Values that Matter: A New Method to Design and Assess Moral Mediation of Technology

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Introduction

How to integrate ethics into design practice? Among the various approaches that have been developed at the interface of the ethics of technology and design research, a well-known focus is that of design for values. "Values" refers to what people consider important in life.[1] As van de Poel and Royakkers state, values are "lasting convictions or matters that people feel should be strived for in general and not just for themselves to be able to lead a good life or realize a good society."[2]

The most well-known design for values methodology is Value Sensitive Design (VSD).[3] This methodology aims at identifying the values that are at stake in concrete technological innovations, to take these values into account in design practices, and to materialize them in a design. Its methodology is threefold. The first phase, "conceptual investigations," aims at identifying and ordering all values at stake in a given context. The second phase, "empirical investigations," is for studying the ideas of stakeholders about values. Third, existing technologies and their embodied values are studied as part of the "technical investigations," followed by the design of the novel product. One of the standard examples in the field—which this methodology actually pioneered two decades ago—is the development of interfaces to fine-tune the cookie settings of web browsers, integrating the value of privacy into the design of information technology.[4] Subsequently, the methodology has been applied in a wide range of domains, including nano pharmacy, transportation services, and safety of homeless young people.[5]

Many design-for-values methodologies, such as reflective design, worth-centered design, values at play, and value-inspired design, find their origin in VSD.[6] These methodologies are "user-driven methodologies," meaning that users define what values are important. In contrast, the values-based methodologies of Vision in Product (ViP) design and Social Implication Design (SID) consider

1 Batya Friedman et al., "Value Sensitive Design and Information Systems," in *Human–Computer Interaction in Management Information Systems: Foundations*, ed. Ping Zhang and Dennis Galletta (Armonk, NY: M.E. Sharpe, 2006): 2.

2 Ibo van de Poel and Lambèrt Royakker, *Ethics, Technology and Engineering* (Oxford: Wiley-Blackwell, 2011): 27.

3 Batya Friedman, "Value Sensitive Design," *Interactions* 3, no. 6 (1996): 16–23.

4 Friedman et al., "Value Sensitive Design": 3–4.

5 Kari Edison Watkins, "Using Value Sensitive Design to Understand Transportation Choices and Envision a Future Transportation System," *Ethics Information Technology* (2018): 1–4; Job Timmermans et al., "Ethics and Nanopharmacy: Value Sensitive Design of New Drugs," *Nanoethics* 5, no. 3 (2011): 269–83; Jill Palzkill Woelfer et al., "Improving the Safety of Homeless Young People with Mobile Phones: Values, Form and Function" in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (New York, NY: Association for Computing Machinery, 2011): 1707–16; and Batya Friedman and David Hendry, *Value Sensitive Design: Shaping Technology with Moral Imagination* (Cambridge, MA: MIT Press, 2019).

6 Phoebe Sengers et al., "Reflective Design," in *Proceedings of the 4th decennial conference on Critical Computing: Between Sense and Sensibility* (Aarhus, Denmark: Association for Computing Machinery, 2005): 49–58; Gilbert

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designers to be the source to identify values (i.e., they are "designer-driven methodologies").[7] ViP has been introduced to create awareness among designers about their responsibility in shaping society. In ViP, designers start with imagining a future for which the desired user–product interaction is visualized, after which the product is designed.[8] Building on ViP, SID aims at creating positive (value) implications in design by asking designers to visualize them and reason backward toward a required behavior and the corresponding design.[9]

Although values-based design methodologies have made a first attempt in bringing philosophy to design, most still lack a clear methodological framework, especially for their understanding and design of values.[10] The problem stems from the way values are often conceptualized in VSD: VSD "seems to assume that values remain stable during adoption and use."[11] Yet, we believe that values arise only in the interplay between users and technologies and therefore are far from stable. Hence, designing for values is impossible without considering potential value mediation. In the following sections, we bring together philosophy and values-based design while considering value mediation of technology.

What Design Can Learn from Philosophy

In this section, we introduce how several philosophical theories—respectively, mediation theory, technology assessment methodologies, and theory on value change—consider the interaction between users, technologies, and values. These theories form the basis for the new design for values methodology that we propose in this article and illustrate by means of a case study.

Technological Mediation

Since the industrial revolution, different assessment methodologies have been used to understand technological risks accompanying the adoption of novel technologies. Technological risks are measurable impacts directly caused by technology—for example, environmental pollution. Design processes have incorporated ways to anticipate these so-called "hard" impacts. However, technology also generates "soft" impacts in addition to these hard impacts. Soft impacts are qualitative and are co-produced in the interaction between a technology and its environment.[12] Soft impacts show that technologies are not neutral tools but have far-reaching individual, social, and societal implications: technologies co-shape the behavior, experiences, and even moral frameworks of their users.[13] Remarkably, soft impacts are only rarely anticipated during design processes.

