User Representations as a Design Resource: Achieving Accountable Design without Access to Users

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Abstract

The study of how the understanding of usages and users is achieved and turned into the characteristics of products comprises 'the sociology of user representation' in Science and Technology Studies. Whilst the early research on the topic was foremost a critique of designers' imposition of their imagination and preferences on prospective users, research has since discovered a richer research landscape by accomplishing the difficult task of anticipating the future contexts and identities of users. Our paper continues this line of work by examining a situation where first-hand access to users was blocked for human-centred design-oriented designers. Constructing an array of complementary user representations helped them to bridge the previously accumulated knowledge on users in their trade to the envisioned technology. The overlaps between the key user segment representations helped the design team to delineate an overall concept whilst the representations of specific usage details aided in the design of product features.

Keywords: User representations, design research, human-centred design

Introduction

Designing the usage of new technologies is notoriously difficult. Approaches for succeeding in it have been proposed one after another ever since the birth of industrial design and customer research early in the 20th century (Marchand, 1998; Hyysalo et al., 2016). After the human-centred design approaches became mainstream in the 1990s, the received view across the design, marketing and product development flanks of academia has been that new innovative technologies require the first-hand involvement or in-depth study of targeted users and their contexts (see, e.g. ISO 9241-210; Preece et al., 2002; Prahalad and Ramaswamy, 2003). The picture is, however, complicated by ethnographic studies of product development, which persistently show that studying users is no guarantee of success; companies may succeed without first-hand studies of users and an explicit study of users almost always turns out be but one source of knowledge in regard to

how usage and user preferences are addressed by designers (see, e.g. Kotro, 2005; Williams et al., 2005; Rohracher, 2005; Wilkie, 2010 Johnson, 2013; Hyysalo et al., 2016; Mäkinen et al., 2019).

The study of how an understanding of usages and users is achieved and turned into the characteristics of products in part comprises 'the sociology of user representation' in Science and Technology Studies (S&TS) (Akrich, 1995; Oudshoorn et al., 2004; Williams et al., 2005; Jensen, 2012; Hyysalo and Johnson, 2015). The sociology of user representation emerged in the 1990s as a corrective programme to the continued stream of problematic products and user interfaces, providing the analytical tools and empirical sensitivity with which to examine how and why an inadequate understanding of users prevailed in companies (Akrich, 1995; Oudshoorn et al., 2004). Theoretically it was part of Actor Network Theory (ANT) development, which sought to address how technology design becomes consequential; user representations lead to designers' 'prescriptions' and 'circumscriptions' for the use of artefacts, which would then meet users' subscriptions or deinscriptions (Akrich, 1992; Akrich and Latour, 1992; Johnson/Latour, 1987).

This early research on user representations had a strong message and ensuing legacy regarding what were termed 'implicit' user representations, particularly 'I-design' or 'ego-design', where designers used themselves as a referent for the future users rather than involving or studying them adequately (Akrich, 1995; Oudshoorn et al., 2004). This is aligned with human-centred and collaborative design in indicating that accountable designs result from 'explicit' representations provided by actual future users through involvement or through informing designers rather than grounding it in the designer's imagination and preferences (Woolgar, 1991; Akrich, 1992; Akrich, 1995; Oudshoorn et al., 2004; Sharrock and Anderson, 1994; Martin et al., 2007; cf. Stewart and Williams, 2005).

Since then research on user representation has been carried out in different strands of S&TS. Whilst many studies have repeated the ANT's I-design and script ideas as they were, the debate began to be shifted because of active ICT consumption in early 2000s (Silverstone et al. 1992; Stewart and Williams, 2005; Mallard, 2005). Social shaping of technology research underscored that users are *always represented* in design practice and that the knowledge of future uses and users remains difficult to anticipate with certainty and without residue even with the involvement of potential future users (e.g., Williams et al., 2005; Rohracher et al., 2005; Hyysalo, 2004; Johnson, 2013). This research suggests that there is more to the sociology of user representation than the assumedly right or wrong values of designers or the accountable and not accountable sources of user insight that are then operationalized (Stewart and Williams, 2005). This also means acknowledging that the S&TS work carried out on user representation carries a somewhat different message than human-centred or participatory design regarding the design of usages – there is simply a richer and more complex empirical reality to be tackled in designing usage than the simple recipes offered by user involvement and user research portray there to be.

This has resulted in a further shift in the lines of the questions to be asked about user representation in S&TS, both by ANT and in the social shaping of technology lines of study. Rather than asking whether user representations are constructed adequately and accountably with future users, the questions to ask address how are they constructed in the first instance and what follows if they are constructed in different ways and within different patterns, not least because the adequacy and accountability also take different forms in different product development contexts (see, e.g. Konrad, 2008; Steen, 2011; Wilkie, 2010; Jensen, 2012; Jensen and Petersen, 2016; Silvast et al., 2018). Another way to phrase this is that there is a move into examining how user representations are used as a design resource (Hyysalo, 2010; Johnson, 2013a, 2013b; Jensen and Petersen, 2016). This line of inquiry has considerable critical potential as well. Developers typically only recognize explicated representations of users, such as using personas (Cooper, 1999) as user representations, whilst research shows that a much larger array of user representation is typically at play and thus merits not only implicit but also explicit attention in design work (Hyysalo, 2004; Johnson, 2007; Wilkie, 2010; Hyysalo and Johnson, 2015).

