Speculative Design for and with the Product Impact Tool

Case Study of Health Monitoring and Sleep Prediction Technologies

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Introduction

The research questions guiding this project revolve around the Product Impact Tool and implementing it in understanding how technologies influence user behaviour and how can it be used for design purposes. Speculative design thinking allows the exploration of unexpected results and inspires innovative approaches to the design and impact of technologies. By employing the four quadrants of the Product Impact Tool - before the eye, to the hand, behind the back, and above the head – the cognitive, physical, environmental, and abstract dimensions of the impact of designs are analysed and, new ideas are designed based on each quadrant which is expected to affect the user behaviour differently.

Sleep, a passive yet vital activity, is at the core of our well-being, influencing our physical health, cognitive function, and overall quality of life. In this digital age, Health Monitoring and Sleep Prediction Technology has been a matter of research and design for understanding and optimizing sleep patterns. This research project utilizes the Product Impact Tool as a robust framework to explore the intricate relationship between sleep-tracking devices and user behaviour and alter their usability, acceptance, and impact on the users' behaviour. This comprehensive analysis lays the foundation for evaluating how the Product Impact Tool can be applied to redesign and alter the influence of products on user behaviour in the context of sleep tracking.

Methodology

Research Design

The Findeli's framework of project grounded research in design will be used in this project. This approach recognizes that research projects often start with design questions. The transition from design to research questions is viewed as a construction process. In this iterative approach, a design answer is implemented to the research question as the project progresses, seeking a research answer.

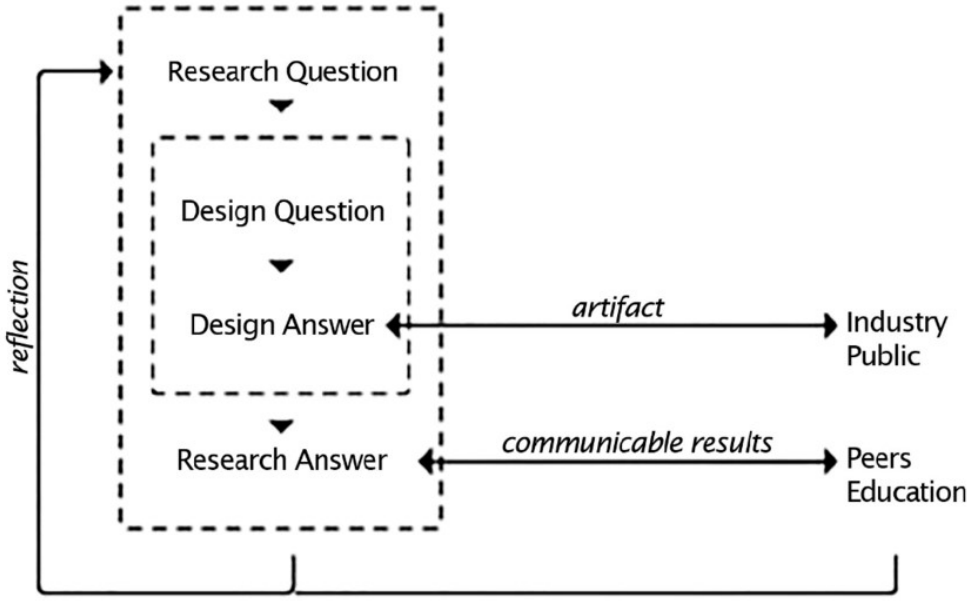


Figure 1 The research though design scheme

Research Questions

In the pursuit of understanding the dynamic intersection between design and user behaviour, the following research questions guide the process:

- How can the Product Impact Tool be used?
- Through which quadrants of the Product Impact Tool are Sleep Tracking and Prediction Technology influence users' behaviour?
- Can this association be changed, if so, how?

Speculative Design

In this project, speculative design serves as a crucial methodology, providing the flexibility needed for uninhibited creativity. The deliberate choice of speculative design is driven by the project's objective to break free from conventional constraints and encourage thinking out of the box. With this approach, the project seeks to explore extraordinary and innovative ideas, unrestricted by practical feasibility. It is essential to note that the primary goal of this project is not the development of functional, market-ready products but rather to showcase the application of the Product Impact Tool in the context of design. Speculative design allows the generation of imaginative concepts, pushing the boundaries of conventional

thinking and enabling a more comprehensive exploration of the tool's potential impact on various design contexts.

Product Impact Tool

The Product Impact Tool is a comprehensive analytical framework derived from the Philosophy of Technology and User Centred Design. It aids assessment and understanding of the multifaceted influences of products and technologies on human behaviour. Developed as a versatile tool for designers, researchers, and stakeholders, it offers a structured approach to dissecting the impact of products across cognitive, physical, environmental, and abstract dimensions. Categorized into four quadrants – before the eye, to the hand, behind the back, and above the head – with each containing three effects, it explores the diverse behavioural impacts of products, offering different perspectives on the levels and types of influence experienced by users (Product Impact Tool Portal – Steven Dorrestijn, n.d.). An overview of the Product Impact Tool is illustrated below.

Figure 2 Overview of the Product Impact Tool.

Target User

In the context of this project, the target user group is intentionally broadened to encompass a diverse range of individuals, aiming for inclusivity rather than specificity. While traditionally, sleep-related technologies may cater to segments such as health-conscious individuals, athletes, or those with diagnosed sleep disorders, the emphasis here is exploring the speculative redesign process through the Product Impact Tool, hence no specific segmentation is the target user of this project. This broad target user group includes people interested in health and wellness, those actively managing stress or anxiety, individuals with sleep issues, and even the ageing population. A diverse audience enables gathering insights and inspiration from various perspectives, needs, preferences, and experiences.

Interview

To gather a broader perspective and insights to the project, interviews were conducted. Users shared initial curiosity and commitment to using the sleep tracking technologies however, over time this interest fades away with the reason of preference towards non-data-driven approach to sleeping habits. Persuasion elements were perceived as ineffective, with users being resistant to notifications. Physical tracking, especially coercion for waking up, was desired, while subliminal influences, such as environmental cues, were acknowledged as potential contributors to improved sleep. Concerns included privacy issues and the potential for technology-induced stress. Users displayed a cautious stance on dependency, advocating for technology as a helpful tool rather than a necessity. The future of sleep-tracking technology was seen as evolving, with hopes for improved accuracy and seamless integration into daily life. These insights underline the complex interplay between users and sleep trackers, highlighting areas for improvement and the need for personalized, non-intrusive solutions. The transcript of the interview is presented in the Appendix 1.

Methodology of Redesign Process

The redesign process is based on the Product Impact Tool. The initial step involves an analysis of the technology or device across the quadrants of the Product Impact Tool to determine its predominant impact. Once the predominant impact is identified, the next step is shifting this dominance into another quadrant. This involves a strategic redesign to amplify the device's influence in a different aspect of the user experience. For example, if the initial impact is more apparent in the Cognitive quadrant, the redesign aims to pivot the dominance towards the Physical, Environmental, or Abstract quadrants. This shift is accomplished by modifying specific features, and functionalities, or even redesigning some elements that align more closely with the target quadrant. The goal is to enhance the efficiency or effectiveness of the products aligned with the user's needs and preferences.

The Abstract quadrant is a culmination of the influences from the other three quadrants—Cognitive, Physical, and Environmental. Shifting the predominant impact to another quadrant prompts users to oscillate between dystopian and utopian ideologies. This perspective holds significant implications for design considerations, especially when tailoring products for users inclined towards either dystopian or utopian preferences. Recognizing that the user experience can shape perceptions along this spectrum allows designers to strategically align features and functionalities with the desired impact quadrant. Therefore, in the results section of redesigning each category of technologies, special attention is given to the Abstract quadrant. Nonetheless, further exploration of this matter is not the aim of this project nor in its scope.

To facilitate a structured analysis, the sleep-tracking technologies are categorized into five main groups. Thes devices in each category work un similar ways or have similar purposes (see Appendix 2). Wearable devices such as smartwatches and fitness trackers, bedside monitors specifically designed for bedside use, smartphones and sleep-tracking apps, environment control devices and lastly, bedding products like mattresses and pillows.

Redesign Process

Wearable Devices

Introduction

Wearable devices have revolutionized the landscape of sleep tracking by seamlessly integrating technology into our daily lives. These devices, typically in the form of smartwatches and fitness trackers, are designed to be worn on the body, offering a convenient and unobtrusive means of monitoring sleep patterns. Equipped with sensors such as accelerometers and heart rate monitors, they capture data throughout the night, providing insights into sleep duration, efficiency, and stages. Notable examples include the Fitbit, Apple Watch, and Garmin devices. Wearables have become popular choices for users seeking continuous and holistic sleep-tracking experiences, allowing for the seamless incorporation of sleep insights into their overall health and wellness routines.

Figure 3 Smartwatch actively tracking sleep data.

Figure 4 Oura Ring Gen 3.

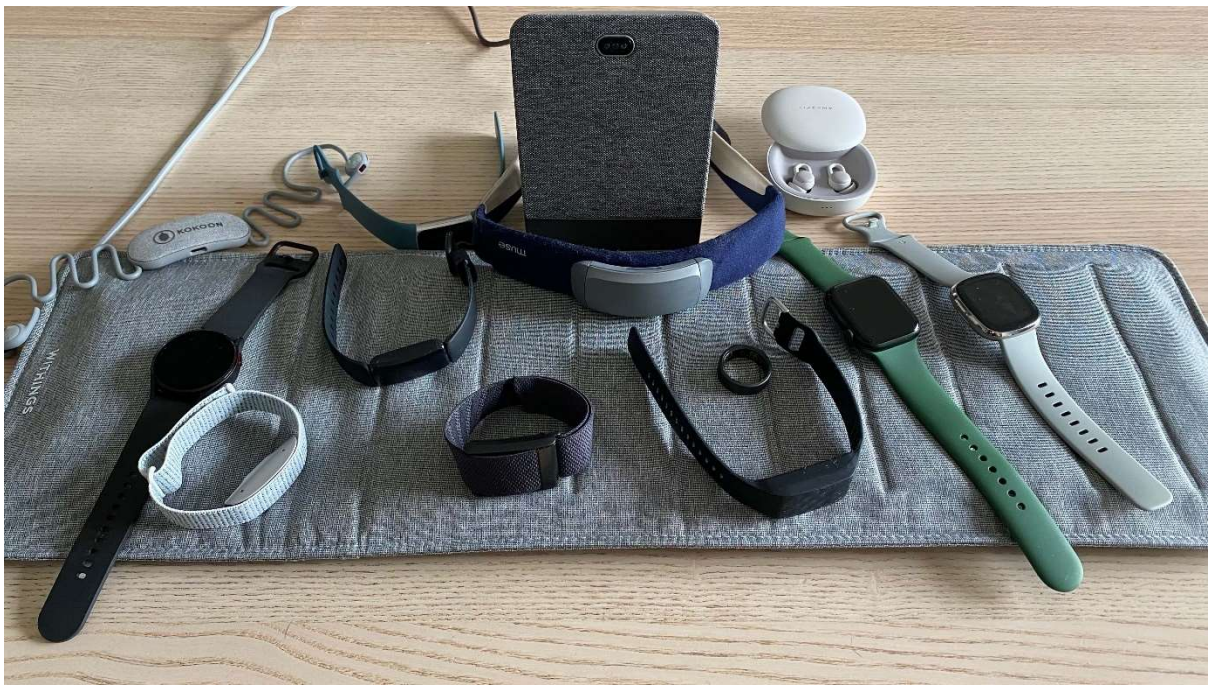


Figure 5 Overview of existing wearable devices used for sleep tracking.

Analysis

The analysis of wearable devices within the Product Impact Tool reveals a dual dominance primarily in the cognitive and physical quadrants. These devices act as cognitive tools, guiding users with insightful sleep data and persuading them toward healthier sleep habits. Moreover, the physical integration of wearables seamlessly coerces users to limit screen time, creating a subtle yet effective impact. While environmental considerations like side effects and background conditions play a lesser role, the comprehensive evaluation underscores the multi-faceted influence of wearables on user behaviour and well-being.

