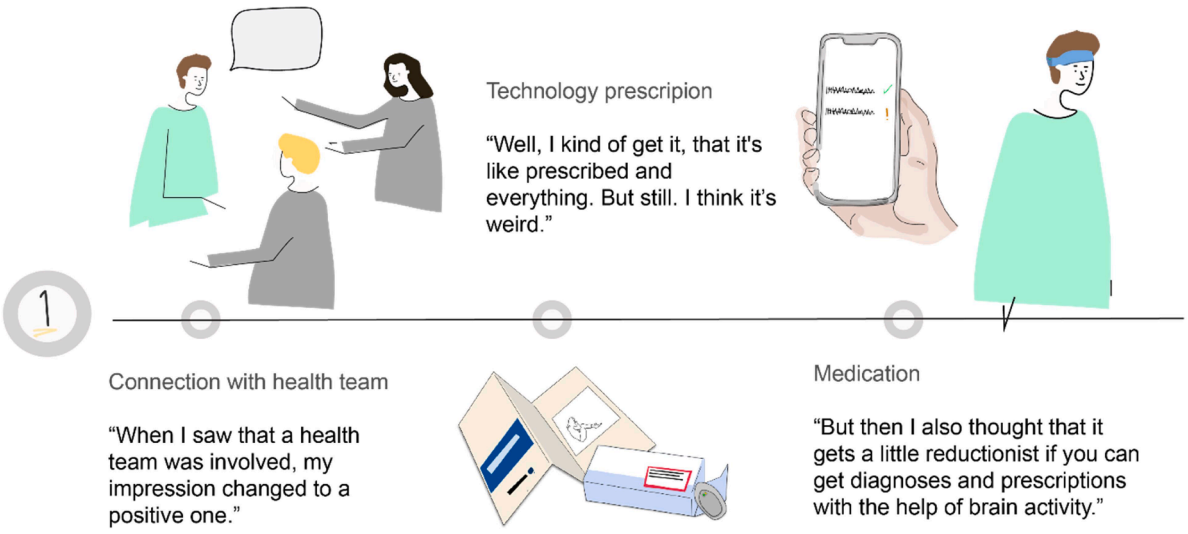

Fig. 3. Participant quotations on details in video 1.

Fig. 4. Participant quotations on details in video 2.