Philosophical mediation theory is one tool that allows for the study of soft impacts of technologies. This approach originates from the post-phenomenological work of Don Ihde.[14] Post-phenomenology studies the relations between humans and technologies and the

Cockton, "Designing Worth Is Worth Designing," in *Proceedings of the 4th Nordic conference on Human–Computer Interaction: Changing Roles* (Oslo, Norway: Association for Computing Machinery, 2006): 165–74; Mary Flanagan and Helen Nissenbaum, *Values at Play in Digital Games* (Cambridge, MA: MIT Press, 2014); Na Liu et al., "Value-Inspired Service Design in Elderly Home-Monitoring Systems" in *IEEE Annual Conference on Pervasive Computing and Communications Workshops* (PerCom Workshops), (Sydney, Australia: IEEE, 2016): 1–6.

7 Pieter Vermaas et al., "Design Methods in Design for Values," in *Handbook of Ethics, Values and Technological Design*, ed. Jeroen van den Hoven et al., (Dordrecht, The Netherlands: Springer, 2015): 179–203.

8 Paul Hekkert and Matthijs Van Dijk, *ViP-Vision in Design: A Guidebook for Innovators* (Amsterdam, The Netherlands: BIS publishers, 2011).

9 Nynke Tromp and Paul Hekkert, "Social Implication Design (SID): A Design Method to Exploit the Unique Value of the Artefact to Counteract Social Problems" (paper presentation, *Proceedings of the DRS: Design's Big Debates* (Umea, Sweden, June 16–19, 2014): 1–15.

10 Till Winkler and Sarah Spiekermann, "Twenty Years of Value Sensitive Design: A Review of Methodological Practices in VSD Projects," *Ethics and Information Technology* (2018): 1–5.

11 Ibo van de Poel, "Design for Value Change," *Ethics and Information Technology* (2018): 1.

12 See Tsjalling Swierstra, "Identifying the Normative Challenges Posed by Technology's 'Soft' Impacts," *Etikk i praksis. Nordic Journal of Applied Ethics*, no. 1 (2015) 5–20; and Tsjalling Swierstra and Hedwig Te Molder, "Risk and Soft Impacts," in *Handbook of Risk Theory: Epistemology, Decision Theory, Ethics, and Social Implications of Risk* (Amsterdam, The Netherlands: Springer Netherlands, 2012), 1049–66.

13 Peter-Paul Verbeek, *What Things Do: Philosophical Reflections on Technology, Agency, and Design* (University Park, PA: Penn State University Press, 2010).

14 See, e.g., Don Ihde, *Postphenomenology: Essays in the Postmodern Context*

implications that technologies have for human practices and perceptions.[15] Based on this theory, technologies should be seen as "mediators" between human subjects and the world, rather than as "objects" contrasting with human "subjects." When technologies are used, they help to establish relations between the person using the technology and her or his environment. Technological mediation has several dimensions, including a hermeneutic dimension and an existential one.[16] The "hermeneutic" dimension is related to the effects of technology on perception and interpretation. It acknowledges that technologies can amplify or reduce the perception of certain elements of the world. The "existential" dimension focuses on how technologies help to shape actions and social practices. Technologies thereby can invite or inhibit certain behaviors. MRI imaging is a good example of a technology in which both types of mediation are present. Hermeneutically, MRI scanners facilitate neuroscientists' understanding of the brain and developing ideas about the human mind and human behavior in relation to the brain; this interpretation also results in new societal frameworks of interpretation, like the idea that "we are our brains." Meanwhile, through an existential frame, the scanners reorganize the actions of doctors and the interactions between doctors and patients, while also changing social practices, like marketing ("neuromarketing") and psychiatric care ("neuropsychiatry").[17]

A special category of the hermeneutic dimension of mediation is the mediation of moral frameworks. As we have argued, technologies cannot be evaluated based only on a set of ethical principles; they also affect our ethical frameworks for evaluating technologies. A recent example of this moral mediation is the effect of Google Glass on definitions of the value of privacy. Empirical analysis of how people discussed Google Glass online allowed for an investigation of how the definition of the value changes when people apply it to a novel technology. People appeared to define privacy not as the right to be left alone, but as the right to be together privately and the character of private interactions in public spaces.[18] Technology and morality are intricately connected. This connection presents an extra dimension to the ethics of technology because it implies that the ethical frameworks with which we evaluate technologies are themselves co-shaped by these technologies.

Mediation theory offers a framework for understanding the interrelated dynamics among users, technologies, and values and forms a basis for a values-based design methodology. Some authors have introduced mediation to design in the past.[19] However, none have proposed a way to use the methodology for designing and assessing the moral mediation of technology.

(Evanston, IL: Northwestern University Press, 1993).

15 Robert Rosenberger and Peter-Paul Verbeek, *Postphenomenological Investigations: Essays on Human–Technology Relations* (Washington DC: Lexington Books, 2015).