Before-the-Eye (Cognitive):

- Guidance: Wearable devices offer guidance by collecting and presenting sleep data to users, allowing them to make informed decisions about their sleep habits.
- Persuasion: Emphasizing the importance of healthy sleep habits through data encourages users to adopt and maintain positive sleeping behaviours.
- Image: The customizable nature of these devices allows users to personalize them, contributing to a self-image as health-conscious individuals.

To-the-Hand (Physical):

- Coercion: While not forcefully restricting behaviours, wearables can limit screen time through notifications, gently coaxing users to reduce device usage before bedtime.
- Subliminal Affect: The constant presence of wearable devices subtly reinforces healthy sleep habits, acting as a continuous, unobtrusive reminder.
- Embodied Technology: Continuous and habitual wearing of these devices integrates them seamlessly into users' daily routines, becoming a natural and unnoticeable part of their lives.

Behind-the-Back (Environment):

- Side Effects: The environmental impact is less dominant but still present, as wearables may have physical implications, especially during sleep. For example, watches might cause discomfort.
- Background Conditions: The accuracy of sleep tracking depends on user's commitment, influencing factors like consistent wear, which may vary based on individual habits.

Above-the-Head (Abstract):

- Utopian: Wearables can positively influence users' self-image by highlighting the significance of healthy sleep habits. Their continuous presence acts as a gentle reminder, positively shaping users' sleep habits without causing stress.
- Dystopian: Wearables, designed for continuous monitoring and guidance, may contribute to an overreliance on technology for sleep decisions. The subtle coercion through notifications might elevate stress related to sleep performance.
- Ambivalent: The seamless integration of wearables into daily routines can be both positive and challenging. While they become a natural part of users' lives,

constant wear may lead to unintended discomfort or potential dependency, creating an ambivalent perception of their overall impact.

Redesign

In the redesign of wearable devices, the focus shifts towards the environmental quadrant, particularly emphasizing technical determinism. The envisioned transformation involves integrating advanced artificial intelligence with a sophisticated algorithm to enhance the device's predictive capabilities. Beyond merely predicting sleep patterns, the redesigned wearables are envisioned to actively adapt to users' changing needs. This adaptation occurs through continuous learning and customization, ensuring the device becomes a dynamic contributor to creating a personalized and optimized sleep environment. The overarching goal is to shift the influence of wearable devices from cognitive and physical quadrants to the environmental quadrant.

To-the-Hand (Physical):

- Negation of Embodied Technology: There is an opportunity to challenge the predominant embodiment impact identified in the analysis. While wearables are currently designed to seamlessly integrate with the user, an alternative approach could explore making users consistently aware of wearing the device. This redesign perspective aims to question whether a continuous awareness of the device's presence would alter user preferences.

Behind-the-Back (Environment):

- Reduction of Side Effects: In the redesigned wearables, meticulous attention is given to environmental impact. Innovative, sustainable materials with advanced biocompatibility ensure a reduced ecological footprint. Users can confidently wear the device, knowing it aligns with their health-conscious choices without compromising environmental sustainability.
- Technical Determinism: Advanced AI Integration: Implement advanced artificial intelligence with a complex algorithm to enhance the device's predictive capabilities. Adaptive Features: The redesigned wearable device should not only predict sleep routines and patterns but actively adapt to users' evolving needs. This adaptation can be achieved through continuous learning and customization based on individual preferences and changes in sleep behaviour. The device should actively contribute to creating a personalized and optimized sleep environment.

Above-the-Head (Abstract):

- Utopian: The use of innovative, sustainable materials aligns with a utopian vision, promoting a positive environmental impact. The integration of advanced AI for predictive capabilities and adaptive features contributes to an idealized notion of personalized and optimized sleep experiences.

- Dystopian: The redesign is focused on environmental sustainability, aiming to mitigate potential side effects. However, if not executed thoughtfully, the increased complexity and AI integration may introduce new challenges, potentially leading to unintended consequences and dependency.
- Ambivalent: While the focus on sustainability is positive, the introduction of advanced AI introduces potential concerns about the ethical implications and unintended consequences. Striking a balance between innovation and responsible technology use will be crucial for the redesigned wearables to be perceived positively in the abstract quadrant.

The image in the left portrays a minimalist wearable device intentionally designed without a user interface, ensuring users are not interrupted by notifications, thereby eliminating the cognitive impact. This speculative design explores an alternative approach to wearable technology that prioritizes a distraction-free experience.

Figure 6 A wearable device without a UI.

The images below show the redesigned designs that are intentionally conspicuous, challenging the typical embodied technology effect of wearable devices. The aim is to question whether wearables need to blend seamlessly into the user's body or if a noticeable, standout design could redefine the human-product relationship by avoiding the sense of oneness with technology.

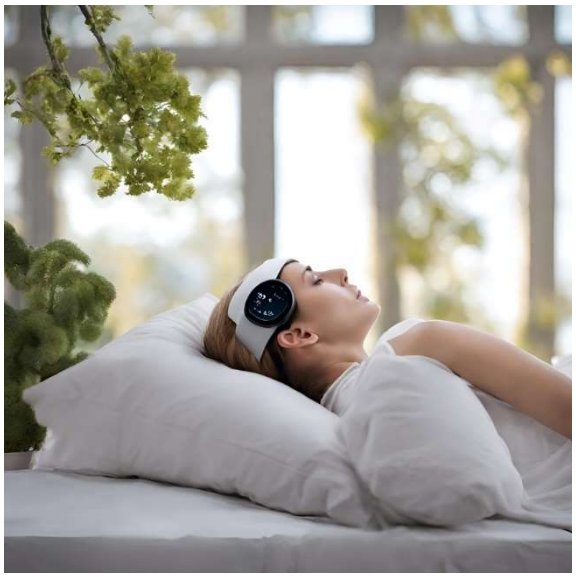


Figure 7 Conspicuous Wearable Devices.

The three images below showcase wearable devices crafted from organic materials such as bamboo and clay, aiming to mitigate side effects, enhance biocompatibility, and promote environmental sustainability. This speculative design explores the integration of natural elements into wearable technology, addressing concerns related to the ecological impact and biocompatibility of conventional materials.

Figure 8 Wearable devices made from organic materials.

Results

The application of the Product Impact Tool to analyse wearable devices were predominant in the cognitive and physical quadrants. These devices function as cognitive tools, guiding users with insightful sleep data and persuading them toward healthier sleep habits. The physical integration of wearables seamlessly coerces users to limit screen time, creating a subtle yet effective impact. While environmental considerations like side effects and background conditions play a lesser role, the comprehensive evaluation underscores the multi-faceted influence of wearables on user behaviour and well-being.

In the redesigned wearable devices, the focus shifts towards the environmental quadrant, emphasizing technical determinism. The envisioned transformation involves integrating advanced artificial intelligence with a sophisticated algorithm to enhance predictive capabilities. The redesigned wearables would actively adapt to users' changing needs through continuous learning and customization, creating a dynamic and personalized sleep environment.

Human-Product Relationships in the Abstract Quadrant:

- Utopian: Wearables positively influence users' self-image and positively shape sleep habits without causing stress.
- Dystopian: Continuous monitoring may contribute to overreliance on technology, potentially elevating stress related to sleep performance.
- Ambivalent: Seamless integration into daily routines can be both positive and challenging, leading to unintended discomfort or potential dependency.

Redesigned Human-Product Relationships:

- Utopian: Innovative, sustainable materials and advanced AI contribute to a positive environmental impact and idealized personalized sleep experiences.
- Dystopian: Despite a focus on sustainability, increased complexity and AI integration may introduce new challenges and unintended consequences.

- Ambivalent: Balancing innovation and responsible technology use is crucial for positive perception in the abstract quadrant.

Bedside Monitors

Introduction

Beside-the-bed monitors constitute a distinct category of sleep-tracking devices tailored for stationary use in the sleeping environment. These devices, often designed as dedicated sleep trackers or integrated into smart alarm clocks, offer a comprehensive approach to monitoring sleep without direct contact with the user's body. Positioned strategically near the bed, these monitors utilize various sensors to capture sleeping data such as sleep duration, interruptions, and overall sleep quality. Notable examples include devices like the Phillips Sleep Smart. Bedside monitors appeal to users who prefer a fixed solution for improved sleep, seamlessly integrating into the bedroom setting.

Figure 9 The Phillips Smart Sleep.

Analysis

Bedside monitors operate in the environmental quadrants. While enhancing the sleep environment, these devices also offer some guidance such as ability to set an alarm and improve user's health-conscious image. The environmental aspects include features like ambient lighting and soothing sounds, contributing to a conducive atmosphere for better sleep.

Before-the-Eye (Cognitive):

- Image: The dominant functionality of these devices revolves around sleep tracking, making them a visible symbol of the user's commitment to monitoring and improving their sleep.

Behind-the-Back (Environment):

- Side Effects: Bedside monitors can contribute to stress or disturbances at night, potentially impacting sleep quality.
- Background Conditions: The environmental aspect is more pronounced, with features like ambient lighting or soothing sounds contributing to a conducive sleep environment. For instance, some models can function as lamps or play calming music.

Above-the-Head (Abstract):

- Utopian: The cognitive guidance and sleep tracking features position bedside monitors as tools for informed decision-making and symbols of commitment to healthy sleep. Their potential to create a conducive sleep environment through ambient features adds positively to the utopian ideal of personalized and comfortable sleep spaces.
- Dystopian: However, the potential for these devices to contribute to stress or disturbances, especially during the night, presents a dystopian perspective. Such unintended side effects could counteract the devices' primary goal of enhancing sleep quality.
- Ambivalent: The dual nature of bedside monitors, serving both cognitive guidance and environmental enhancement, introduces an ambivalence. Striking the right balance between these aspects will determine whether users perceive them positively or negatively in the abstract quadrant.

Redesign

In the redesigned bedside monitors, the primary focus is on shifting towards the Physical quadrant of the Product Impact Tool. This redesign introduces innovative features that enhance the tactile and sensory experiences, emphasizing the tangible and embodied aspects of the sleep environment.

Before-the-Eye (Cognitive):

- Guidance: Bedside monitors provide cognitive guidance through notifications, like wearable devices, aiding users in making informed decisions about their sleep patterns.
- Persuasion: The monitor can provide personalized insights and recommendations based on the user's sleep patterns, suggesting adjustments for better sleep quality. Incorporating a gamification element, where users receive rewards or achievements for consistent sleep improvements, can contribute to a persuasive impact on user behaviour in the cognitive quadrant.

To-the-Hand (Physical):

- Subliminal Effect: The redesigned bedside monitors aim to incorporate a soundscape feature that plays soothing music, nature sounds, or even storytelling to create a serene atmosphere conducive to sleep. Additionally, a display can highlight meditative visuals, fostering a calming environment that subtly influences the user's state of mind.
- Semi-Coercion: Adaptive materials are introduced, transforming the monitor into a textile experience. The user can interact through gesture controls, where different touches, pressures, or locations trigger specific responses. The materials dynamically change, adapting to various times of the day, contributing to a more personalized and immersive sleep environment. The incorporation of haptic feedback, such as vibrations, further enhances tactile engagement.

Above-the-Head (Abstract):

- Utopian: The redesigned bedside monitors prioritize subliminal effects, aiming to create a serene atmosphere with soothing sounds and visuals. This emphasizes a utopian vision of technology actively contributing to a peaceful and personalized sleep environment, enhancing overall well-being.
- Dystopian: Introducing coercion through adaptive materials and haptic feedback presents a potential dystopian angle. While intended to enhance the user experience, there is a risk of making the environment overly responsive, potentially causing discomfort or stress.
- Ambivalent: The balance between utopian and dystopian aspects lies in the execution of subliminal effects and coercion. Striking the right balance ensures that these redesigned monitors are perceived as calming and personalized without being intrusive or discomforting, adding an ambivalent layer to their impact.