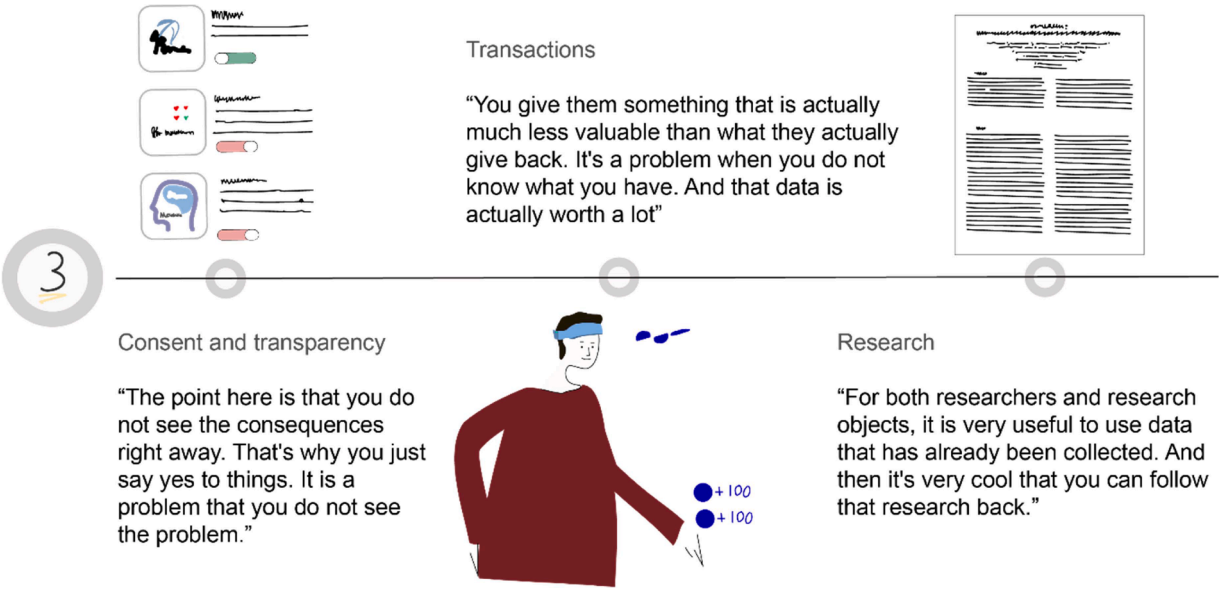

Fig. 5. Participant quotations on details in video 3.

participants' attitudes towards data sharing for research and for commercial purposes.

The premise is Unwind's design strategy for selling and sharing data. Trym, one of the three fictive characters, is in charge of whether data is shared and with whom. If he chose to share with private companies, he could earn points. Participants trusted public research more than private companies buying the data. This resulted in a discussion on whether true consent and transparency were possible in such interactions. One participant said:

> *"It is not like the other companies do not tell you they are using your data. They tell you, it is just not that transparent. It is not transparent enough. They are not transparent on purpose."*

In the video narrative, the fictive character Trym wants to share his data with a private company to earn points. The focus group participants' reaction to this was both positive and negative. On the one hand, reflections concerned that Trym would get something back for what he shares, regardless of his involvement. On the other hand, he won't know the value or impact of the shared data, as it might be analysed in the future based on unknown purposes. Another challenge of using sensor data for research, mentioned by the focus groups, was that the owners of such devices do not represent the whole population. Although the availability of the data makes it attractive for research, it could skew the results.

Discussion

The central question guiding this discussion was: How can speculative videos help explore potential value dilemmas in different designs of wearable non-invasive brain monitoring technology?

This question sets the foundation for the rest of the discussion by emphasising the significance of investigating the interplay between

humans, technology and values in an early phase of problematising technology (Urueña, 2021). To address this question, 10 participants were invited to engage in four focus groups, during which they discussed three distinct speculative video scenarios based on the same technology. The discussions from the focus group resulted in the conceptualisation of value dilemmas, and norms, guided by van de Poel's (2013) bottom-up hierarchy of design requirements, norms, and values.

Our analysis involved thematically grouping the transcribed texts from focus group discussions based on the videos. We highlighted relevant text segments to translate them into design principles or norms using van de Poel's (2013) framework. We grouped the highlighted quotes into subthemes that represented participants' expressed norms. Contrary to van de Poel's categorisation, we did not directly include the design specifications. Nonetheless, the speculative videos displayed design specifications prompting discussions about norms. For instance, the possibility of collecting the technology from a pharmacy, as shown in video 1, stimulated a conversation about how healthcare services are delivered to the public. Ultimately, we organised these subthemes into value dilemmas, a shift from van de Poel's (2013) focus on values alone.

Through our analysis, we identified three main categories of value dilemmas based on the expressed norms or design principles by the participants. The first category, "Healthcare and Responsibility," delved into norms concerning "Holistic Health," emphasising a holistic approach to healthcare, and "Regulated Technology", addressing the need for responsible governance and oversight. The value dilemma revolves around technological opportunities to deliver better services to a growing population while avoiding a reductionist use of technology in health care. Furthermore, it involves questions about how health technology should be developed. Video 1 exemplified how non-invasive brain monitoring could be used for home diagnostics and treatment and was the starting point for such discussions. In this scenario, the public healthcare system takes on the central role of providing health technology to the general public.