16 Verbeek, *What Things Do.*

17 Bas De Boer et al., "The Perspective of the Instruments: Mediating Collectivity," *Foundations of Science* 23, no. 4 (2018): 793–55.

18 Olya Kudina and Peter-Paul Verbeek, "Ethics from Within: Google Glass, the Collingridge Dilemma, and the Mediated Value of Privacy," *Science, Technology & Human Values* 44, no. 2 (2019): 291–314.

19 Tsjalling Swierstra and Katinka Waelbers, "Designing a Good Life: A Matrix for the Technological Mediation of Morality," *Science and Engineering Ethics*, no. 18 (2012):157–72; Peter-Paul Verbeek, "Technology Design as Experimental Ethics," in *Ethics on the Laboratory Floor*, ed. Simone van den Burg and Tsjalling Swierstra (Basingstoke, United Kingdom: Palgrave Maxmillan, 2013), 83–100; and Heather Wiltse, "The Mediating Role of Responsive Digital Materials: A Conceptual Investigation and Analytic Framework" (PhD diss., Indiana University, 2013).

Technology Assessment

Technological mediation theory analyzes technological mediation in retrospect. In contrast, design methodologies should anticipate technological mediation. For this task, philosophy currently employs technology assessment methodologies. Two well-known approaches are the sociotechnical experimentation methodology of Van de Poel and the techno-moral change approach of Swierstra, Stemerding, and Boenink.[20] The sociotechnical experimentation methodology sees technology as an experiment needing responsible guidance. Three design strategies are proposed for technology to "better adapt to changing values in the later phases of the life cycle of a product or system": adaptability (permit changing the design during its life-cycle), flexibility (permit multiple types of use), and robustness (permit design to perform its function under any circumstance).[21] The techno-moral change approach suggests creating future scenarios for visualizing how a new technology might change standard morality. These moral scenarios are compared to current morality to envision technology-induced changes.[22]

These two methodologies provide a diverging view on dealing with changes in moral frameworks. Sociotechnical experimentation illustrates how to deal with changing values during the design process, but it considers technology as an object needing guidance to deal with external value changes, rather than placing technology at the heart of the value change itself. The techno-moral change approach acknowledges technology's mediation of moral frameworks. Yet, design decision making remains difficult following this approach because the anticipated technology-induced changes are very speculative.

Ideally, users of a technology are involved in the anticipation process to observe how they interact with the technology. Unfortunately, this involvement brings about the "control dilemma" of Collingridge.[23] This dilemma explains that involving users early on in the design process provides opportunity to adjust the design according to the empirically anticipated moral mediation. Yet, this early anticipation remains speculative because the real dynamics between a technology and the moral frameworks of users can be visualized reliably only when a technology is societally adopted. Regrettably, making design changes has by then become difficult. Kudina and Verbeek provide a solution to the control dilemma by studying technologies "at the threshold of society."[24] They consider the Google Glass as an example because this technology is still under development but already is used by some people and is widely discussed online. According to these authors, studying technologies at the threshold of society gives early insight into real-life user–technology dynamics. Their line of reasoning would aid a design team in reliably anticipating moral mediation by technology.

20 Ibo van de Poel, "An Ethical Framework for Evaluating Experimental Technology," *Science Engineering Ethics* 22, no. 3 (2016): 667–86; and Tsjalling Swierstra et al., "Exploring Techno-Moral Change: The Case of the Obesitypill," in *Evaluating New Technologies: Methodological Problems for the Ethical Assessment of Technology Developments*, ed. Paul Sollie and Marcus Düwell (Dordrecht, The Netherlands: Springer Netherlands, 2009), 119–38.