Figure 10 Examples of bedside monitors with screens, able to have cognitive impact.

This image showcases a futuristic bedside monitor. The design features a dynamic material that changes with touch, enhancing the tactile and sensory experience. The intentional limitation of certain options introduces a coercive element, gently guiding user behaviour. Additionally, the incorporation of music and light effects serves as subliminal environmental manipulations, aiming to create a soothing and personalized sleep atmosphere.

Figure 11 Dynamic material change of a bedside monitor.

Results

Bedside monitors operate dominantly in the cognitive and environmental quadrants. They offer cognitive guidance through notifications and contribute to users' self-image as individuals focused on sleep improvement. Simultaneously, they enhance the sleep environment with features like ambient lighting and soothing sounds. In the redesigned bedside monitors, the primary focus shifts towards the Physical quadrant of the Product Impact Tool. This redesign introduces innovative features that enhance tactile and sensory experiences, emphasizing the tangible and embodied aspects of the sleep environment.

Human-Product Relationships in the Abstract Quadrant:

- Utopian: Bedside monitors contribute to informed decision-making, symbolizing a commitment to healthy sleep. Their potential to create a conducive sleep environment adds positively to the utopian ideal of personalized and comfortable sleep spaces.
- Dystopian: Potential contributions to stress or disturbances present a dystopian perspective, counteracting the devices' primary goal of enhancing sleep quality.
- Ambivalent: The dual nature of bedside monitors, serving both cognitive guidance and environmental enhancement, introduces ambivalence. Striking the right balance will determine whether users perceive them positively or negatively in the abstract quadrant.

Redesigned Human-Product Relationships:

- Utopian: The redesigned monitors prioritize subliminal effects, creating a serene atmosphere with soothing sounds and visuals. This emphasizes a utopian vision of

technology actively contributing to a peaceful and personalized sleep environment, enhancing overall well-being.

- Dystopian: Introducing coercion through adaptive materials and haptic feedback presents a potential dystopian angle. There is a risk of making the environment overly responsive, potentially causing discomfort or stress.
- Ambivalent: Striking the right balance ensures that these redesigned monitors are perceived as calming and personalized without being intrusive or discomforting, adding an ambivalent layer to their impact in the abstract quadrant.

Smartphones and Sleep Tracking Apps

Introduction

Smartphones have evolved beyond communication tools to become versatile sleep-tracking devices. With the integration of sleep-tracking apps, these devices offer users a portable and accessible means of monitoring their sleep patterns. Sleep tracking apps leverage the built-in sensors of smartphones, such as accelerometers, to capture data related to sleep duration, stages, and interruptions. Popular apps like Sleep Cycle, Pillow, and Sleep as Android exemplify the integration of technology into our nightly routines. The ubiquity of smartphones makes this category appealing to a broad user base, providing a seamless way to gain insights into sleep habits and optimize sleep schedules on the go.

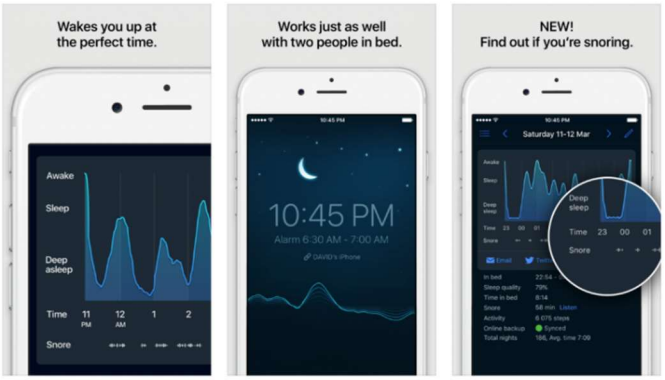


Figure 12 An example of sleep health App.

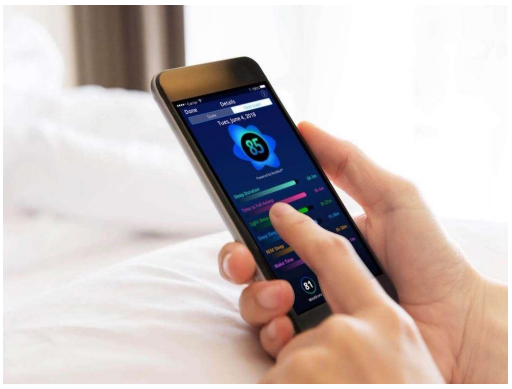


Figure 13 Risk of obsession with sleep tracking.

Analysis

Smartphones and sleep-tracking apps influence users in the Cognitive quadrant, sharing similarities with wearable devices in providing guidance and emphasizing the importance of healthy sleep habits. Additionally, they have a notable impact in the Physical quadrant, coercing users to adopt specific sleep behaviours through their presence and functionality. Furthermore, there is a major influence of Technical Determinism, reflecting the profound integration of smartphones into daily life, making them indispensable.

Before-the-Eye (Cognitive):

- Guidance: Sleep tracking apps guide users by delivering cognitive insights through visualized sleep data, aiding in self-reflection and adjustments to sleep

habits. Emphasis on the importance of sufficient and quality sleep contributes to users making informed decisions about their sleep routines.

- Persuasion: Sleep-tracking apps persuade users to adopt healthier sleep habits by emphasizing the significance of adequate and quality sleep. Encouraging positive sleeping behaviours through data-driven insights aligns with the persuasive aspect within the Cognitive quadrant.
- Image: Using a sleep-tracking app contributes to users' self-image as health-conscious individuals, aligning with the customizable nature of these apps.

To-the-Hand (Physical):

- Subliminal Affect: The app's continuous presence on the user's device serves as a constant subliminal reminder of the importance of sleep tracking. The unobtrusive nature of this reminder reinforces the subliminal aspect within the Physical quadrant.

Behind-the-Back (Environment):

- Technical Determinism: The deep integration of smartphones into daily life reflects a form of technical determinism, shaping behaviours and routines. Moreover, smartphones have become indispensable, influencing various aspects of users' lives, including sleep tracking and management.

Above-the-Head (Abstract):

- Utopian: Sleep-tracking apps promote an ideal scenario by guidance and persuasion for healthier sleep habits have a utopian impact. The emphasis on self-reflection, data-driven insights, and positive behaviours contributes to an idealized view of technology supporting overall well-being.
- Dystopian: Within the physical aspect, the continuous presence of sleep-tracking apps may lead to a dystopian impact, potentially causing stress or anxiety. The subliminal effect, while intended as a positive reinforcement, might inadvertently contribute to negative feelings associated with constant surveillance or reminders.
- Ambivalent: The technical determinism in the environment shows an ambivalent impact. While smartphones seamlessly integrate into daily life, their influence on sleep tracking can be seen as both positive and negative. The convenience of a widely used device can enhance accessibility, but dependence on a single device for critical aspects of life introduces potential drawbacks. The ambivalence lies in balancing the benefits and drawbacks of smartphone integration in sleep management.

Redesign

Redesigning smartphones and apps using the Product Impact Tool is tricky due to their interconnected nature. One approach is isolating individual quadrants; however, this may be challenging because smartphones are designed to seamlessly integrate various features. Trying to separate the impact of one quadrant could affect the overall user experience. Another approach can be highlighting the impact of a specific quadrant, focusing on enhancing a particular aspect while recognizing the interplay with other quadrants. Balancing the emphasis on specific aspects while acknowledging the interdependence of quadrants seems like a practical and user-friendly strategy for this analysis and redesign.

Before-the-Eye (Cognitive):

- Guidance Enhancement: Redesigning focuses on enhancing guidance elements by introducing more personalized and actionable insights. The app could provide tailored sleep improvement suggestions based on individual data, encouraging more proactive engagement with the guidance aspect.
- Persuasion Reinforcement: To strengthen persuasion, the redesigned app incorporates interactive features and challenges, creating a more dynamic and engaging user experience. Gamification elements, rewards, and goal-setting functionalities could amplify the persuasive impact, making the pursuit of healthy sleep habits enjoyable and motivating.
- Image Customization: Redesign emphasizes allowing users to customize their sleep-tracking app interface. This includes personalized avatars, themes, and achievement badges, reinforcing the self-image aspect by aligning with users' preferences and styles.

To-the-Hand (Physical):

- Subliminal Reinforcement: The redesign enhances the subliminal effect by introducing periodic, unintrusive notifications that gently remind users of their sleep-tracking goals. These notifications are strategically timed and subtly designed to maintain a balance between encouraging users and avoiding potential stress associated with constant reminders.
- Tactile Interaction: Introducing tactile interaction elements, such as haptic feedback during certain app interactions, strengthens the physical connection users have with the app. This subtle tactile reinforcement aims to create a more tangible and memorable experience, enhancing the overall physical impact of the app.
- Wearable Integration: Exploring seamless integration with wearables introduces a more direct physical impact. This allows the app to leverage wearable device features like vibrations or gentle pulses as additional cues, contributing to the physical reinforcement of sleep-tracking habits.

Behind-the-Back (Environment):

- Reduced Dependency: The redesign addresses potential drawbacks related to technical determinism by promoting reduced dependency on smartphones for sleep management. It introduces features that seamlessly synchronize sleep data

with other smart devices or cloud platforms, allowing users to access insights and manage sleep conditions beyond a single device.

- Enhanced Integration: Focusing on enhancing the integration with smart home devices, the redesigned app aims to play a more active role in optimizing the sleep environment. This includes features like automated adjustments of lighting and ambient sounds based on sleep patterns, contributing to a more harmonious integration with the sleep environment.
- Customizable Ecosystem: Redesign encourages the development of a customizable ecosystem where users can choose from a variety of sleep-tracking devices and seamlessly integrate them into their sleep routines. This addresses the potential dystopian concerns by providing users with more choices and flexibility in managing their sleep environments.

Above-the-Head (Abstract):

- Utopian Reinforcement: The redesigned app prioritizes positive reinforcement by actively celebrating users' achievements and progress in achieving better sleep habits. This includes personalized congratulatory messages, virtual rewards, and periodic summaries of positive impacts on overall well-being.
- Dystopian: To counter potential dystopian impacts related to stress or anxiety, the redesign introduces stress-mitigation features. Mindfulness exercises, relaxation techniques, and mindful breathing exercises become integral components, offering users tools to alleviate any negative feelings associated with constant surveillance.
- Ambivalent: The redesign acknowledges ambivalence and seeks a balanced approach by providing users with more control over privacy settings and data sharing. Transparency about how data is used and empowering users to make informed choices helps maintain a delicate balance between the benefits and drawbacks of technology integration in sleep management.

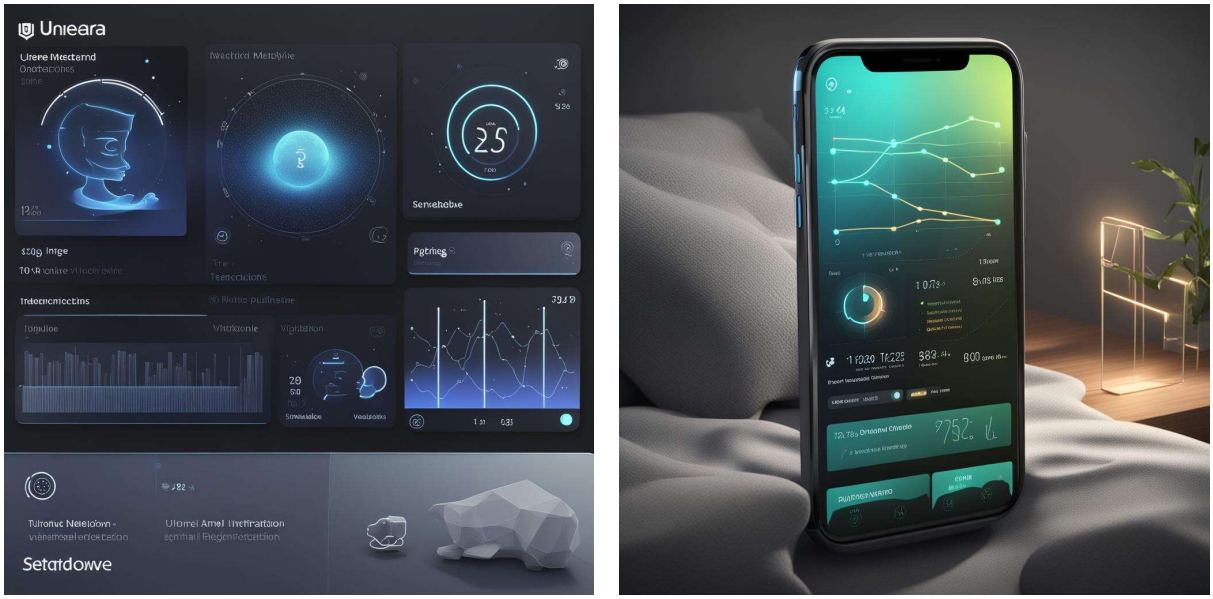


Figure 12 An improved user interface with personalized insights, actionable recommendations, and engaging visualizations.