The "Self-care and Autonomy" dilemma explored norms that revolved around "Avoiding Manipulation," ensuring users are not manipulated or influenced against their interests while also giving them the freedom to choose what suits them best. Both Video 2 and 3 contributed to this discussion by illustrating through the narratives how these principles could be put into practice. The concept of "manipulation" had nuanced interpretations among the participants, as revealed by the findings. One participant voiced concern about data storage and the appeal of advanced games using brain waves (Table 2), while another emphasised the importance of trust and not over-protecting individuals from influence (Table 2). The norm of "Empowerment rather than Control," was about promoting users' autonomy and empowerment in health decisions. Most participants resonated with this principle, suggesting a consensus on the importance of autonomy in health decisions. However, there might be differing opinions on what empowerment looks like in practice or how it should be implemented in design. This variation was exemplified in the findings as the videos promoted different conceptualisations of autonomy and empowerment. In video 1 and video 2, this was touched upon in terms of what role the technology plays in interpreting the data and how the interpretation is communicated directly to the user or by a health professional.

The third dilemma, "Justice and Society," encompassed norms related to "Transparency and Privacy" and "Misuse of Power". The narrative in video 3 describes the potential benefits to public healthcare by the increased use of data sharing. By aggregating health data, patterns could emerge that might lead to breakthroughs in treatment. This represents a collective good where everyone benefits from the broader societal advancements. However, there is a challenge of balancing pros and cons. Such advancements require a large amount of data, often personal and sensitive. The very act of collecting, storing, and analysing this data can infringe on an individual's right to privacy. Even with the noblest of intentions, the use of this data can easily stray into areas of misuse or overreach. Furthermore, this quest for collective good creates

Table 2
Concept development in categories of value dilemmas and norms.

Value dilemma	Norm	Exemplar quotation
Healthcare and responsibility Should the healthcare system be responsible for regulating and guiding health technology development? Participants expressed concern about the reductionist perspective on health that technology may promote. Conversely, participants also articulated the view that the healthcare system should play a responsible role in shaping technology development based on healthcare principles.	**Holistic Health** Participants rejected reductionist perspectives on health that only consider physical aspects. They argued for the need to promote more holistic perspectives that also include mental, emotional, and social aspects of health.	"It was probably the solution I reacted to, the very purpose. Something like that has so much potential, but it should be part of a treatment offer, and it just gets a little too easy with just medication". (Focus group 4, Discussion comparing the tree videos) "I think it can be a nice complement to a larger approach. Does not replace other options." (Focus group 4, Discussion comparing the tree videos)
	Regulated technology Participants also discussed the need for transparency and accountability in the regulation process to ensure that the technology is developed with the best interests of individuals in mind.	"But if it is implemented in the public sector, then this is a very sober way to do it. I think public health care becomes a gatekeeper of technology in a way. And you have to go through a referral ‘' (Focus group 3, Discussion video 1) "There must be good legal systems for this. I think that will come with time." (Focus group 4, Discussion comparing the three videos)
Self-care and autonomy Should individuals have the right to make decisions about their health and be responsible for their self-care, and should technology be developed with this principle in mind?	**Avoid manipulation** The participants emphasized the individual's right to make decisions and take responsibility for their own health, while also highlighting the potential manipulation of technology by the capitalist market to convince individuals that they need technology to enhance their abilities.	"People will say yes because they want to play the coolest games that use brain waves, of course, and the data will be stored." (Focus group 3, Discussion video 3) "No, I know there are manipulating people in a lot of different stuff, but on the other hand, I think we should have trust. We shouldn't protect anyone from any influence to decide." (Focus group 2, Discussion video 2)
	Empowerment rather than control The participants had varying views on the relationship between empowerment and control, with some expressing scepticism about potential soft impacts while others considered the opportunities.	"You should do things like this, and that everything should be so ultra-structured in life and that you focus a little too much on the body being a machine and you should work then and train then. It might be a little over-analytical, perhaps on how to live life." (Focus group 4, Discussion video 2) "It feels sometimes like technology takes over too much, we human beings lose the ability to make decisions ourselves. We have fewer abilities of judgement, and we are relying on technology to do that for us." (Focus group 2, Discussion

(*continued on next page*)

Table 2 (*continued*)