Our paper continues this line of study by examining a situation where first-hand access to users was blocked from the designers who work in a company that has award-winning competence and a long history in human-centred design. Similarly to Johnson (2007, 2013) and Jensen and Petersen (2016), we do not examine design teams as somehow misguided actors who lack the social science competencies to study the people implicated by their designs. Neither do we see them as actors who would seek to do away with the burden of studying users, let alone try to avoid the constraints which a study of users could impose. On the contrary, the design team we study is formed of a group of skilled professionals who want to investigate prospective users, involve them and test with them but who cannot do so in this project because of strict trade secrecy imposed on their project by the top management. Because of this, they have to rely on information that they and their company already have and construct representations of users on the basis of it. In turn, the condition provides us with an extraordinary setting for examining how user representations are used as a key design resource in bridging stocks of knowledge on the users of previous products to the envisioned characteristics of a new product type. We thus ask: What kind of design resource does the construction of user representations provide for a design team who cannot have first-hand access to users?

The business-critical innovation project we observed throughout its course is particularly suited for such analysis as the designers had no other way to work than building representations of users and testing their ideas and solutions against them. Succeeding as they then did (the product got great reviews in the final testing phase) shows the power that explicit and implicit user representations can have as a design resource in a company that is mature in its human-centred design. We shall next venture into research on user representations more thoroughly, after which we describe the case context and research methods. We then move onto examining the array of user representations that informed the design work, after which we move onto elaborating how the array of user representations helped delineate the design space for the product. We finish with the discussion and conclusions.

User representations as a design resource

The sociology of user representations examines the processes by which actor positions become built-in to the characteristics of technology (Akrich, 1995; Woolgar, 1991) regarding who the users are, how they relate to producers and what they are supposed to do with that particular technology and in which situations and contexts (Akrich, 1992; Akrich and Latour, 1992). It examines how developers 'build bridges' toward eventual users during a technology's design, whether it be via business models, market studies, consumer panels, co-design workshops or even just via using their common sense (Hyysalo and Johnson, 2015). The user representations that result from these bridge-building activities link the multiple modalities of emerging technologies – ranging from visions to requirement specifications – to models and prototypes, to marketing materials and manuals, to pilot assemblies and, eventually, to the uses of concrete people in concrete settings (Hyysalo, 2004).

The most easily graspable user representations are those that directly guide development work and design decisions (Akrich, 1995; Oudshoorn et al., 2004; Hyysalo, 2004; Johnson, 2013). Within such user representations there is considerable variation as to how specific and detailed the representations are. Some are based on clearly delineated user demographics and specific use cases, and are typically found in specific application contexts or as clearly targeted parts of larger systems (Konrad, 2008; Johnson, 2013; Hyysalo and Johnson, 2015). Others are more generic and are typically those of mass-produced consumer goods and large systems. The diversity among users tends to increase beyond what can be meaningfully responded to by means of segmentation, needs analysis or product differentiation (Johnson, 2013). A common developer response has then been to respond by simply implicating no-longer-specific users and the actions that users would perform with the technology (Oudshoorn et al., 2004; Johnson, 2013; Mäkinen et al., 2019).

As noted in the introduction, the original ANT agenda related to research on user representations was premised on showing and making available tools for critical analysis of how devel-

opers chose, or ended up with, poorly considered user representations, judged by the standards of critical social scientists. This is exemplified by notions such as the 'I-methodology', ego-design or 'configuring the user as everybody', and the 'implicit vs explicit sources of user representation' that all underscore designers' misguided or inadequate orientation towards the identities, specificities and contexts of users (Akrich, 1992, 1995: 169; Oudshoorn et al., 2004: 33). Whilst important in showing that the grossly inadequate consideration of the impacted and implicated people certainly continues to happen in development labs, this early orientation has proven to be too simplistic (Stewart and Williams, 2005; Woolgar, 1991; Stewart and Williams, 2005; Konrad, 2008; Steen, 2011; Wilkie, 2010; Johnson, 2007; Jensen and Petersen, 2016; Hyysalo, 2004; Mäkinen et al., 2019; Wilkie and Michael, 2009). Firstly, it neglected the dynamics between different layers of user representation (Mallard, 2012; Hyysalo et al., 2016; Silvast et al., 2018). Some user representations are held more widely than just by a particular design team and may circulate among particular companies or even whole technology fields and be sported in the media to reach a mobilization effect on a range of actors in industry and policy (Konrad, 2008; Wilkie and Michael, 2009; Williams et al., 2005).

Secondly, the sources of user representations cannot be adequately categorized as *explicit* or *implicit*. When literature on the sources of user representation were examined analytically, over 30 different types of sources for main user representation were found, and even clustering them produces eight main areas: user representations in component systems and those encouraged by tools and infrastructures used in development work; the cultural maturation of the artefact and interaction genres; regulatory demands; business models; gathering the explicit requirements; direct user involvement; developers' using their common sense as citizens; and professionals using their experience from their previous work as a source of representing users (Hyysalo and Johnson, 2016). This last distinction is important as it shows that even I-design or using oneself as a reference simply forms too much of a lump category as designers commonly draw representations from both their own personal and professional life but in very different ways (see, e.g. Kotro, 2005).