This image portrays a seamless integration scenario. Visualize a tranquil bedroom setting where a sleep-tracking app, synchronized with various devices, orchestrates a harmonious sleep environment. Emphasize the reduced prominence of smartphones as the app effortlessly communicates with other smart devices, adjusting ambient lighting and other environmental factors. Showcase a customizable ecosystem with diverse sleep-tracking devices seamlessly integrated, offering users flexibility in managing their sleep routines. The image conveys a utopian vision of technology working in tandem to create a personalized, stress-free sleep environment.

Figure 13 Enhanced integration of sleeping apps.

Results

The redesign of smartphones and sleep-tracking apps navigates the intricacies of the Product Impact Tool, emphasizing a shift in the dominance of quadrants. The initial analysis highlighted significant impacts in the Cognitive and Physical quadrants, with technical determinism influencing users' routines. The redesign strategically enhances each quadrant, making its impact more apparent. Cognitive guidance is personalized, persuasion is dynamic, and image customization caters to individual preferences. Physical interactions are reinforced with subtle tactile elements and seamless wearable integration. Environmental impacts address reduced dependency, enhanced integration with smart home devices, and the promotion of a customizable ecosystem. In the abstract quadrant, utopian aspects are reinforced with positive celebrations and stress mitigation, while potential dystopian effects, such as stress from notifications, are countered. The redesign maintains an ambivalent approach by providing users control over privacy settings, ensuring a balanced integration of technology in sleep management.

Human-Product Relationships in the Abstract Quadrant:

- Utopian: The redesigned smartphone app envisions a utopian future, actively celebrating user achievements and promoting stress mitigation, contributing positively to overall well-being.
- Dystopian: Potential stress from continuous notifications is acknowledged as a dystopian perspective, emphasizing the need for mindful design to counteract negative impacts.
- Ambivalent: Striking a balance between benefits and drawbacks, the redesigned app provides users with more control over privacy settings, maintaining a delicate equilibrium between technology integration and user autonomy.

Redesigned Human-Product Relationships:

- Utopian: The redesigned app prioritizes positive reinforcement, offering personalized insights and celebrations, contributing to an idealized view of technology supporting overall well-being.
- Dystopian: To counter potential dystopian impacts related to stress, the redesign introduces stress-mitigation features, providing users with tools to alleviate negative feelings associated with constant surveillance.
- Ambivalent: Acknowledging ambivalence, the redesign empowers users with control over privacy settings and data sharing, ensuring a balanced approach to technology integration in sleep management.

Environment Control Devices

Introduction

The environment control devices introduce a novel dimension to sleep tracking by optimizing the conditions of the sleep environment. These devices, equipped with sensors to measure air quality, room temperature, and other environmental factors, aim to enhance overall sleep quality. Examples include smart home devices, air purifiers, and environmental sensors. Rather than directly tracking physiological sleep data, these devices indirectly influence sleep by creating a conducive atmosphere. Users interested in a comprehensive approach to sleep improvement may turn to these technologies to address external factors that impact their sleep experience.

Figure 14 Example of house thermostat.

Analysis

Environment control devices impact the Behind-the-Back quadrant, specifically focusing on background conditions that shape the sleep environment. These devices, designed to optimize factors like room temperature and air quality, contribute to a utopian vision by actively creating an ideal setting for quality sleep. Their success depends on technical determinism, driven by advancements in technology that facilitate their integration into modern households.

Behind-the-Back (Environment):

- Background Conditions: Environmental devices are highly dominant in shaping background conditions, as they primarily operate to enhance the sleep environment. These conditions include regulating room temperature, air quality, and other factors that directly impact sleep quality. The success of these devices depends on their ability to create an optimal environment for sleep, making background conditions a critical aspect of their influence.

- Technical Determinism: The invention and integration of environmental devices into modern houses can be seen because of technical determinism. The advancements in technology have paved the way for these devices, addressing the need for creating conducive sleep environments. The debate around their necessity in contemporary households can be framed as a positive outcome, considering their potential to positively impact sleep quality.

Above-the-Head (Abstract):

- Utopian: In the dimension of background conditions, environment control devices contribute to a utopian vision by actively shaping and optimizing the sleep environment. Their primary focus on regulating factors like temperature and air quality aims to create an ideal setting for quality sleep, aligning with users' aspirations for a restful night.
- Dystopian: While background conditions represent a utopian ideal, the technical determinism in the environment introduces potential dystopian concerns. The integration of these devices into modern homes may be driven more by technological advancements than genuine user needs, raising questions about their necessity and potential drawbacks.
- Ambivalent: The overall impact of environmental devices on the sleep environment remains ambivalent. On one hand, they strive to create an optimal setting, reflecting utopian aspirations. On the other hand, their origin and integration may be influenced by external factors, introducing potential dystopian elements.

Redesign

In reimagining environment control devices, the focus has strategically shifted towards enhancing cognitive and physical impacts. By infusing eye-catching designs and connectivity options, these devices now offer personalized guidance, extending beyond sleep tips to promote a holistic healthy lifestyle. The aesthetic transformation introduces captivating designs that dynamically alter environmental elements, conveying a conscious and health-conscious image. In the physical realm, the redesign emphasizes coercion through more pronounced manipulation of the environment, ensuring a direct impact on user feelings and behaviours. Subtle, subliminal effects, contribute to a positive sleep atmosphere. The embodiment of technology is now seamless, operating discreetly in the background as a 'sleeping angel,' subtly guarding users without conspicuous disruptions.

Before-the-Eye (Cognitive):

- Guidance: Transform the device into an eye-catching design that directly communicates with users, providing personalized notifications and guidance for improved sleep. Consider connectivity to smart devices or a standalone portable gadget.

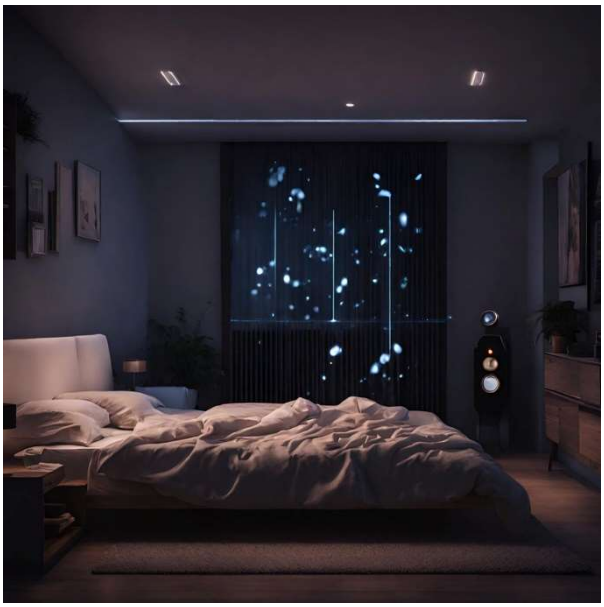
- Persuasion: Elevate persuasive elements by offering eye-opening insights beyond sleep-related tips, such as eco-footprint awareness, and promoting a broader healthy lifestyle.
- Image: Redefine the device's aesthetics, introducing captivating designs that alter environmental elements like scent, colour, light intensity, and music. Craft an ambience that conveys a conscious and healthy lifestyle.

To-the-Hand (Physical):

- Coercion: Leverage the device's environmental manipulation capabilities to have a more pronounced impact, directly altering the user's feelings and behaviours by changing the surrounding environment.
- Subliminal Effect: Introduce subtle environmental manipulations for instance, through scents to create a subliminal effect that users may not consciously notice but contributes to a positive sleep environment. Shift the device's design to operate in the background without a visible display or gadget, creating a seamless and natural experience for users. Position the product as a 'sleeping angel,' subtly guarding the user without drawing attention.

Above-the-Head (Abstract):

- Utopian: The redesign of environment control devices envisions a utopian future where technologies are interactive and communicative. The guidance provided through personalized notifications aims to actively engage users, fostering an improved understanding of sleep habits. This transformative approach enhances the user experience, aligning with utopian ideals of user-centric, informative technology.
- Dystopian: The redesigned devices introduce potential dystopian elements through coercion, as environmental manipulations may exert a more pronounced impact on users' feelings and behaviours. The shift towards altering the surrounding environment, while aiming for positive outcomes, raises concerns about the extent of influence and the potential for unintended consequences.
- Ambivalent: The redesign navigates ambivalence by introducing subtle subliminal effects through scents, creating a positive sleep environment without users consciously noticing. The shift towards a background operation, symbolized by the 'sleeping angel' concept, introduces an ambivalent aspect – providing a seamless experience while potentially raising questions about the extent of influence on users' lives.



In this redesign image, the emphasis is on coercion and subliminal effects. The scene depicts a dark room with ambient music, reflecting a holistic approach to sleep facilitated by technology. The deliberate adjustment of environmental conditions, hindering other activities, and encouraging a serene atmosphere, represents the coercive impact. The subliminal effect is achieved through the seamless integration of ambient elements, subtly guiding users towards a sleep-conducive environment without explicit instructions.

Figure 15 Coercive and Subliminal effects of environmental control devices.

These images showcase the redesign of environment control devices with the focal point on the cognitive quadrant. The devices are intentionally attention-grabbing, making it challenging for users to overlook them. Each device features a screen displaying notifications, sleep insights, and information about eco-footprints and healthy lifestyle choices. The persuasive impact is evident, as users are encouraged to adhere to healthier sleep habits through informative content and a visually appealing interface. The combination of aesthetics and informative elements aims to actively engage users in a more conscious and health-conscious living.

Figure 16 Selection of redesigns of environment control devices with focus on the cognitive quadrant.

Results

Environmental devices operate dominantly in the background conditions, focusing on shaping the sleep environment for optimal quality. The advancements in technology, driven by technical determinism, have introduced these devices into modern households, positively impacting sleep quality. In the redesigned environment control devices, the focus strategically shifts towards enhancing cognitive and physical impacts. Infusing eye-catching designs, personalized guidance, and coercion in environmental manipulation contribute to a positive sleep atmosphere.

Human-Product Relationships in the Abstract Quadrant:

- Utopian: Environment control devices contribute to a utopian vision by actively shaping and optimizing the sleep environment. Their focus on regulating factors like temperature and air quality aligns with users' aspirations for a restful night.
- Dystopian: Technical determinism introduces potential dystopian concerns, raising questions about the necessity and potential drawbacks of these devices. The origin and integration may be influenced more by technological advancements than genuine user needs.
- Ambivalent: The overall impact of environmental devices remains ambivalent, striving to create an optimal setting while potentially being influenced by external factors. The tension between utopian aspirations and potential dystopian elements characterizes the ambivalence.