Value dilemma	Norm	Exemplar quotation
		comparing the tree videos)
Justice and society Should the development of health technology be guided by societal needs and considerations, and how does this intersect with individual privacy rights and concerns? Participants discussed the potential for technology to be developed for the greater good of society but also acknowledged the risks associated with compromising individual privacy. They expressed concerns about the level of control that society and institutions might have over individuals' personal data and emphasized the importance of transparency in using personal data.	**Transparency and privacy** The participants argued the need for a balance between the societal benefits of technology development and the protection of individual privacy rights. However, whether true transparency and consent were possible were argued among the participants.	"If the first video is anonymised and if the data is deleted. If it is not reused for other things, so maybe. Then it is to promote research, and I think that is fine." (Focus group 1, Discussion comparing the tree videos)
		"But it's a bit like you said earlier, I have not noticed the negative consequences of sharing my data. So really, it is mostly a principled idea that one does not share due to privacy." (Focus group 3, Discussion video 2)
	Misuse of power Whereas some of the participants were not too concerned about privacy, many of the participants were sceptical about the potential for misuse of the power.	" ok, think about if the boss gives "unwind to all his employees" (Focus group 2, Discussion video 2)
		"Imagine if two of the scenarios were combined. And it was used to monitor people who were suspected of misusing the system…"(Focus group 2, Discussion comparing the tree videos)

opportunities for misuse of power.

"Transparency and Privacy" theme included the participant discussion on what was considered openness and safeguarding individuals' privacy. While advancements in health technology, like wearable brain monitoring, offer unprecedented opportunities for societal progress, they also raise concerns about potential intrusions into an individual's private realm. Participants' concerns revolve around ensuring that technological designs incorporate safeguards that ensure user data isn't misused or accessed without explicit consent. For instance, the distinction in data use intent across the three videos, especially the conditional third-party sharing in video 3, underlines the norm of transparency as informing users beforehand. This points to a notion of privacy built on trust, not just on detailed user agreements, which, as participants noted, may not always offer genuine transparency. As such, a reframing of how the concept of transparency is implemented is needed.

"Misuse of Power," was based on the participants' discussion on how their use and sharing of data could be used for different purposes other than expected. This subtheme emerges as a repercussion to the issues of transparency and privacy. With the production of personal health data, there exists the potential for misuse, be it by corporations, governments, or other entities. The power to access and interpret such intimate data might provide these entities an undue advantage, leading to potential ethical breaches and manipulation. Participant concerns were particularly heightened when envisioning scenarios where health data could be used to discriminate, exploit, or overly influence. For instance, one participant speculated on the idea of an employer providing "unwind" to all employees (Table 2), describing a potential scenario where personal health metrics might influence employment decisions or dynamics. As users, one might think to simply avoid using such services to protest against this misuse of power. But, in the modern world, avoiding digital services can put one at a disadvantage, making this approach less feasible. A look at the social media landscape shows a lack of regulations that genuinely safeguard users from such power imbalances (Egliston & Carter, 2021; Van Dijck et al., 2019).

The findings from the focus group include reflections from the participants on several connections between humans and technology, including norms on sharing data and the use of sensor technology for health purposes. By having three design variations, the findings suggest that these variations influenced the way the technology was perceived and how it was evaluated by the participants. In the methods section, we described the shift between levels as "for the sake of relation". While this provides a good heuristic for moving up and down the hierarchy, we want to emphasise technology's mediating role in these relations and not necessarily instrumental.

Implications for the design of digitalised patient-professional relationships

Drawing on insights from the focus group findings, we discuss the significance of incorporating these findings back into the design process and their impact on digitalised patient-professional relationships. For instance, the unexpected relevance of the medication detail in one of the first video led to discussions about mental health issues, medication, and the boundary between holistic care and reductionist paternalistic control (Kühler, 2021). This provocation raised questions about the interpretation of data by patients and the shifting dynamics of responsibility in the patient-healthcare professional relationship. The findings highlight the need to consider personalised relationships and the balance between patient inclusion in decision-making and the delegation of responsibility. Designing technology that supports this relationship requires a comprehensive understanding of how gathered data can facilitate treatment and changes in behaviour within specific practices and relationships. Furthermore, it requires an in-depth understanding of the possible dilemmas described as "Healthcare and Responsibility" and "Self-care and Autonomy" in this work.