Thirdly, and most importantly for us here, the early research assumed that recourse to actual user settings could somehow settle the understanding of user needs correctly. But humans are fickle beings whose needs, preferences and contexts continue to change and are not only affected by a particular design but also by the sociotechnical evolution around it as well (Hyysalo, 2003; Mallard, 2005 Jensen, 2012; Jensen and Petersen, 2016; Johnson, 2013). What results from this is that even if users were directly themselves involved in designing, they would be representing, for themselves as well as to others in the design team, their future selves in different future situations that even they themselves would not have an unmediated or direct access to. Users are *necessarily and always represented* in design practice (Williams et al., 2005; Rohracher, 2005; Hyysalo and Johnson, 2016). The sources of user representations are typically manifold, ambiguous and potentially in conflict with each other, indicating that all representations are but resources rather than definitive facts upon which designers can ground their decisions (Hyysalo, 2010; Wilkie, 2010; Jensen, 2012). A telling example is Johnson's (2007, 2013) analysis of on-line game development where the act most strenuously avoided in human-centred design, recourse to designing for the 'average user', was in fact used as a reflexive and democracy-fostering category among developers who were bombarded by requests from several very vocal user subcommunities. The implication here completes a full circle in orientation from the early sociology of user representation: accountable design followed from the representational practice of developers using their own professional experience and not their first-hand contact with users and certainly not the active participation of the most vocal groups of users who are busy lobbying their self-interests.

Our interest in the present study is to further the above line of studies on what kind of design resource user representations provide, particularly to the complementary effects of carefully built arrays of user representations. We can do so qua having had access to an extraordinary situation

where designers are versed in human-centred design but cannot study or involve users first hand.

The research process

The research was carried out at a case company during 2014–2018. For anonymity reasons related to the business-critical project we studied, the company will be called CompanyIM. CompanyIM is an industrial company that manufactures machinery and software, and offers services (such as training and consultation) related to a specific technology, mainly for industrial use. Their products are used more or less worldwide as they export to over 70 countries and they have a turnover of over €110M/year. They employ over 600 people. Having won several design and innovation prizes (including the Red Dot and iF Design awards), CompanyIM has a strong background in design and innovation. They have a high level of maturity in human-centred design. Based on J Earthy's (1998: 10) Human-Centeredness Scale, CompanyIM would be on level C or D of the model, having also implemented parts of level E, the highest level of maturity in human-centeredness.

The qualitative research process was mainly conducted by semi-structured interviews and ethnographic meeting observations. In addition to the interviews conducted across the different parts of the organization, a single innovation project – from here on anonymized as ProjectND – was followed in more detail in order to gain a better understanding of how the development projects function. ProjectND's goal was to develop a new type of device for the company – a battery-operated device whereas their previous devices had been wired. As the top management defined a very high confidentiality level for the project, no external stakeholders could be involved and, thus, user tests and user research with external users were also prohibited.

Our research is comprised of 37 interviews and observations of 33 weekly project meetings related to the design in ProjectND. The interviewees were selected by choosing representatives from different parts of the organization, by interviewing all the main participants of ProjectND and by snowball sampling (Goodman, 1961; Welch, 1975). Some of the main participants of ProjectND, such as the project manager and the industrial designer, were interviewed several times during the project. In addition, the company documentation was inspected. The research data are described further in table 1. All the interviews and meetings were voice recorded and transcribed. In addition, field notes were taken during the interviews and meetings. The transcriptions were coded using Atlas.ti, following open coding in grounded theory (Strauss and Corbin, 1990). After open coding, a case narrative was written and different information sources were analyzed and cross compared. User representation sources and applications were identified from the data and these are further described in the results section.

Table 1. Data types and amounts.

Data type	Amount
Interviews • The main focus is on R&D, and there is also a focus on sales and marketing • Lengths vary from 25 min to 2 h • The interviews were voice recorded and transcribed; field notes were taken	37 interviews 28 interviewees
Observed meetings • Weekly project meetings • Some larger project meetings • Lengths vary from 18 min to 89 min, on average, 38 min • An initial meeting when starting this study • The meetings were voice recorded and transcribed; field notes and some pictures and video were taken	33 meetings
Documentation • Organizational charts • Project documentation templates • User study 'guidelines' • Project documentation (requirements, specifications, concepts)	33 documents involving approx. 250 pages

Table 2. An overview of the sources of user representation in CompanyIM and ProjectND.

Source of representation	Examples in CompanyIM	Examples in ProjectND
User involvement	In-house users, co-creation with customers and partners, site visits	In-house users acting as proxies for prospective users (during product development and the testing phase)
Requirements gathering	General market studies, interviews (internal and external), site visits, care cases, an idea bank	General market studies, there were no official user studies for this project but there had been several for earlier projects
Business concepts	Business case documentation, project portfolio, brand guidelines	Business case documentation, brand guidelines represent usages and users
Regulatory demands	Regulations and standards	Standards coming from the required ingress protection level and the industry, regulations for the battery and electricity, other regulations for the industry
Parallel technologies	Earlier products, competitors, other industrial machines	Earlier products, competitor products, other battery-powered devices and machines, a parallel project that feeds into the user interface for example
Cultural maturation	A long history of products in the industry, earlier products in different categories	A long history of products in the industry, the general development of batteries and battery machines
The designer as a professional	Experience from earlier products and working in other companies in the industry, the apprentice model used to train designers in the company, a mandatory course about work done with the machines produced by CompanyIM	The product is for specific professional contexts and everyday experience provides limited guidance; the industrial designer has worked for a few days as an apprentice learning about the profession; all the employees have used the company's machines at least during a mandatory two-day course
The designer as a citizen	Using one's leisure time experience from other products, services and interfaces as a representation for how products in CompanyIM's line of business could work	The designers draw analogues from other products such as backpacks, carrying cases for tennis rackets, trumpets and biathlon rifles