Redesigned Human-Product Relationships:

- Utopian: The redesigned devices envision a utopian future where technologies are interactive and communicative. Guidance through personalized notifications actively engages users, fostering an improved understanding of sleep habits and enhancing the user experience.
- Dystopian: Potential dystopian elements are introduced through coercion, as environmental manipulations may exert a more pronounced impact on users' feelings and behaviours. The shift towards altering the surrounding environment raises concerns about unintended consequences.
- Ambivalent: The redesign navigates ambivalence by introducing subtle subliminal effects through scents, creating a positive sleep environment without users consciously noticing. The shift towards a background operation, symbolized by the 'sleeping angel' concept, introduces an ambivalent aspect – providing a seamless experience while potentially raising questions about the extent of influence on users' lives.

Bedding Products

Introduction

Bedding products, encompassing innovations such as the Tesla Smart Pillow and Dream Sense Pod Mattress, represent an advanced approach to sleep tracking. Unlike traditional wearables or bedside monitors, these products embed sensing technology directly into the fabric of items integral to the sleep environment. The integration of sensors into pillows, mattresses, and other bedding elements offers users a passive and unintrusive way to monitor their sleep patterns. By combining comfort with technology, these products aim to redefine the sleeping experience. This category appeals to individuals seeking a seamless integration of sleep-tracking capabilities into essential elements of their sleep sanctuary, emphasizing the importance of both comfort and technological innovation in the pursuit of optimal sleep.

Figure 1917 TESLA Smart Pillow: smart heating, sleep monitoring and bedtime music.

Figure 20 Eight Sleep's mattresses include features like temperature autopilot, which learns and automatically adjusts to users' temperature needs.

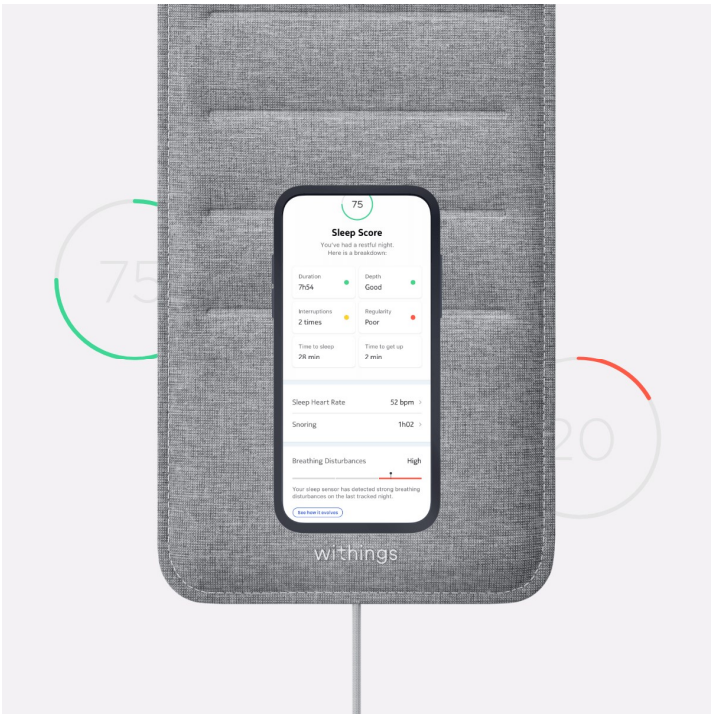


Figure 18 Withings under-mattress sleep tracker

Analysis

Bedding products, particularly mattresses and pillows, have a dominant impact on the Behind-the-Back quadrant. They actively shape background conditions for quality sleep without drawing attention, emphasizing seamless integration into users' routines. This influence falls under the utopian ideal within the Above-the-Head quadrant, contributing to a serene sleep environment. However, potential dystopian concerns arise from technical determinism, questioning the extent of control over users' sleep environments, especially when the underlying technologies are inconspicuous.

Behind-the-Back (Environment):

- Background Conditions: Mattresses and pillows play a fundamental role in shaping the sleep environment, actively influencing the backdrop for quality sleep without drawing attention.
- Technical Determinism: Bedding products, like smart pillows and mattresses, are designed to be inconspicuous, integrating seamlessly into users' sleep routines.

Above-the-Head (Abstract):

- Utopian: Within the cognitive realm, bedding products offer a utopian vision by actively contributing to a serene sleep environment without drawing attention. Background conditions set by smart pillows and mattresses enhance the overall sleep quality, aligning with utopian ideals of technology subtly supporting users' well-being.
- Dystopian: The technical determinism of bedding products, while contributing to their seamless integration, may introduce potential dystopian elements. The inconspicuous nature of these products raises questions about the extent of their influence and control, especially if users are unaware of the underlying technologies shaping their sleep environments.
- Ambivalent: The analysis presents ambivalence in the bedding products' impact, balancing between utopian aspirations and potential dystopian concerns. While the background conditions are optimized for better sleep, the inconspicuous integration prompts users to reflect on the fine line between helpful support and potential overreach in technological influence.

Redesign

Regarding the bedding products, the redesign can have an innovative leap by focusing on cognitive, physical, and environmental impact. The AI-driven app brings a new level of guidance and personalized feedback to users, fostering a deeper understanding of sleep patterns. The persuasive capabilities of the app can provide informative notifications to instigate healthier sleep practices. The redesign envisions a shift in the image of bedding products, embracing high-end, futuristic designs to promote a health-conscious and luxurious aesthetic. On the physical front, coercion takes centre stage, transforming fundamental aspects such as firmness and introducing dynamic features like air-filled pillows to encourage users to wake up. Subtle subliminal effects, including smart materials and environmental adjustments, delicately influence user behaviour. Acknowledging potential side effects, the redesign balances short-term sleep benefits with long-term health considerations. Embracing technical determinism, bedding products seamlessly integrate into users' lives, connecting with smart home devices and contributing to a broad approach to health and lifestyle.

Before-the-Eye (Cognitive):

- Guidance: Integrate an AI-driven app that analyses sleeping data, providing personalized feedback and cognitive responses to enhance user awareness of sleep patterns and habits.

- Persuasion: Elevate persuasion by delivering informative notifications and insights through the guidance app, encouraging users to adopt healthier sleep practices with persistent reminders.
- Image: Redefine the image of bedding products with high-end, futuristic designs and premium-quality materials. Emphasize the health-conscious and luxurious aesthetic, contributing to improved mental well-being and enhancing overall sleep quality.

To-the-Hand (Physical):

- Coercion: Transform the fundamental state of pillows and mattresses by adjusting firmness dynamically. Experiment with innovative features like an air-filled pillow that requires users to wake up and get out of bed.
- Semi-Embodied Technology: Bedding products can have the option of becoming one with the user's body, for instance the material of the bed attaches to the body and user does not feel it as an object anymore but part of his body. It is controversial whether this effect can be considered as embodiment according to the definition of the embodied technology in the Product Impact Tool. Nonetheless, this effect is the most fitting for the idea.
- Subliminal Effect: Using smart materials that subtly change in response to user behaviour. Integrate features like temperature adjustments, sound, colour, and light variations to subtly influence user behaviour.

Behind-the-Back (Environment):

- Side Effect: Acknowledge potential unexpected sensations from smart fabric technology and exposure to artificial elements. Highlight the balance between short-term sleep benefits and potential long-term health considerations.
- Technical Determinism: Leverage the ubiquitous use of mattresses and pillows to ensure their continued presence in users' lives. Establish connectivity with smart home devices and position them as integral components of the Internet of Things. Enable a holistic health approach by shaping user habits and lifestyles through seamless integration.

Above-the-Head (Abstract):

- Utopian: Utopian ideals are emphasized through the cognitive dimension, where an AI-driven app provides personalized guidance and insights. This feature enhances users' awareness of sleep patterns and habits, promoting an initiative-taking and informed approach to sleep health. The persuasive elements, coupled with high-end design and premium materials, contribute to a utopian vision of bedding products fostering improved mental well-being and enhanced overall sleep quality.
- Dystopian: Potential dystopian elements lie within coercion and embodied technology. Dynamically adjusting firmness and experimenting with features like an air-filled pillow may raise concerns about the intrusion of technology into personal comfort. The concept of bedding products becoming one with the user's

body poses questions about the boundaries between technology and personal space, introducing potential dystopian implications.

- Ambivalent: Subtle environmental manipulations and the integration of smart materials introduce a balance between short-term sleep benefits and potential long-term health considerations. The interconnectedness with smart home devices creates an ambivalent relationship, shaping user habits and lifestyles through seamless integration, but prompting reflection on the broader implications of such connectivity.

The images below illustrate smart beds designed for optimal sleep experience. They feature a clean and futuristic design, providing a visually appealing and interesting aesthetic. Integrated with light and music options, the smart bed not only tracks sleep but also analyses the data to offer personalized feedback and notifications. Also, the bed can be connected to other devices such as smartphones. The connectivity aspect allows the bed to expand its network and enhance its capabilities for a holistic approach for better sleeping habits.

Figure 19 Smart beds with cognitive and environmental impacts.

This images below feature a revolutionary bed and pillow design incorporating dynamic stiffness and hardness adjustments. The bed intelligently transforms its comfort level, becoming deliberately uncomfortable when it's time for the user to get out of bed. This coercion mechanism encourages users to leave the bed promptly. Additionally, the smart materials used in the design provide an extra layer of innovation, allowing the bed and pillow to mimic the texture of rocks, adding a unique and discomfort-inducing element to promote waking up.

Figure 23 Bed with dynamic stiffness

Figure 24 Pillow with dynamic texture

The Rotating Bed is an avant-garde bed with a circular design, capable of rotation around the X or Y axis. The innovative feature is designed to add an element of urgency to the waking-up process. If the user does not get out of bed promptly, the rotating mechanism threatens to gently tip them out, providing a playful yet effective encouragement to start the day. In slopped mattress design, a user-friendly approach to morning wake-up is presented. The bed features a unique design with gentle slopes on the mattress. Rather than forceful rotation, these slopes make it easier for the user to naturally move towards the edge of the bed. This design aims to provide a subtle and comfortable way of encouraging users to get up without the abruptness of more forceful methods.

Figure 25 The slopped mattress.

Figure 26 The rotational bed

Figure 20 Embodied technology effect of a duvet

This image showcases a revolutionary duvet design with futuristic technology. When the duvet is placed on the user, it seamlessly integrates with their body, creating a sensation as if it becomes one with the skin. The innovative concept aims to enhance comfort during sleep by eliminating the awareness of the duvet's presence, creating semi-embodiment effect.

Results

Bedding products operate dominantly in the behind-the-back category, influencing background conditions and seamlessly integrating into users' sleep routines. The technical determinism inherent in their inconspicuous design raises questions about the extent of their influence, introducing potential dystopian concerns.

The redesign of bedding products focuses on cognitive, physical, and environmental impacts. It introduces an AI-driven app for guidance and personalized feedback, elevates

persuasion through informative notifications and futuristic designs, and explores coercion, embodied technology, and subliminal effects to influence user behaviour. The redesign acknowledges potential side effects and embraces technical determinism.

Human-Product Relationships in the Abstract Quadrant:

- Utopian: Bedding products contribute to a utopian vision by actively enhancing the sleep environment without drawing attention. Smart pillows and mattresses optimize background conditions for better sleep, aligning with utopian ideals of technology subtly supporting users' well-being.
- Dystopian: The technical determinism in bedding products, while contributing to seamless integration, may introduce potential dystopian elements. The inconspicuous nature of these products raises questions about the extent of their influence and control, especially if users are unaware of the underlying technologies shaping their sleep environments.
- Ambivalent: Ambivalence characterizes the impact of bedding products, balancing between utopian aspirations and potential dystopian concerns. The optimization of background conditions for better sleep prompts users to reflect on the fine line between helpful support and potential overreach in technological influence.

Redesigned Human-Product Relationships:

- Utopian: The redesigned bedding products envision a utopian future where technologies are interactive and communicative. An AI-driven app provides personalized guidance, fostering an improved understanding of sleep habits and enhancing the user experience. Futuristic designs and premium materials contribute to improved mental well-being and overall sleep quality.
- Ambivalent: Subtle environmental manipulations and the integration of smart materials introduce a balance between short-term sleep benefits and potential long-term health considerations. The interconnectedness with smart home devices creates an ambivalent relationship, shaping user habits and lifestyles through seamless integration, but prompting reflection on the broader implications of such connectivity.