As a result, a new question emerged: how much should the patient interpret the data produced? If the design is not a tool for the health team to assess the patient, but is a tool for the patient to share their perspective with the health team this changes the responsibility in this relationship. Similarly, Kiran (2017) described how sensors used for rehabilitation shifted responsibility for one's health condition, based on the human–technology relationship. The patient to a larger degree becomes the responsible actor. This shift also changes the purpose of the technology, from monitoring to self-care. In our example, the different interpretations of the video led to new questions about digital design practices in health services.

From the perspective of person-centred health (Jacobs et al., 2017), the relationship between the health professional and the patient should acknowledge a holistic perspective on health, including all aspects of the patient, including personal experiences. This also includes the patient actively engaging in their treatment and decision-making process. Digitalising this process also must deal with the balance of including patients in decision-making and delegating responsibility. However, as pointed out by the participants, there are different perspectives on the ideal of this relationship. Hence, human-centred design in this context is not only about "personalised" treatment but also about designing personalised relationships. In essence, the responsibility for an individual's health cannot be viewed as a simple dichotomy between two opposing options but rather must be examined within the context of the particular healthcare practice and the associated patient-professional relationship. From the empowerment perspective, you need an agency to act (Christens, 2012; Perkins & Zimmerman, 1995). Hence to avoid the reductionist perspective mentioned by the participant, just knowledge or awareness is not necessarily empowerment. Thus, it is vital to investigate the role of technology beyond its instrumental capabilities and consider its potential to mediate relationships between patients and health professionals. In order to design technology that supports this relationship, it is necessary to understand how the data gathered can provide opportunities for treatment or changes in behaviour in specific practices and relationships. Therefore, empirical investigation is crucial

to inform the design of such technology and ensure that responsibility for health is not overlooked but is considered in the context of specific practices and relationships.

The work of Kiran (2017) supports this approach by arguing how value dilemmas could be approached, not by assessing whether technology is good or bad, but how it can be made good given the circumstances of a particular patient. Similarly, Swierstra (2015) argue that soft impacts are less tangible than hard impacts as they manifest themself sometimes in subtle changes in practices. Swierstra (2015) points to the challenge of anticipating soft impacts: we are not aware of the normativity and moralities around us until we are conflicted with other norms.

Further work and limitations

In moving forward, it is valuable to adopt an iterative approach that incorporates the concepts of reflexivity and responsiveness within the framework of Responsible Innovation. Such an approach could include an iteration between the questions: 'what values are at stake?' and 'what values do we want to design for?'. Furthermore, for this specific research, a relevant question to consider could be: How can we design for a personalised relationship between healthcare providers and patients? This question delves into the patient's preferences for how they want to approach their health.

Many aspects of the variations were based on existing designs (Apple, n.d.; Mendi, n.d.; Tankevirus, n.d.). The brain-monitoring alternative to digital mental care can be seen as a more extreme version of digital health care intervention and the idea of picking the device up in the pharmacy is perhaps less plausible in many practices today. However, according to the German Federal Ministry of Health, a prescription app will be a future option (Federal Ministry of Health, 2019). Similarly, the Norwegian Directorate of Health is working on a library for quality-assessed apps for use as prescription apps (Norwegian Board of Technology, 2021). As sensors become more integrated in apps and services, there could be an argument for a similar health technology assessment.

Many participants were sceptical of the claims of the Unwind technology, which is reasonable considering many of the existing commercially available devices do to meet the requirements of validity and reliability (Wexler & Thibault, 2019). In retrospect, it might have been beneficial to share some of the techniques on which the Unwind design was based to ensure that the participants would believe in it.