User representation in the company and the focal project

We will begin by going through the sources of representations at CompanyIM. After this, we move to ProjectND, first listing the different representations constructed in ProjectND and then examining the most important representations in detail. Finally, we take stock of what these user representations, on the whole, helped to do in the development project and how they did that.

Sources of user representations

As is typical of R&D-intensive companies, CompanyIM has many kinds and sources of user representation. To give better clarity to their dimensions, in table 2 we have categorized them according to the taxonomy presented by Hyysalo & Johnson (2015, 2016). Table 2 presents the general sources in CompanyIM and more detailed sources in ProjectND. CompanyIM has a unique resource as they have so-called in-house users. These are professionals who have worked for CompanyIM's customers or in similar environments and, thus, have first-hand experience of the users and usage environments. To use an analogy so as not to give away the anonymity of the case company, if its line of business were piano manufacturing, these internal users would be former professional pianists or piano tuners.

The users for CompanyIM products do not act independently and are typically people working

in teams in different environments. Manifold sources of user representation are thus needed to provide insights into the complex environments and interactions they have with machinery and other people:

> So, a CompanyIM user can be anything from a farm maintenance team, factory maintenance team, a mobile [worker].[1] It can be [from] ship maintenance, ship repair, ship outfitting. It can be from the construction of large marine drilling platforms – so it can be heavy industry, oil-based sectors. It can be a pipe, plate ... (Product manager)

The company-wide and relatively generic user representations have to be rendered as more concrete ones when linked to the particularities of specific products. Here an example of an exchange between the project manager and service team in ProjectND reveals well the mutually defining nature of product features, and user and target group specifications:

> A couple of weeks ago [the project manager] sent a question to the [service team that has in-house users], asking if we had some ideas about what kind of features a battery-powered machine should have. And I answered that of course we'd like to comment, but in order to get to the features, we'd have to think who is the user and what is the usage environment and the target group. (An in-house user speaking in a project meeting)

Yet once such target-group, user and usage-environment questions become more clarified, user representations start to interrelate with the potential design features. Let us consider an example of the portability considerations in a project meeting. In the excerpt below, the considerations move from requirements and usage environments, and potential usage patterns to potential design solutions and then move on to a concretizing representation of a maintenance worker having to climb up a few stairs and a pairing of this with a further, more detailed design solution:

> [Let us] then [move to] the requirements related to the usage of the devices [that are affected by] the usage environments. Well, the[re is] lightness and the ease of transport; all the cables are brought along and can go in one hand. Then, as an alternative, [there is the possibility of] a wearable model. That aroused some comments noting that not many would like to wear it during the work, but I myself thought that [when the designer] showed us those straps, '[It could work] if it were possible to get that [strap solution]'. Think about a maintenance guy needing to climb a few stairs up – he could wear it like a biathlon rifle – put it on like a backpack. (In-house user)

In this meeting transcript we meet one of the key user representations for ProjectND, that of the 'maintenance guy'. Should we just examine the transcript snippet, the represented user having

Table 3. The main user representations to ProjectND.

Representation	Where the representation was deployed
A worker up a mast	In a picture in a brochure, in a marketing video, in nearly every interview
A worker with a van	In discussions
A farmer	In a marketing video, in an in-house users' list
A DIY person	In discussions, in an in-house users' list
A repairer in the wilderness	In a marketing video
A moving worker	In interviews, in discussions
The production industry, small fixes	In discussions, in an in-house users' list
A hefting worker	In an interview
An oil platform maintenance worker	Interviews, discussions
A worker maintaining a sewage pipe	In marketing video considerations
A shipyard worker	In a marketing video, in an in-house users' list
A military user	In an in-house users' list
An offshore ship	In an in-house users' list
A one-person company (doing fixing and maintenance)	In an in-house users' list
Forestry and shovel operators	In an in-house users' list

to climb a few steps of a ladder may appear as an illustration improvised for the benefit of engineering team members. Such an evocation of 'users as scenic features' of a proper design space (Sharrock and Anderson, 1994; Martin et al., 2007) is however not what happens here or in ProjectND more generally. As we see above, the user representations, the features of the usage environment, the target requirements' specifications and the design solutions all work in conjunction. Whilst the design ideas and solutions are not somehow mechanistically derived from user representations (in a manner akin to the early social and behavioural science thrust in regard to how user-centred design should work, visible in, e.g. early ISO standard models), the user representations provide both design anchors and constraints for the possible design ideas. To better understand how this works, we need to be aware that designers seldom operate with just singular user representations but use an array of them to delimit the design space (Hyysalo, 2004; Wilkie, 2010). Table 3 documents the main user representations used in ProjectND and where they are deployed during the development project.