Results

The results of the report consist of two components: an assessment of the research questions and an evaluation of the methodology employed in the project.

Assessment of Research Questions

- **How can the Product Impact Tool be used?**

The utilization of the Product Impact Tool proved instrumental in systematically assessing and redesigning sleep-tracking technologies. The tool facilitated an exploration of each category of technology's impact across cognitive, physical, environmental, and abstract dimensions.

- **Through which quadrants of the Product Impact Tool does Sleep Tracking and Prediction Technology influence users' behaviour?**

Sleep-tracking technologies exhibit multifaceted impacts, primarily gravitating towards the cognitive and physical quadrants. The analysis revealed that these technologies often intertwine in the cognitive realm, influencing user behaviour through guidance and persuasion. Physical aspects, such as coercion and subliminal effects, also play a significant role. The exploration of environmental and abstract impacts provided a comprehensive understanding of the intricate connections shaping user interactions.

- **Can this association be changed, and if so, how?**

The redesign process, anchored in the Product Impact Tool, effectively demonstrated the potential for altering the predominant impact of sleep-tracking technologies. Strategic shifts from cognitive dominance to physical, environmental impacts were achieved through targeted redesigns. Innovations ranged from incorporating soothing sounds in bedside monitors to altering smartphone interfaces for a more deliberate impact. The results underscored the malleability of product impact, offering avenues for improvement and tailoring to diverse user preferences.

Assessment of the Methodology

The methodology, rooted in Findeli's framework, proved to be an iterative approach to address the research questions. The cyclic progression from research questions to design questions, design answers, and research answers provided clarity and structure. The systematic application of this framework in the redesign process ensured a thorough exploration of the Product Impact Tool's utility. Reflecting on the methodology, its sequential nature allowed for a comprehensive understanding of the technologies and facilitated an organized and insightful redesign process.

In general, the employed methodology successfully addressed the research questions, providing a robust foundation for the assessment and redesign of sleep-tracking technologies. The iterative nature of the process allowed for continuous refinement and improvement, ensuring a thorough exploration of the Product Impact Tool's applicability in speculative design.

Limitations / Discussion

It is important to note a key limitation in our approach, which assumes the technology caters to individual users. Many products, like sleep trackers and environment control devices, are often shared among users, such as couples sharing a bed. The project's focus on individual experiences provides a foundational understanding, but future work should consider shared dynamics for a more comprehensive view. Acknowledging these shared contexts is vital for a thorough exploration of the technological landscape.

This project's scope and subsequent findings are constrained by a singular focus on sleep-tracking technologies as the exclusive case study. The insights and outcomes derived from the analysis and redesign process are inherently tied to this specific context, limiting the generalizability of the results to other technological domains. While the study provides valuable insights within its designated scope, the application of the Product Impact Tool's conceptual framework to diverse technologies remains an unexplored territory. Further research can be executed enhancing the broader understanding of the tool's effectiveness, within multiple case studies across different technological landscapes. This broader exploration is essential to validate and extend the applicability of the insights gained in this project to a more diverse range of technological contexts.

Lastly, the categorization of technologies, encompassing wearable devices, bedside technologies, smart home devices, smartphones and apps, and bedding, plays a pivotal role in shaping the outcomes of this project. Altering these categories could impact the insights gained and the redesign results. Each category represents a distinct technological landscape with user interactions, contextual influences, and product impact dynamics. If the classification differs, the dominant quadrants within each category might shift, leading to varied emphases on cognitive, physical, environmental, or abstract impacts. Additionally, the interplay between these technologies and their impact on user behaviour may manifest differently, necessitating a tailored approach for each redefined category. Consequently, the conclusions drawn and the effectiveness of the Product Impact Tool in guiding speculative redesigns would be contingent on the specific nature and characteristics of the technologies within the revised categories. Thus, a recalibration of the technology categories would entail revaluation of the project's insights, demonstrating the sensitivity of the findings to the chosen classifications.

Conclusion

In conclusion, this project has demonstrated the effective utilization of the Product Impact Tool as a framework for speculative design. The research questions were addressed, uncovering the influences of sleep-tracking technologies on human behaviour across the quadrants of the tool. The redesign process provided valuable insights into reshaping the predominant impact of these technologies to enhance user experiences. The recognition of the Abstract quadrant as a culmination of influences from Cognitive, Physical, and Environmental aspects has implications for strategic design, particularly in catering to users with dystopian or utopian inclinations.

While the project focused on sleep-tracking technologies, the broader applicability of the Product Impact Tool in diverse technological domains remains an intriguing subject for future exploration. The categorical analysis of wearables, bedside monitors, smartphones, environment control devices, and bedding products enriched the understanding of how different technologies impact users' behaviours. However, it is essential to acknowledge the project's limitations, primarily stemming from its exclusive focus on sleep-tracking technologies. Future research could involve multiple case studies across diverse technological landscapes to validate and extend the applicability of the insights gained. In summary, this project explored the potential of speculative design through the Product Impact Tool. It provides a practical method and useful insights that can be applied in future design projects.

Recommendations / Future work

Understanding the pivotal role of the abstract quadrants of the product impact tool as a synthesis of the other quadrants, the discussion can be the shifting of the predominant impact influences the user's perception, contributing to a dynamic interplay between dystopian and utopian ideologies, which can be a basis for future research. This perspective over the Abstract quadrant may add a layer of comprehension to the overall impact and user experience considerations, offering insights into the potential implications of design choices on users with varied preferences along the dystopian-utopian spectrum.

Another topic requiring more in-depth research is determining the application of the Product Impact Tool across various technological categories. While this project provides valuable insights within the context of sleep-tracking technologies, it is essential to ascertain the tool's effectiveness in other domains. Conducting multiple case studies will contribute to a more comprehensive understanding of the tool's applicability and refine its conceptual framework for diverse technological landscapes.

Furthermore, an intriguing matter to explore is the hypothetical scenario of fully shifting the impact quadrants within the redesign process and investigating whether the ultimate designs converge or diverge across various categories of sleep-tracking technologies. For instance, if the impact of environment control devices is deliberately shifted from the environmental quadrant to the physical quadrant, it raises the question of whether the final design would share similarities with wearable devices.

Exploring the impact of smartphones and sleep-tracking apps has revealed a complex interplay across all quadrants of the Product Impact Tool, posing both a challenge and an intriguing case for future exploration. Despite the intricate relations between cognitive, physical, environmental, and abstract aspects, smartphones have emerged as ubiquitous and user-friendly devices. The inherent interconnectedness between these quadrants raises questions about whether their popularity and ease of use are linked to their multifaceted impact on users. Future regarding this case could explore deeper into unravelling these relationships, investigating how the seamless integration of different quadrants of the Product Impact Tool contributes to the widespread adoption and user-friendliness of smartphones in daily life.

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AI Disclaimer:

For writing of this report, ChatGPT is used to improve the structure and the vocabulary of the document. After using this tool, the document has been reviewed and its content has been edited as needed.

The images presented in this project are created by NightCafe an AI-powered image synthesis platform and Canva (Magic Studio) and may not represent real-world data.

Appendices

Appendix 1: Transcript of the Interview

1. **How does the sleep tracker guide your decision-making regarding your sleep habits?**

In the beginning it would be interesting to use, but then lose interest. Just check phone before and after sleep.

Not very data driven, it's a natural habit. It doesn't add anything, it wouldn't tell much about my sleep. For improving my sleep, it may be useful.

You can figure out your sleep habit yourself, without the technology.

For medical use, it would be useful to know if patients had good sleep or not, so for monitoring someone else's sleep not yourselves.

2. **Can you provide examples of how the guidance from the sleep tracker has influenced your sleep-related choices?**

It would help to keep sleeping schedule consistent. But telling it wouldn't do a lot. Sleeping isn't the problem, waking up is.

3. **In what ways do you feel persuaded by the sleep tracker to adopt healthier sleep habits?**
   Not at all.

Slightly, because sleep tracker tells to go to sleep, so comes to mind, but usually I sleep because I'm sleepy.

I'm also a bit stubborn, and ignore the notifications sent by the technologies.

Persuasive technology should try to change it and not just suggest it.

It's more about the decision of going to sleep than sleeping.

Technologies which would make the home ready for sleeping, is not welcome. I want to make the decision myself. Though these features can help elderly people than healthy young people.

4. **Do you associate wearing a sleep tracker with a particular self-image or lifestyle? If so, how?**

No, I would hate that. It doesn't feel normal to wear somethings.

Having sth to keep track of sleep is nice but wouldn't really care about keeping track of my sleep. Specially if it's about forcing sth on me.

I care about the image, but the technology itself doesn't attract me itself.

Though statistics generated by the devices is amazing, maybe it would be better for people who care about these more.

If it goes to extreme, as need to keep it in place, it would be even worse to use them.

It would be better for technology to calibrate it and give recommendations itself and not just data. It would be also kind of impossible for technology to do as it seems like an AI thing to do.

The general way of giving suggestions based on the average people's lives would not be useful, want personalized recommendations.

5. **How does the physical tracking aspect of the sleep tracker influence your adherence to recommended sleep patterns?**
6. **Have you found the physical tracking feature to be motivating or restrictive in your sleep routine?**

If it forces to sleep no, but for waking up would really like that. If you want extreme structure sure.

It feels restrictive, like loosing the control. It can give the option of would you like to be hindered and keep asking. It can just give the suggestions. It would be frustrating to coerce, it would make me more nervous than motivate to go to sleep.

e.g., I put my phone in a box with an alarm, and lock it, put the key in bathroom upstairs, so when I wake up, I must go to upstairs, and probably take a shower as well, then start the day. A device that helps with this kind of tips and tricks would be helpful.

A device to help with keeping the good habits, doing it once or twice is easy. (getting out of bed mostly)

7. **Does the constant wear of the sleep tracker serve as a subconscious reminder of the importance of sleep tracking? How?**
8. **In what ways has the subliminal influence of the sleep tracker impacted your overall awareness of sleep habits?**

I already have a clock, that I can put coffee in it, so when I wake up, it brews the coffee. It is fabulous (coffee addict!). Stimulus of having the coffee in morning is nice. Coffee would also get cold if I don't get out of my bed. Also, nice boiling voices help in the morning to get out of bed.

Opening the curtains would help a lot. Day light lamp would be great, only if it doesn't do that if I wake up at night. It would be better if it's based on my alarm and not the actual time of me waking up.

It helps against stress.

I may sleep after seeing these signs as well.

9. **How has the integration of the sleep tracker into your daily routine shaped your gestural habits related to sleep?**
10. **Can you share instances where the sleep tracker became seamlessly integrated into your lifestyle?**

Data doesn't interest, but the behaviour.

Using pillows and mattresses can help but some people would be against it.

Giving personalized recommendations is better than data. If they have trouble sleeping is better.

You can also compare your data with how you slept previously, like you slept 2h less in average this week (for example), so make people conscious about this. Or maybe someone feels tired for weeks, so then sleep tracking can help to identify the problem if it's due to the sleeping habits.

11. **Have you experienced any unintended side effects from using the sleep tracker, such as increased stress or anxiety?**
12. **How do you manage or cope with any side effects that may arise from using the sleep tracker?**

If wearing bracelet, yes, others now.

It depends, privacy is important. I don't like to share my data.

Some may care about their performance, and can add to their anxiety, rather than helping them.

Average person wouldn't mind using these technologies, but maybe people with more awareness about health habits.

13. **In what ways do your overall health and lifestyle conditions affect the success or effectiveness of the sleep tracker?**
14. **Can you think of instances where background conditions played a significant role in your experience with the sleep tracker?**

I like the room very dark, silent. Though some people go into sleep with podcast, or a conversation in other room.

Perhaps there are some influences set by people, not natural. Alarm clocks can be confounded in it. So, it does what it's supposed to independently of what is being measured.