21 Van de Poel, "Design for Value Change," 3.

22 Swierstra et al., "Exploring Techno-Moral Change."

23 David Collingridge, *The Social Control of Technology* (New York, NY: St. Martin's Press, 1982).

24 Kudina and Verbeek, "Ethics from Within," 298.

Technology-Induced Value Change

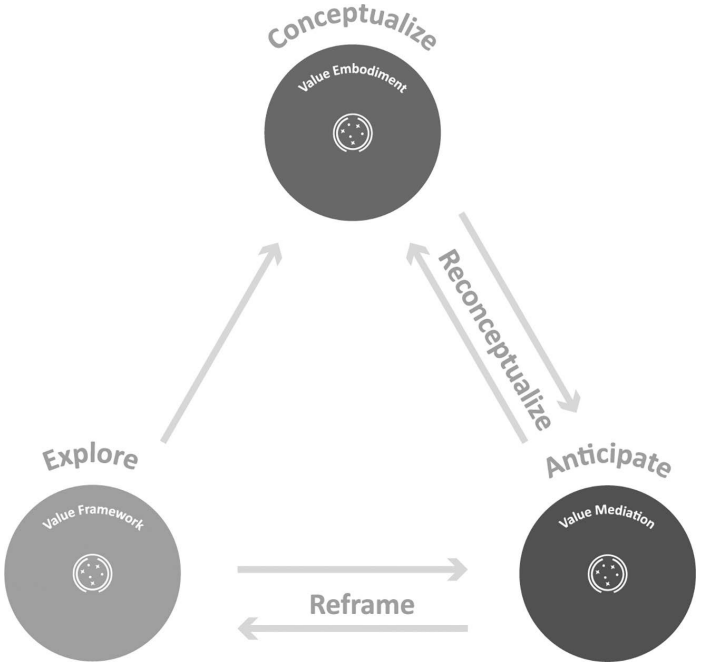
Before describing how the combination of mediation theory and technologies at society's threshold leads to a novel method to assess and design moral mediation, we illustrate the concept of moral mediation by means of value frameworks. We define a value framework as the *current moral perception of a certain group of people in a certain societal context*. It comprises a set of values and the ways these values are experienced. Technological moral mediation then refers to the changes in this value framework caused by the introduction of novel technologies. Van de Poel illustrates this technology–value dynamic by means of five forms of value change.[25] The first form refers to value change when new values emerge in society. For example, the value of sustainability only emerged in the late 1990s as a novel value; it was not mentioned as a value before then but has often been considered in technology's design since. Second, existing values could gain in importance as they are considered in design processes. For example, for a long time, privacy in information technology was not considered important. Now, this value is prominent in each list of design requirements formulated for information technologies. Third, value changes happen in a relative sense, as one value increases in importance over others. The value tension between the values of privacy and safety illustrates this form. Because cameras can improve safety by decreasing privacy, particular locations and contexts determine which value—privacy or safety—matters most and what decisions are made. Fourth, the definition given to a certain value is subject to change. As explained, Google Glass has affected how privacy in public space becomes defined. Fifth, value specifications might change. Value specifications form the process of translating values into norms and design requirements. One example is a change in design requirements related to the shape of Dutch dikes. Because of climate change, the shape of these dikes must change to meet the same water safety levels. These five types of value change illustrate that value frameworks are dynamic and that technologies not only mediate how they are experienced but also how they are constructed.

Values that Matter Approach

Values that Matter (VtM) integrates into design the philosophical approaches already discussed by enabling designers to anticipate technologically induced value mediation in an empirically informed way, rather than in a merely speculative way. It aims to create a "threshold position" for the technology during its design, from which empirical study of its social implications and potential moral mediations becomes possible before the technology has become societally embedded. Thus, it aims to find the right balance between speculation and experimentation: without trying to look too far into

25 Ibo van de Poel, "Translating Values into Design Requirements," in *Philosophy and Engineering: Reflections on Practice, Principles and Process*, ed. Diane P. Michelfelder et al., (New York, NY: Springer, 2013): 253–66.

Figure 1
Values that Matter framework. © Authors.



the future, and also without giving up the possibility of anticipation at all, it acts as a tool that can be used in the process of responsible design of technology. The method consists of three phases (see Figure 1). Depending on the specific needs of the design process, these phases can be followed multiple times in the desired order. We explain the three phases in the following sections.

Explore

This first phase theorizes the current value framework. Because a value framework comes into existence in a specific context for a certain group of people (actors), clearly defining the study area is important: what context should be studied, and what group(s) of actors will be affected by the future technology? For each actor or group of actors, a separate value framework can be theorized. A value framework consists of multiple facets, which we have adapted from van de Poel's different kinds of value change:

1. What values are important for the actor?
2. What definition is given to each value?
3. What is the relative importance of each value?
4. How is each value specified in norms?
5. How is each value experienced?[26]

The value framework can be constructed based on empirically gathered data of the actors in their context. Different types of qualitative (value-oriented) research could be valuable—for example, semi-structured interviewing, value sketching, observations, diaries, and context-mapping exercises.[27]

26 Van de Poel, "Design for Value Change."

27 Friedman and Hendry, *Value Sensitive Design.*

Depending on the goal of using this methodology, a design team can continue to the *visualized* phase for designing a new technology meeting the current (or desired) value framework, or it can proceed to the *anticipate* phase to assess a technology's moral mediation that results from adopting an existing technology in the studied context.

Conceptualize

Because a new technology might mediate actors' actions, perceptions, and values, designers can consciously design for a certain value framework. They can either start with the value framework previously constructed, or they can envision a preferred value framework as a basis to embed in a technology's design. Van de Poel illustrates how to embody values in technology.[28] He starts by translating each value into several norms. We define norms as *all conditions needed to realize values in practice*. Norms can be identified empirically, as users refer to a set of norms when reflecting on an overarching value. Consequently, the design team can translate each norm into several design requirements that are needed to achieve that norm. The list of design requirements aids in designing the new values-based technology.