The simple listing of user representations tells us that the portable device is to be used by a variety of target industries in similar types of repair, maintenance and small construction tasks. The separation of the categories indicates that there are some important differences in these environments, tasks, skills and interactions, which all need to be taken into consideration in the ideation and assessment of potential solutions. Some of the representations of target groups add relatively little to the mix while others are well articulated and carry substantial weight in setting the design space, as we see next.

What is being represented in a 'simple' user representation

We will now focus on the five most important user representations and the representation of competitor products and parallel technologies in order to open up what they denote in more detail. The selected user representations have often been used in internal discussions; most of them have been selected as representing key usage areas for target marketing as well. The representations are:

1. A worker up a mast
2. A worker with a van
3. A DIY person
4. An oil platform maintenance worker
5. A farmer
6. Competitor products and parallel technologies

To make sense of them, we analyse the content of each regarding the following aspects suggested by earlier studies on user representations (Akrich, 1995; Preece et al., 2002; Hyysalo, 2004; Oudshoorn et al., 2004; Robertson and Robertson, 2006; Johnson, 2013; Hyysalo et al., 2016):

- Representations of the primary user
- Representations of secondary users and other implied people
- Representations of the immediate context of use
- Representations of the surrounding context of use
- The implied characteristics of the product
- Other representations that define the user or the technology
- Implications for design
- Where the representation originates from

In addition, we will present some examples of the usage of each representation. These examples demonstrate what can be learned from the representation and how they are being applied in design work.

The worker up a mast

The 'worker up a mast' can be considered as the design driver of the new product. The representation comes up in many different discussions, both in meetings and in the interviews, when asking about the main users for the product. In addition, it has been used as the key marketing example as the picture in the product brochure features a man up a mast. An example of its use follows:

> It might be a high place somewhere, like a high mast, where you can't take long cables and someone climbs up there and has to do some [repair work] there. (An engineer)

This image appears to be borne in mind whenever designers think of the different features of the device. This representation ensures that the portable product is truly portable: it is not too heavy and can be carried around easily. It has also affected the durability tests of the product as it needs to survive certain types of handling. This was the most mentioned user representation in different meetings:

> Because there is the fact that you don't [work] there for very long; if you're somewhere at a T-line or up a mast or wherever you are, then the easy transportability is more essential than how long you can operate with it. (From a project meeting)

We can analytically discern several features of this user representation:

Representations of the primary user: This user is a professional, for whom this activity is only one maintenance activity among others. In addition to the repair equipment, the worker up the mast needs special gear for climbing the mast safely. The uniqueness of this represented user is the extreme place, high up a mast, where the repair activities need to be done. This device enables him or her to actually do the work on the mast properly.

Representations of secondary users and other implied people: The worker up the mast is working up on the mast alone and thus cannot have any help from others while doing the repair work (apart from perhaps help provided through an earbud). He or she might have a colleague on the ground and the same device might be used by others as well, but the actual work is done alone.

Representations of the immediate context of use: The represented user has to climb up to an extremely high place to do her or his work. The mast does not have a solid and spacious floor to stand on, thus, the location is rather uncomfortable. As the worker holds on to the mast with one hand, she or he only has the other hand free to do the repair with, in addition to that fact that her or his position is not very stable or ergonomic.

Representations of the surrounding context of use: The circumstances (high up on the mast) can be unpredictable; strong wind and rain can complicate the repair work. The mast might be located in a rural area, so the worker might have to drive along bumpy roads in order to get to the mast and, in addition, carry the device for a while.

The implied characteristics of the product: The user cannot carry many different things with him or her, so the product needs to have everything required, arranged neatly in one compact package. The device has to be able to be easily placed somewhere on the mast and also to be operated with only one hand. This requires very high ease of use and a high enough ingress protection level for the product.

Other representations that define the user or the technology: The length of the represented stay in the high place is not very long as the user only stays up there for the needed length of time to do the repair or maintenance work. Thus, the device needs to operate for long enough so that the needed work can be done. The user does not want to hang around up on the mast and wait for the device to cool down in order to continue her or his work, but neither does she or he want to climb down to recharge the device and then climb back up again. However, the repair work on one mast is often not that lengthy and rather consists of small tasks.

Implications for the designer: This main user representation highlights the importance of portability. When designing for the worker up the mast, the designer has to constantly keep in mind the physical dimensions of the product. In addition to the size and weight of the product, the designer needs to consider the shape of the product. It cannot have any sharp edges that would make carrying it uncomfortable as the device will be hanging against the person's back or side. In addition, the device needs to stay balanced when being hung somewhere. The designer also needs to figure out how all the other needed equipment can be carried together with the actual device. This results in different options for straps and hooks. The user must also be able to use the device while wearing gloves, which affects the user interface design. In addition, taking account of the height of the mast, different

tests need to be conducted to ensure the safety of all the designed elements. Taken together, the designer gets most of the necessary physical features from this representation.

Where does the representation originate from for these product developers? The worker up a mast is based on the company's cumulated knowledge on the different usage situations for its products. They have seen their products in use in numerous different contexts and know that their existing products do not serve this user group well.