What if two people sleeping together?

Consistency would be the best thing.

15. **Do you feel that the sleep tracker determines certain behaviours or expectations related to sleep? How?**
16. **How have the features of the sleep tracker set expectations or norms for your sleep-tracking behaviour?**

There was surely a demand first, then the technologies were created. With time more people saw some advantages in using such technologies.

It is becoming more normal by time, but not all devices are necessarily for everyday use still. Some are way more useful in medical scenarios than casual everyday life.

17. **How do you perceive the sleep tracker as a utopian solution for better sleep? Can you provide examples?**
18. **Have your initial optimistic views about the sleep tracker's impact evolved over time?**

It would be better for specific kind of users, for instance in hospitals so doctors can adjust medications, treatments, etc based on the patient's sleeping. It can be valuable. But for the normal people, how useful can the data be! Maybe add value more than just collecting data. Also, the trackers are not that accurate.

19. **Have you encountered any negative aspects or stress associated with using the sleep tracker over an extended period?**
20. **In what ways has the sleep tracker become a potential source of concern or dependency?**

If everyone would use this and everyone starts talking about data than the quality, it can take the humanity away.

It’s no secret that people have more work and things to get done compared to past, and if trend continues, it will require less sleep. For instance, in Japan, which work hours are a lot, sleep track can be useful to increase their awareness to take care of themselves.

When there is a need, people would do sth about it. So, if people work longer, they need to get better sleep.

If get dependant on a devise, then people don’t organise their days well. Dependency is heathy if it isn’t an addiction, so you can back down from it. It also depends on how dependant you are.

If it’s going to help you sleep, so you should be able to sleep without it as well, just improve it. It is really few people who can’t fall asleep without external help. It should be helping with self regulation.

21. How do you envision the future of sleep-tracking technology based on your current experiences?

I hope it improves, as it gets more accurate. How it’s integrated in the lives.

In fields of research and medicine, it would be a common place item. If it’s not forced for people, I don’t think it’s a daily household furniture. It should remain an option, for demanded people. Stay as the niche.

It can become a device like phones, so integrated. It can measure the alarms as well besides tracking the sleep. Permanent sleep tracking and alarm called Smart Glock!

Appendix 2: Scans of the Redesign Process

Figure 1 presents a comprehensive overview of various sleep-tracking technologies. The placement of these technologies in the quadrants of the Product Impact Tool facilitated the identification of their primary impacts on users. Additionally, the visual representation allowed for a clear understanding of the interrelations among these technologies. This overview was useful in categorizing the sleep-tracking technologies based on their shared characteristics and impacts.

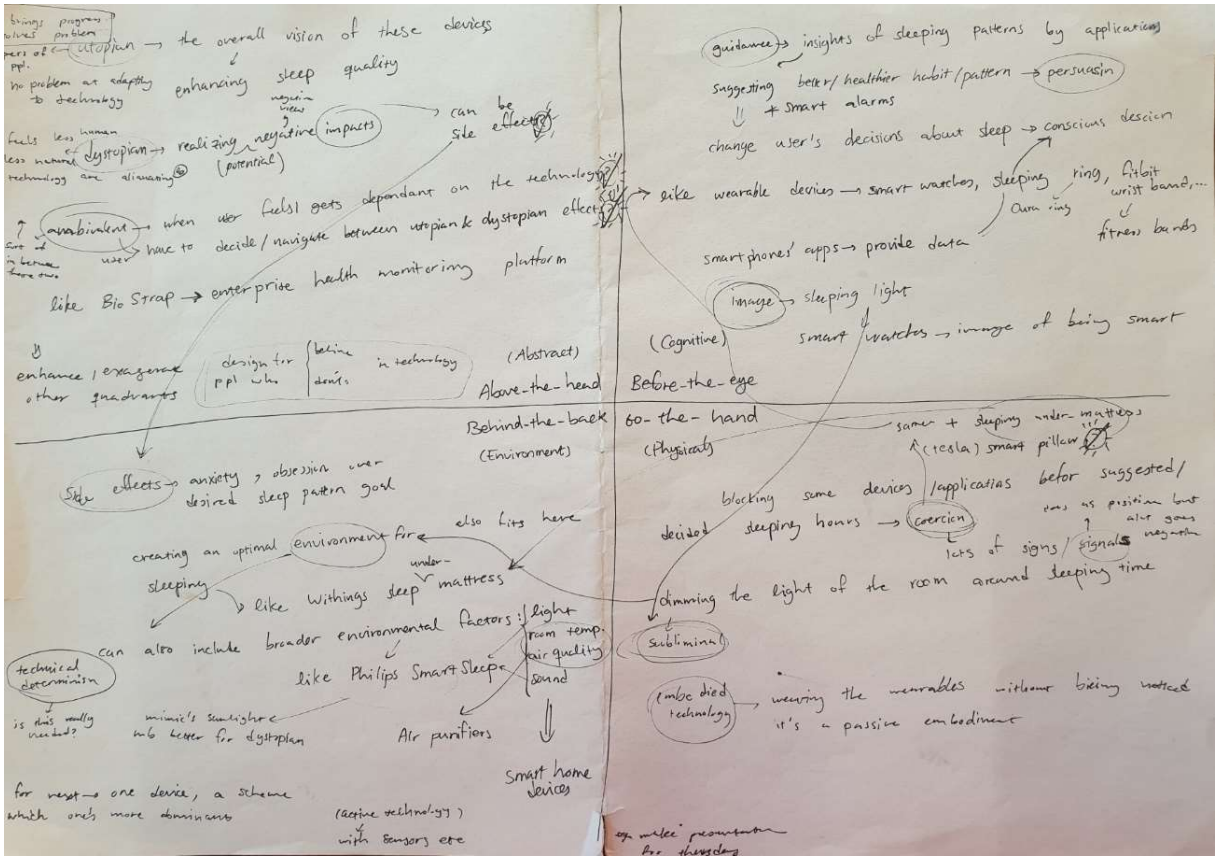

Figure 21 Overview of impacts of all Sleep Tracking Technologies based on the Product Impact Tool.

In the following, the sheets the filled-in Product Impact Tool worksheets for each category of technologies, namely wearable devices, bedside monitors, smartphones and sleep-tracking apps, environment control devices and bedding products is presented. These sheets serve as the foundational elements for the subsequent analysis in the redesign process, forming a comprehensive basis for evaluating the impact of each technology category across various quadrants. The notes written in the black are the preliminary analysis of the products and the texts written with blue ink are the initial ideation for the redesign.

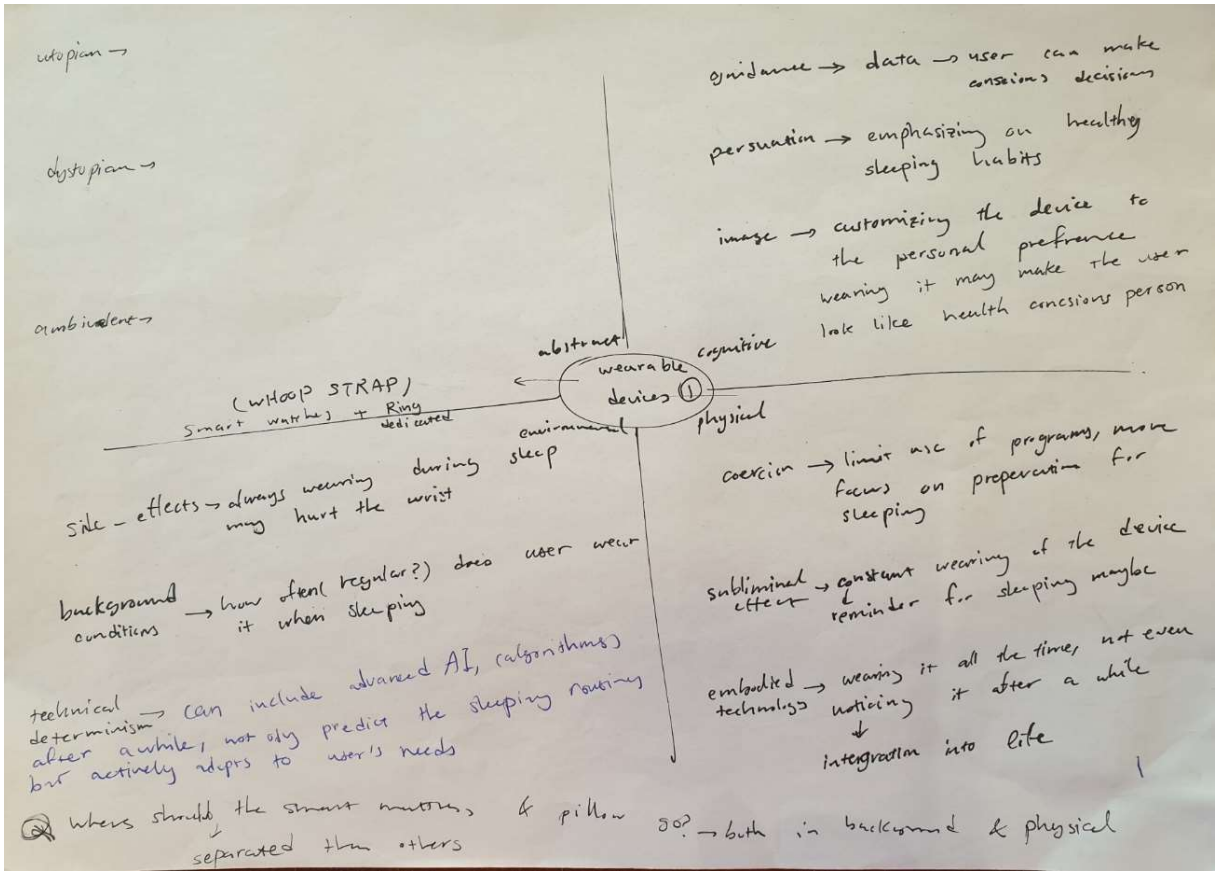

Figure 22 Filled-in Product Impact Tool worksheet for Wearable Devices.

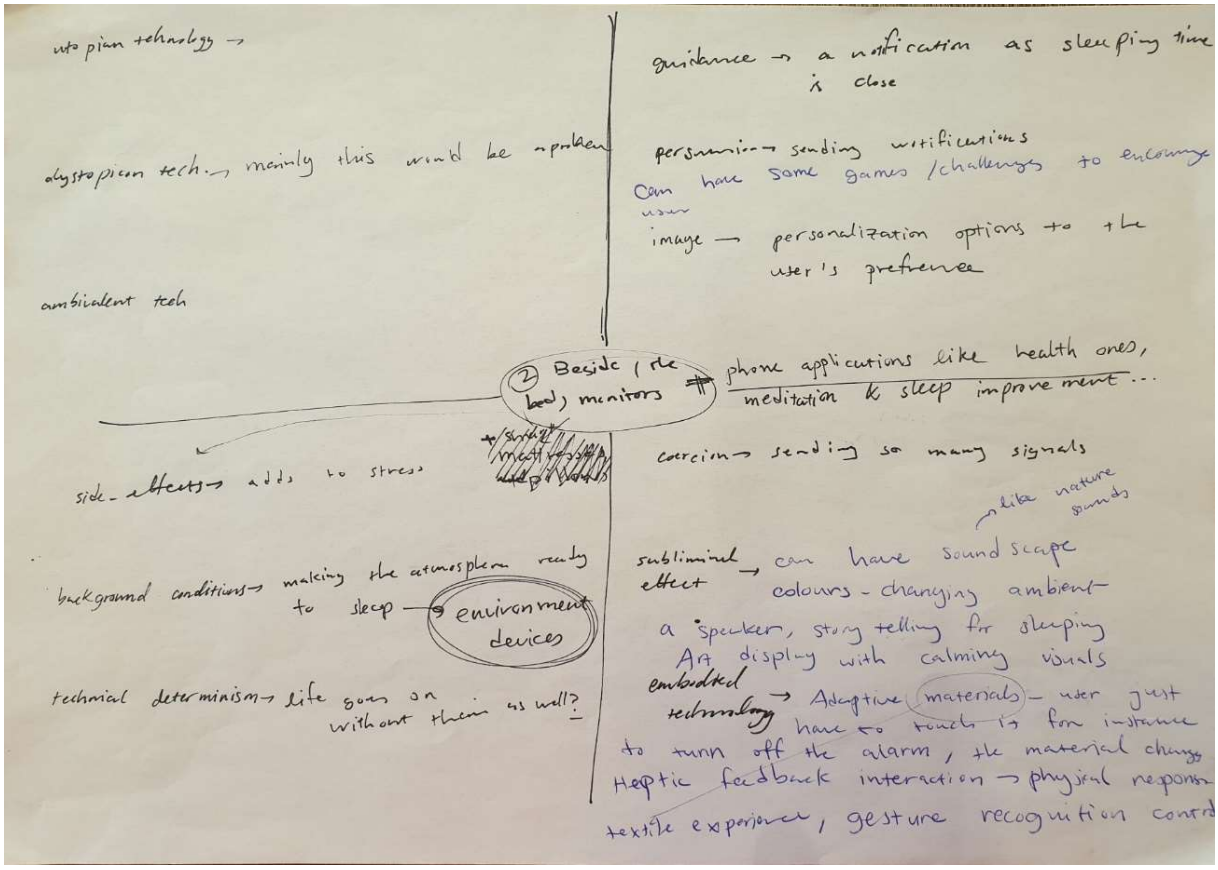

Figure 23 Filled-in Product Impact Tool worksheet for Bedside Monitors.