Anticipate

The anticipate phase aims to acquire an understanding of technology's soft mediating impacts on the current value framework of actors. To develop an understanding of these mediating effects, VtM follows Kundina and Verbeek's suggestion to create a threshold position for the technology in question. A pilot study meets the requisites of this threshold position, allowing actors to use a prototype or even a virtual or imaginary version of a technology for a specified period in the context already studied.[29] As empirical research, the pilot setup generates insights into a technology's moral mediating effects. This research allows designers to construct new potential value frameworks per actor, again answering the questions:

1. What values are important for the actor?
2. What definition is given to each value?
3. What is the relative importance of each value?
4. How is each value specified in norms?
5. How is each value experienced?

Comparing this new value framework to the value framework defined in the exploration phase provides insight into the moral mediation of technology.

Technological mediations could both benefit and harm actors' existing value frameworks. For each beneficial mediating effect, the current value framework can be "reframed." Thus, the

28 Van de Poel, "Translating Values into Design Requirements."

29 Olya Kudina, "Accounting for the Moral Significance of Technology: Revisiting the Case of Non-Medical Sex Selection," *Journal of Bioethical Inquiry* 16, no. 1 (2019): 75–85; Kudina and Verbeek, "Ethics from Within."

design team accepts that a technology positively affects the value frameworks. Technology also could harm current value frameworks. These undesired mediations should be prevented through "reconceptualization" of the technology. In this step, the technology is redesigned to better meet the desired value framework (again, see Figure 1). This reconceptualization should start with seeking to understand what aspect of the technology causes the negative effects on values; design teams do so by translating the threatened values into norms and the norms into design requirements, as done in the conceptualize phase. The design requirements causing the undesired outcomes can then be adjusted, and the technology can be redesigned accordingly, after which the whole process can be repeated.

What Philosophy Can Learn from Design: Hospital Case Study

To understand VtM's usability, we applied the VtM method in the redesign of a continuous vital sign monitoring device used with hospitalized patients. This device has strong mediating effects on its professionals and patients because it enables patients to continuously face their health condition. We sought to understand how this device mediates patients' values so that the device could be redesigned for optimal mediation of patients' value framework.

Traditionally, nurses have measured vital signs of patients manually three times a day: heart rate, respiratory rate, blood pressure, body temperature, and oxygen saturation. Measuring patient's vitals, writing them down, and registering them in the electronic medical record takes approximately six minutes. Taking vitals is subject to inter-observer variability; in addition, the large gap of eight hours between two subsequent manual measurements could cause caregivers to miss relevant data for optimal care. Continuous vital sign monitoring of patients using a device worn on the wrist—one showing vital signs in real time—potentially could overcome these drawbacks and predict and prevent (deterioration of) the disease course. In 2017, the Radboud University Medical Center, Nijmegen, started a pilot study with a continuous monitoring device, ViSi Mobile® (Sotera Wireless, San Diego, CA, USA). The aim was to assess its potential in improving the quality and safety of in-hospital patient care on a general ward (see Figure 2).[30]

Explore

To understand the current value framework of patients subjected to traditional vital sign measurements, two studies were conducted in the same university hospital. In the first, experiences of 21 patients at the surgery ward were collected by means of context-mapping exercises and semi-structured interviews.[31] The second

30 SoteraWireless, "Visi Mobile," http://www.soterawireless.com; Mariska Weenk et al., "Continuous Monitoring of Vital Signs Using Wearable Devices on the General Ward: Pilot Study," *JMIR MHealth Uhealth* 5, no. 7 (2017): 1–14; Mariska Weenk et al., "Wireless and Continuous Monitoring of Vital Signs in Patients at the General Ward," *Elsevier* 136 (2019): 47–53.

31 Gijs Hesselink et al., "Environmental Needs, Barriers, and Facilitators for Optimal Healing in the Postoperative Process: A Qualitative Study of Patients' Lived Experiences and Perceptions," *HERD: Health Environments Research & Design Journal* 13, no. 3 (2020): 125–39.

Figure 2
Continuous vital sign monitoring device, ViSi Mobile. © Authors.

study, conducted under similar circumstances, collected (value) experiences of 17 volunteers who underwent 24 hours of simulated post-surgical care. Data were collected via context-mapping exercises and semi-structured, value-oriented interviews.[32] Based on these studies, we were able to construct a value framework comprising six values important for patients in their healing environment: autonomy, safety and security, privacy, social comfort, sensory comfort, and spatial comfort. Regarding autonomy, we found that patients greatly value being in control over and understanding their treatment, ambient environment, mobility, and help requests. Safety and security involved feelings of being safe during admission. Participants explained privacy as being related to having sufficient personal space. Social comfort was an important contributor to patients' well-being and was experienced when they had good contact with hospital personnel, relatives, and other patients. Sensory comfort included comfort in light, sound, temperature, and smell. Finally, spatial comfort related to a comfortable environment, including a pleasant view, easy-to-use technology, and positive distractions. Participants of both studies offered multiple recommendations to improve the values. Only safety and security and privacy were already satisfactorily met. This current value framework was used as a reference for understanding the moral mediating effects of continuous vital sign monitoring.