The worker with a van

The representation of the worker with a van highlights the importance of robustness: the device needs to survive bumpy roads when thrown into the back of a van. This also added the idea of the possibility of charging the device from the van charger (the cigarette lighter). This affected the testing of the device as its prototype was thrown into a trailer during a serviceman's trip, so the designers had to ensure that it would not break due to being bumped around:

> The idea is that if this is a tool for some serviceman, he or she throws it into the back of the van and goes somewhere and [...] so it must tolerate that kind of usage. (A project manager at a project meeting)

We can analytically discern several features of this user representation:

Representations of the primary user: The user is a repair worker who drives around with his or her van to the needed repair sites but he or she can also be someone that does some constructions in the wilderness. This user's uniqueness is the fact that they drive around to different repair sites in their van and thus the device is often thrown into the back of a van. This device enables doing the repair work without the need for an aggregate device.

Representations of secondary users and other implied people: The user might have a colleague with her or him, so she or he may work alone or in a pair and thus assistance might be available. In addition, the device might be used by others so it is not a personal device.

Representations of the immediate context of use: The person may throw the device into the van and drive around on bumpy roads. The repair work can be done practically anywhere: from inside a building to in a forest or a desert. Therefore, the device must be able to function in changing weather conditions and environments.

Representations of the surrounding context of use: The environments in which this person does the repair work varies from hot to cold and wet to dry. Additionally, the device might be stored in various kinds of places, from in the van to in a hot or cold warehouse.

The implied characteristics of the product: The device needs to survive hits and bumps. It cannot be too large as the user has many other pieces of equipment and machinery in the van as well. All the needed equipment needs to be in one package.

Other representations that define the user or the technology: The device needs to function in wet and dirty environments as well as in extreme cold and heat. The device could be charged from the van cigarette lighter when driving.

Implications for the designer: The main point that the designer needs to take into account when designing for the worker with a van is the robustness. The materials need to be strong enough, and the device cannot have any easily breakable parts, such as knobs. In addition, the designer needs to think how all the needed equipment can be stored together and taken easily from one place to another. Also, testing the durability of the device needs to be well planned.

Where does the representation originate from in the development team? This representation can be observed in different discussions and is based on the project participants' personal contacts and knowledge of the type of work that can be done with their devices.

The DIY person, farmer and oil-rig maintenance worker

We shall discuss three further user representations in a more condensed form, delineating foremost ease of use, durability and safety requirements. The DIY person user representation highlights the importance of ease of use and this is particularly featured in discussions of the user interface type. In addition, it was remarkable for sales and marketing as it presented a new customer type.

This product was the first that was designed to be used in a home environment as the previous products should not be plugged into a normal AC power supply:

> The user groups also include these DIY persons who then use this for their own needs, either for small repair work or for their own building projects or something. (A representative of the sales department)

This then implies different design principles for the user interface:

> So, there're a lot of these farmer and home users and so on. So, in a way for them, they don't necessarily have the understanding of that [the professional user interface and its details]. So, should there be a similar user interface for them, like the ones they are used to using at home, with all the other things that are all digital these days? (From a project meeting)

The farmer representation complements the worker up a mast and the DIY person by designating users who are not professionals in repair activities and who move around over a large area attending to small repairs that need to be done. These can be a broken fence or a farming machine that need repair. This representation brings ease of use and robustness to the development, but it also affects the capacity of the machine:

> So, what type of applications do you need for a maintenance machine? Certainly [X capacity]. But, if you're in an agricultural environment and you've got to repair a large gate or a tractor bucket or something like that, [X capacity is] almost useless in that type of environment. (From a project meeting)

Farmers operate on large areas of land and in an environment that is at times wet, muddy and dirty:

> You [can] imagine just some old guy wearing old boots and arriving with this thing banging around in the back of a truck; next thing … dropping it into a pool of mud in the farmyard when [repairing] a gate. (From a project meeting)

During drier periods, it is hot and dusty, and the surroundings also need to be protected against the heat from the repair work, and thus, a safety blanket to cover the dry surroundings is necessary. When designing for the farmer, the designer underscores ease of use, robustness, ingress protection and air flow inside the device.

The oil platform maintenance worker's representation brings the requirements for fire safety to the product development:

> If you're talking about oil platforms and the roughest [requirements] in that environment, that would then have to be the explosion protection rate. (From a project meeting)

It also raises the issue of water resistance. (Water resistance is also important for, e.g. the repairer in the wilderness, and forestry machinery and shovel operators.)

The users in the oil platform maintenance worker representation might be quite advanced users. They might often do repair activities, as well as other related work. They are unique due to their extreme circumstances as they operate on an oil platform out in the ocean, alone or in teams. The device comes in handy for them as they can easily move around the oil platform with it, which raised the question of how to design for a higher ingress protection level. As mentioned before, the selection of materials affects this but also aspects such as the tightness and fit of all the parts. This is also the only representation that requires an explosion protection classification.

Whilst oil-rig use has been studied and targeted before, DIY users and farming use have not and the representations rest on in-house users' personal knowledge and product managers' discussions with dealers and customers rather than resting on research results.

Competitor products or parallel technologies

As a different type of representation, we chose a competitor product that was already announced when ProjectND started. This affected the product, especially in: the size and weight, the charging system and the operating time of the device. In addition to the competitor product, a product from parallel technologies especially affected the charging options for the device.