Another limitation of the method of using speculative design videos is that there is no step-by-step approach, and different contexts must be designed to fit the purpose in each case. The videos were based on an initial review of the field and the purposes identified in the literature. This framing set the stage for the discussion in this study, and a different framing would lead to a different discussion. In future studies, it would be interesting to explore how this process can be done in a more inclusive and iterative way, drawing on participatory design methods. For instance, one approach could be to conduct workshops with participants to explore additional variations of the technology that can be integrated into the speculative scenarios. Such an approach can allow for increased inclusiveness and can mitigate biases linked to the authors' interpretations, thus enriching the overall process. Another limitation of this study arises from the recruitment of participants through the four authors' networks. Diversifying participant recruitment by involving individuals from other networks could have yielded additional valuable insights. In particular, it would be interesting to involve participants with less expert knowledge in the field.

Transitioning from these limitations, a notable challenge lies in effectively integrating the insights gained from the anticipation work into outcomes that extend beyond the project's duration. A specific obstacle entails merging critique into the design and development process, which is often segregated from critical analysis. The work discussed in this article was conducted as part of a larger project focused on developing non-invasive brain monitoring devices for rehabilitation purposes. Within this context, using speculative videos provided an opportunity to present aspects beyond the technical aspects of development to other project members. Employing these videos offered a broader perspective, allowing for a more comprehensive understanding of the project's goals and potential impacts. However, if the project were to progress further with the development, the design heuristics could be subject to iterative exploration, gradually evolving the videos into functional prototypes.

While the practical applications of the findings are constrained within the project's timeline, the work contributes to the project's overarching objectives, particularly by promoting interdisciplinary collaboration within the local scientific network. For instance, one of the authors played a role in establishing a collaborative course in higher education involving health science, design, and technology-related education (Berg et al., 2023).

Concluding remarks

In the rapidly evolving landscape of health technologies, the need to carefully assess the impacts of emerging innovations has become paramount. This is particularly relevant when designing technologies that have the potential to reshape our perceptions of health and well-being, such as wearable non-invasive brain monitoring devices. Our study set out to explore how speculative design heuristics can help including ethical considerations in the development of such technologies. This study adds to responsible innovation research by showing how incorporating anticipatory speculative design methods can help identify potential value dilemmas early in the design process.

Through the utilisation of three speculative video scenarios, each presenting a different purpose for non-invasive brain monitoring, we engaged participants in expert focus groups to delve into the nuances of these designs. The narratives within the videos served as tools for discussion, enabling participants to envision conflicting norms and values. This process revealed potential value dilemmas, highlighting the multifaceted nature of wearable non-invasive brain monitoring devices' impacts on individuals.

These subthemes converged into three main categories of value dilemmas derived from participants' expressed norms and design principles. The "Healthcare and Responsibility" theme discusses the need for holistic health and regulated technology, weighing the potential benefits of technology against its reductionist tendencies. The "Self-care and Autonomy" category explored design principles addressing manipulation avoidance and promoting empowerment over control. The "Justice and Society" category revolved around transparency, privacy, and the risk of power misuse. These insights underscore how nuanced considerations can be essential in health technology development.

Our findings explored the complex relations between humans and technology, particularly regarding sensor technology for health purposes. The influence of different design choices on participants' perceptions and evaluations of the technology was described and analysed. Looking ahead, we advocate for such integration of reflexivity and responsiveness within future development of the technology, with a focus on designing personalised patient-professional relationships. This reflexivity starts with acknowledging how the perceived future is shaping the design actions in the present and the perspective of the designer.

This work contributes by including elements from the field of design, anticipation, and technological mediation (Kiran et al., 2015; Kudina & Verbeek, 2019; Smits et al., 2022), resulting in an exploration of value dilemmas in the context of emerging health technologies. By drawing inspiration from speculative design (Dunne & Raby, 2013; Johannessen et al., 2019; Malpass, 2013), the study introduces hypothetical scenarios that serve as engaging entry points for participants to envision divergent technological futures. This approach aligns with Urueña's perspective (2021) that anticipation can extend beyond mere prediction,

encompassing the early problematization of science, technology, and innovation processes. Moreover, the incorporation of anticipatory commitment, as highlighted by Stilgoe et al. (2013), underpins the study's endeavour to engage with uncertainties surrounding novel technologies.

Ethics statement

The Norwegian Centre for Research Data (NSD) approved the interview protocol, and all the participants signed written informed consent.

NSD: 611406

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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