32 Merlijn Smits et al., "Do Simulated Hospital Admissions Reflect Reality? A Qualitative Study of Volunteer Well-Being During a 24-Hour Simulated Hospitalization," *HERD: Health Environments Research & Design Journal*, (2021).

Table 1 | Value Mediation of Patients Wearing the Continuous Vital Sign Monitoring Device, *ViSi Mobile*

Value	Norm	Positive Value Experience (number of patients mentioning this item)
Autonomy: Having insight into and control over own health without interference	Independent from technology	Trusting the technology (2x)
	Insight into own health	Device improves self-understanding (7x) Device confirms feelings by vital signs, even in retrospect (6x)
	Control over own health	Being able to intervene in own health (3x)
	Ability to mobilize	Having more freedom to mobilize (2x)
Safety and Security: Feeling safe in the patient room	Being monitored	Feeling safer due to constant monitoring by others (11x) Feeling safer by being able to monitor yourself (1x) Feeling safer because the doctor will see more of your vitals (1x)
	Fast response time	Feeling safer because nurses can intervene more quickly when something is wrong (7x)
Privacy: Protection of personal data	Personal data is protected	Privacy is not an issue (10x)
Social Comfort: Valuable contact with other people	Valuable contact with nurse	More quality time with nurse (9x)
	Valuable contact with family/relatives	Relatives feel comforted (5x)
Sensory Comfort: Comfortable sensory experiences	Sensory comfort in design	
	Easy-to-use technology	Device is easy to use (1x)
Spatial Comfort: Feeling of comfort in the patient room		
	Clear information provision	
Health: Having your vital signs within range	Expressing own feelings	

Anticipate

We systematically analyzed 17 semi-structured interviews that Weenk et al. had conducted with patients wearing ViSi Mobile.[33] Interview data were categorized into values and norms and then compared to the value framework of patients not wearing such a device to understand moral mediation by the technology. Where the technology held negative mediation, a design recommendation was created. To summarize, the current continuous monitoring

33 Mariska Weenk et al., "Continuous Monitoring of Vital Signs in the General Ward Using Wearable Devices: Randomized Controlled Trial," *Journal of Medical Internet Research* 22, no. 6 (2020): 1–11.

Table 1 | *continued from previous page*

Negative Value Experience (number of patients mentioning this item)	**Design Requirements**
Distrusting the technology (4x) Fear that device does not reliably measure vital signs (3x) Fear of technological failure (2x)	The device should indicate that it is turned on and functioning well. Patients should be well-informed on alternative ways of measuring vital signs, in case of technological failure. The device should never replace the "clinical look" of the nurse.
Fear of seeing own vital signs (6x) Obsessively checking own vital signs (2x	Patients should be well-informed on the meaning of the displayed vitals. The device should not show vitals constantly to prevent patients from checking their vitals obsessively.
Device's alarm generates anxiety (4x)	The device should generate an alarm at the nurse station when a patient's vital signs deteriorate. Patients can decide themselves whether to turn on the alarm in their own room.
Less quality time with nurse (3x)	The time nurses gain from not having to measure vital signs manually should be spent on good contact with patients. The device should not replace nurses but should empower them in their daily job.
Relatives feel insecure (1x)	Relatives should not be able to monitor the vital signs of the patient.
Screen lights up by accident (3x) Beeping alarm is stressful (4x) Device not well connected to the arm (4x) Band aids generate discomfort (8x) Difficult to shower with the device (9x) Device has too many cables (4x) Size of device is not hindering patients (14x), but it could be smaller (4x) Device's design is stigmatizing (1x)	The screen should not light up by accident. Patients should be able to turn off the alarm. The device should be adjustable on the arm. Band aids should be prevented when possible. The device should be waterproof. The device should be smaller. The device should not be stigmatizing.
Device is not easy to use (1x)	The device should be easy-to-use for any type of patient.
Battery does not last long (5x)	The device should have a long-lasting battery.
Some nurses and patients not well-informed on how to use device (2x)	All nurses should be well-informed about the use and functionality of the device. Patients should be well-informed about the use and functionality of the device, and expectations should be managed well.
Device does not register feelings (1x)	The device should provide insight into past healthcare data. The device should register a patient's feelings.

device mediates value frameworks of patients: mediation is found in almost all values, based on how the value is experienced and how it is translated into norms. In response to the technology, definitions of privacy and health seemed to change, making the value of health suddenly more apparent. However, we observed no changes in the relative importance of values or in what values were important for patients. Results are listed in Table 1 and per value explained below illustrated with a quote of a patient.