The weight issue came up in one project meeting:

> *Marketing director:*
> The whole thing – with cases and everything – the man is carrying is like 12 kilos or something like that? Isn't that quite heavy?
> *Engineer:*
> […] No, it's not …
> *Project manager:*
> Yeah, [the competitor product], the power source itself weighs 11 kilos without—
> *Product manager:*
> The legal limit is 20 …

In another project meeting, the engineers and designers discussed the charging options for the device:

> *Engineer:*
> Yes, should we get the [competitor] machine and take it apart and see what it has [inside]?
> *Project manager:*
> So, they have done – at least, judging by what I looked at on their website – they have demoed it on their webpage and there is– there's a coil in the charging station and a corresponding coil there – there inside the battery. Or in the battery package […]

The competitor device provided certain concrete benchmarks that needed to be exceeded. The main criteria were the duty cycle and charging time. The very technical details have a great effect on the user experience and, therefore, the new device had to exceed or at least match these targets. In addition to these, the weight of the competitor device in particular was set as a limit for the new device. Together these very specific details provided a frame for the physical dimensions of the product.

In sum, the most important representations provided a quite specified image of the users, their backgrounds and usage environments. A number of features and traits could be derived from these representations. In addition to the represented users, the competitor and parallel technologies provided more detailed targets and solutions for the technical specifications. These were actively referred to in the discussions and in project meetings during the development phase, and thus they affected the designs heavily. Yet, as hinted above, it is their combination that reveals how they help the design team to gain direction and focus, and this is where we now turn to in the final analytical section.

What the combination of user representations provides for designers

To delve deeper into the question of how these representations guide the design process, let us depart from the worker-up-the-mast representation which guides the design towards a small and compact device that is easy and comfortable to carry. If the device can be carried up a mast, it can be carried nearly anywhere else as well. The user also needs to be able to operate the device with only one hand while wearing gloves and hanging from the mast. This is a restrictive user representation that cuts off many design avenues and renders many potential target markets secondary.

However, the worker-up-the-mast representation is not very binding from the handling, duty cycle or battery capacity points of view. These aspects are addressed most strictly by the worker-with-a-van representation. It indicates that the device needs to be robust in order to survive the bumpy roads while in the back of the van or pick-up truck, potentially without having been tied down. In addition, it highlights the need to charge the device from the power source available in the van or truck and the need to have a carrying case so that all the additional equipment stays with the device and is potentially given some added protection.

In turn, the oil platform maintenance worker and farmer impose a high ingress protection level that makes the device survive moist and rapidly changing weather conditions. The oil rig also requires an explosion protection classification. The farmer representation adds dusty and muddy environments and adds the importance of ease of use for users not professionally trained in using the device. The DIY person representation underscores this and adds to the requirement for the device to be as maintenance free as possible, as well as pointing to potential new distribution channels.

Furthermore, input from the parallel technologies and competitor devices adds some of the technical specifications, such as the duty cycle, battery capacity, charging time and the charging method. In addition to all these, the company's product portfolio and brand image also guide the design as they provide guidelines in regard to colours and other brand elements. Figure 1 summarizes how the main user representations relate to key product features. As noted above, the interrelation is not mechanistic, but features from competitor products and previous products affected how ProjectND was positioned and hence what could be its target market segments. However, the user representations concretize the features and how to design for them.

Even more important, however, is how the user representations, taken together, delineate the design space, and in doing so, how they can guide design work. Figure 2 elaborates (in the leftmost pane) how the key user representations overlap and broadly map the target user segments. Considering further representations and requirements (in the centre pane) – such as competitor products, parallel technologies, cultural maturity and regulatory demands – intensifies the potential represented use space and design space for ProjectND. As the product cannot accommodate all features, usages and users, the array of representations helps designers to exclude aspects of the product that are secondary for the users or for ProjectND, or those that are already the strongholds of earlier or competing products (the grey areas in the figure represent the excluded aspects).

This array of key- and supporting-user representations thus delineates the design space where the product needs to operate and also renders more explicit the aspects and selling points the design targets in different target markets. Having been constructed on the basis of the company's and its designers' long experience in this industry and the accumulated stock of user studies and tests, the array of user representations further helps to explicate which target users, user environments, usage patterns and secondary users are most relevant for the design. In so doing, it renders more manageable the potentially daunting variety and complexity which this globally sold device could face and explicates design constraints, as well as clarifies the conditions against which testing of the product is to take place.