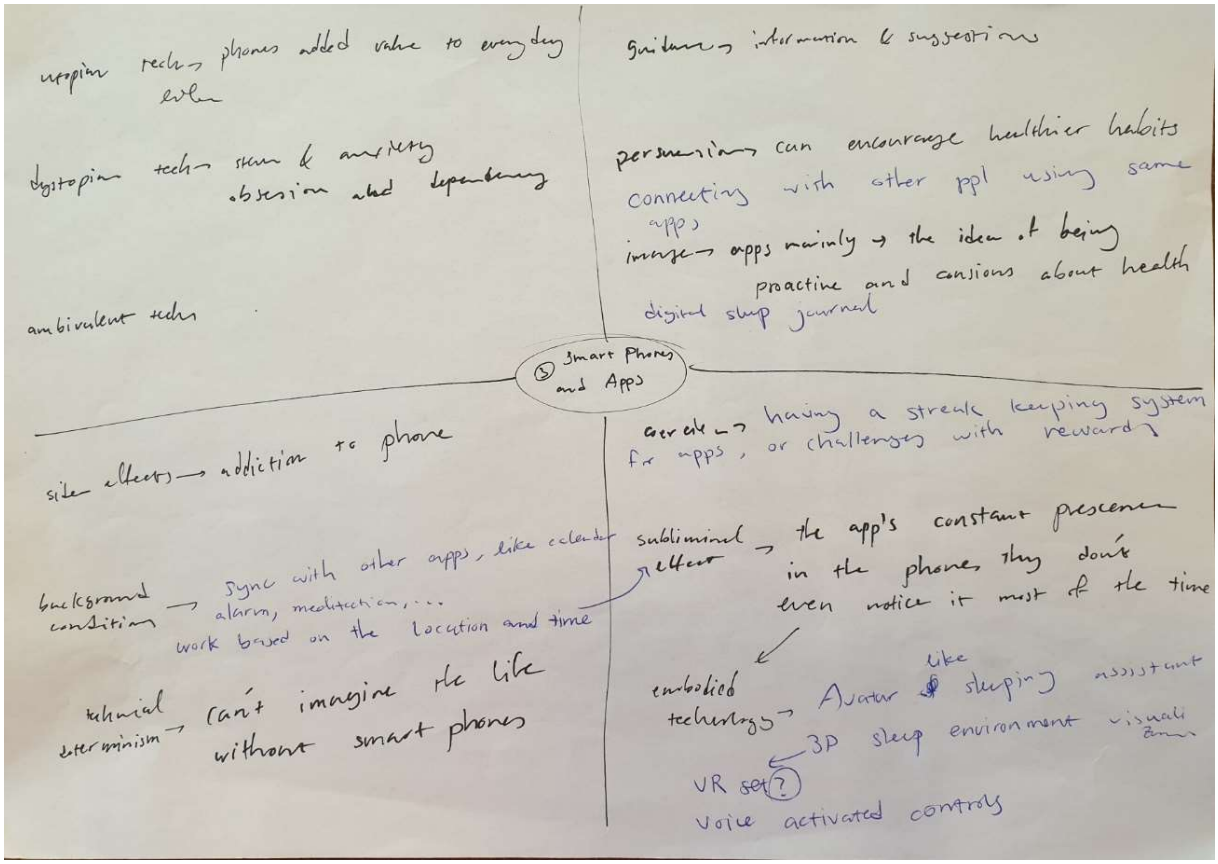

Figure 24 Filled-in Product Impact Tool worksheet for Smartphones and Apps.

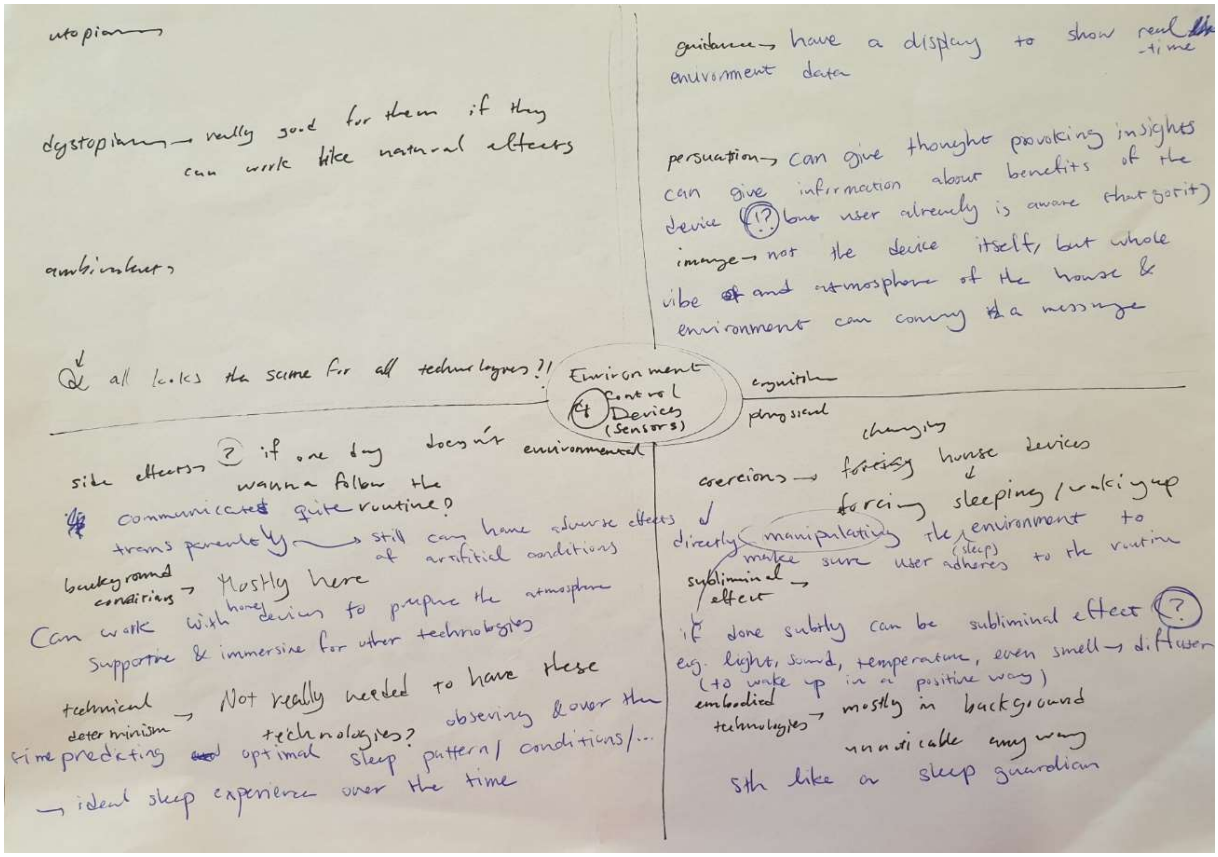

Figure 25 Filled-in Product Impact Tool worksheet for Environment Control Devices.

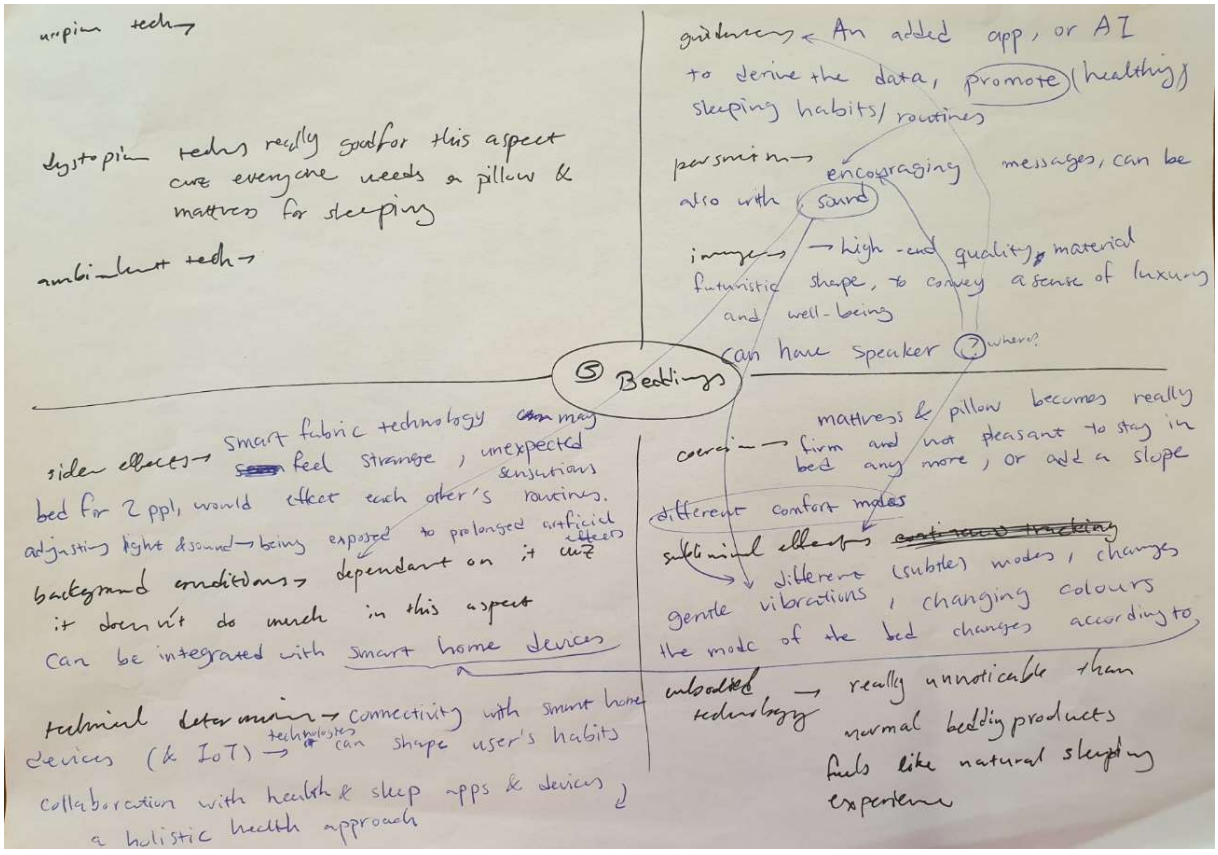

Figure 26 Filled-in Product Impact Tool worksheet for Bedding Products.