The continuous vital sign monitoring device affects the autonomy of patients in different ways. Patients wearing such a device defined autonomy in the same way as patients not wearing such a device. Autonomy was subdivided into a set of new norms, including the ability to have insight into and control over their own health, the ability to mobilize, and being independent from technology. Half of the patients experienced improved autonomy in wearing the device, indicating the ability to mobilize, gain better self-understanding by seeing their own vitals, feeling reassured in looking at their vitals, being able to express feelings by relating them to the vital signs, and being in control to call a nurse when vital signs change. *P54: "At night, when I did not feel well, I looked at the device to find reassurance that everything was okay."*

Meanwhile, for the other half of patients, the ability to see personal vitals generated stress and anxiety because they did not understand how to interpret the data and because some patients became obsessed with checking their vitals constantly. In addition, several patients experienced a threat to their autonomy because they did not trust the technology or feared it would fail.

All patients experienced a positive mediation of their experiences of safety and security by the device. They valued the idea of being monitored constantly by the hospital staff, felt safer for being able to monitor themselves, and felt safer for knowing that hospital personnel could intervene faster when something was wrong. *P17: "Then I thought, oh they are monitoring me constantly! That made me feel relaxed, safe."*

Continuous monitoring devices seem to change the definition of privacy. Before, patients defined privacy as their own visual and auditory space. After wearing the device, patients defined it as the protection of personal data. All participants indicated that sharing health-related data could affect privacy, yet none of the participants believed this data collection to be a concern, as long as it would improve their health. *P23: "I don't care at all about healthcare personnel being able to see my vitals. It is actually desired that they can see it!"*

Social comfort—good contact with healthcare personnel and relatives—does not change in definition or norms, but patients' experiences of the value are mediated in different ways. Because the device would reduce the need of nurses to measure vitals manually, the majority of participants liked the idea that this time could be spent on patient–nurse communication. However, a few patients feared seeing nurses less often. In addition, most relatives felt reassured knowing that the patient's vitals were measured constantly. Yet, when relatives could see the vitals of the patients, some indicated that they became anxious about not understanding the data. *P03: "When I was asleep, my daughter saw that the screen lit up. She woke me up asking: 'mum, is everything all right? Is your oxygen level well?'"*

Sensory comfort mostly expressed itself in design recommendations for a better value experience, including recommendations that the screen not light up at night, that patients have the ability to turn off the alarm function and to shower with the device, and that the design be made more attractive to prevent stigmatization. *P62: "When the device was close to my head, the light made me wake up."*

Spatial comfort did not express itself clearly with respect to this technology. Patients briefly mentioned that the technology should be user-friendly, that it should have a longer lasting battery, and that information about its functionality should be provided well. *P23: "It all depends on how the doctor explains it. If I would be anxious."*

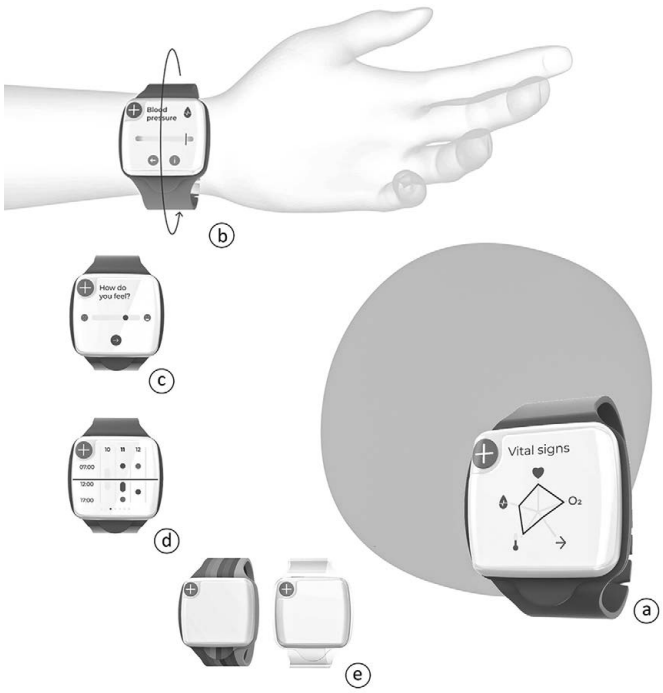
Although health was not mentioned by patients as an important value in the earlier value analysis, its value became apparent with the continuous monitoring device and had a particular definition. Instead of being located in the patient's body, with health understood as feeling well, it became defined as having vital signs within a healthy range. To prevent datafication of health and to illustrate that feelings are important as well, one patient indicated a desire for regular questions about how he felt. *P55: "The devices are not able to register pain. When the nurse does not visit me, I cannot tell her I am having a headache. The device will not register that."*

Several negative moral mediations were observed in patients wearing a continuous monitoring device. In the following section, we address these negative mediations with a redesign. In this redesign, we aim to improve the values of autonomy and of social, sensory, and spatial comfort; patients had negative experiences of norms related to these values. In addition, we aim to redefine the value of health in the new design because patients negatively experienced the current design as focusing only on vital signs and not giving attention to their feelings.

Reconceptualize

We held two participatory design sessions, with volunteers and former patients, respectively—the former with three participants and the latter with four. Our intent was to co-create a new continuous vital sign monitoring device for better value mediation. Participants were first given scenarios representing value mediation by the current device and were asked questions about how to improve its design. Participants then were asked to create a low-fidelity paper mock-up of an ideal interface for a continuous vital sign monitoring device by selecting from elements of pre-designed interfaces that our team made. Together with data from the analysis of the anticipation phase, these sessions served as input for creating a morphological chart that identified design elements for each value that were intended to optimize value mediation. Based on this chart, we then created three concepts and evaluated them. Insights resulted in a final design that reflected all design requirements for optimal mediation of patients' values (see Figure 3).

Figure 3
Values-based design of a continuous vital sign monitoring device. © Authors.



First, we sought to prevent the redefinition of the value of health as having vitals within the normal range; to do so, we recommend including regular questions about patients' feelings and well-being in the device's design, so that nurses receive this information as well (see Figure 3c). This feature allows patients to connect their feelings to the vital signs and to communicate that actions may be needed to address patient's worsening feelings as well.

To improve experiences of autonomy by design, we propose changes to the graphical user interface (GUI). In the adapted GUI, patients are not continuously exposed to their vital signs but instead see an abstract visual confirming that they are still being monitored (see Figure 3a). This visual would improve feelings of safety. To access detailed vital signs and information about how to read them, patients would need to turn the device to the inside of their wrist. The screen then reveals an overview of their current vital sign data (see Figure 3b). Having control over when they see this level of data could help patients to avoid obsessively checking their vitals.

To improve the patient–nurse relation through the design of the continuous monitoring device, we suggest that it serve as a tool for conversations. Because the redesign requires that the device be turned inward to see the vitals (as in Figure 3b), the nurse and patient both attend to the same task, strengthening their relationship. Also, because the device does not show detailed vital sign information by default, relatives cannot easily over-monitor the patient's health (see Figure 3a).

To target spatial comfort through design, we propose an increased engagement and ability for positive distraction. The GUI could offer patients personalized advice about joining activities at the ward, showing plans for the day, and generating advice on physical exercises or stress-relieving breathing exercises (see Figure 3d).

Sensory comfort increases by decreasing the size of the current device, preventing its lighting up by accident, and allowing patients to turn alarms off or on. To reduce stigmatization, we propose an attractive design that can be personalized based on individual preferences—for example, by changing the design of the wristband (see Figure 3e).

Conclusion

In this article, we propose a new design-for-values methodology. Most of the current values-based methodologies do not acknowledge that the technologies designed for values then can affect users' experience of the value frameworks for which they were originally designed. To consider this capacity for influence in the design process, we studied several philosophical theories: mediation theory, technology assessment methodologies, and theory on value change. These philosophical theories were brought together to give shape to the VtM method. This method studies the mediating soft impacts of (a preliminary version of) the technology on actions, perceptions, and morality in an experimental use-case setting. Results are compared to the situation without technology to understand the moral mediation of the technology. Designs can be created or redesigned based on new insights. We tested the method via the case study of redesigning a continuous vital sign monitor for hospitalized patients. This method has led to a new design that better addresses the values of patients.

The VtM methodology benefits values-based design. Still, several questions arise in its implementation. Future research might address these questions to ease the implementation of VtM, as well as of any values-based design methodology. First and foremost, concerning the exploration phase, questions still need to be answered regarding the actors a design team should consider. For example, in continuous monitoring technology, nurses also clearly should closely interact with the device and should influence its design. In addition, apart from actors present during the use of a technology, should actors involved in the hygiene of these devices or its production and recycling be targeted in design as well?

Second, a pressing question arising in the conceptualize phase relates to the translation of values in design. In the past, van de Poel proposed the methodology of values–to norms–to design requirements. This methodology seems to work to improve value experiences by design, but it is difficult to apply in designing for

all other aspects of the value framework—that is, what values are important, and what is the definition of values? For addressing these questions, we have yet to study which design processes can best be followed.

Third, in the mediation analysis, we found mediation of the value framework on only a few levels: mediation of value experiences, of the way values are translated into norms, and the definition of values. Better understanding the ability of technology to affect the different layers of a value framework would facilitate values-based design. Moreover, we found that in the same group of actors, individuals' value mediation differs, and that it even differs for the same individual over different time frames, depending on personal health conditions (i.e., differences in experienced feelings of autonomy resulting from the same design). These insights encourage the exploration of the use of personalized, adaptable technology.

We have introduced a next step in the development of a systematic design framework based on several philosophical theories for assessing and designing positive value mediation. VtM shows the importance of transcending the boundaries of design practice and bringing in philosophy. Better bridging the gap between philosophy and design is needed to make future design more responsible.