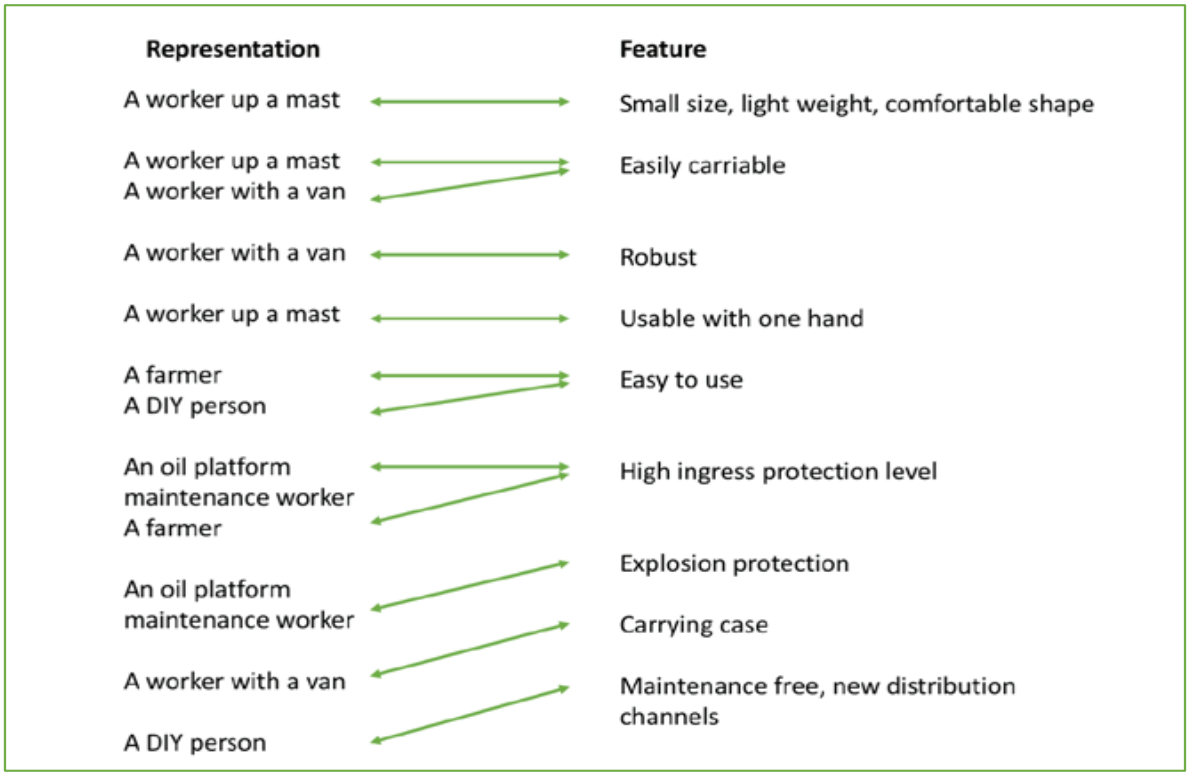

Figure 1. Interrelations between key user representations and product features.

Figure 2. Complementary user representations explicate the space for the product and its usages, help order the various demands of the product and close off potential but secondary characteristics and usages (simplified image).

The delineation of the design space does not, however, result in some miraculously unambiguous specifications for the device. Figure 2's rightmost pane draws attention to how the needs of the key represented user groups are not met in full but rather the product is targeted to work sufficiently for each group, whilst each group elaborates the most demanding aspects for a feature of the device. This allows user representations to act as checks and balances to each other in design considerations, as they do in the below example about the user interface controls and display:

> *In-house user:*
> If we think how the factory service man would use the machine, he would take the [size 1 tool]. He has the [tool package] with him. […] He knows from before what the right setting is for that [tooling], so he simply sets the power to that. If it doesn't work, he adds more.
> *Marketing director:*
> But hey, what you have there is service men and other semi-professionals that are only one target group to whom these would be sold. There are the farmer and home users and so on. And they do not have that understanding you describe. So, would they need a similar user interface to that which they are used to at home? Where all things are digital nowadays?
> *Engineer:*
> No, I would say that for them the display is even less [desirable]. That–
> *Marketing director:*
> Or only one knob? One knob at this end.
> *Engineer:*
> –just like those on coffee makers and toasters, which people are used to. You turn a knob that has numbers. And I think it seems more reliable; it creates more confidence.

Towards the end of this excerpt we see another key pattern that takes place in design discussions in ProjectND time and again, namely, how the eventual user representations blend with specific usage representations when it comes to solution ideas. Here the usage representations are from the operating conventions of devices present in the context of use, in this case, the factory and home. This is a source of user representation that has been previously aptly described as *artefact genres* within the broader category of cultural maturation (Williams et al., 2005; Johnson, 2013; Löwgren and Stolterman, 2004; Hyysalo et al., 2016). The implicated usages and contexts of use in key user representations (see and Figure 2) in a sense feed forward the search for specific representations that could provide eventual design solutions. Here the differences between usage patterns by professionals and by amateurs, and correspondingly the artefact genres suited for approximating what kind the suited design solution might eventually be were anchored by the explicated user representations – the marketing director here using one of the key user representations to prevent the in-house user from proceeding from only profes-

sional or semi-professional usage pattern point of view.

Neither does the arraying of user representations remove difficulties in managing the difficult trade-off decisions as they guidepost the path the design should take. The potentially most difficult trade-off regarding ProjectND concerned the duty cycle, so let us examine how user representations featured in decisions regarding it. Let us first rewind to a project kick-off meeting:

Designer:
I find it most important to find the right question to answer. That is, what the worker needs if we are designing a battery powered device … batteries make mobile [work] activity possible. Then, if we bring a car-size battery machine, it is not very portable anymore.
Engineer:
Yes, we need to keep that clearly in mind. What our competitor has forgotten is that mobility is exactly what batteries provide … and they have done a [heavy] battery machine but not at all used the greatest strengths it could have.

And then we fast forward to situation much later when the duty cycle limitations and product heating limitations begin to become revealed to the design team:

Product manager:
But [this product design] is so unusual in terms of [this line of] product that it makes it extremely interesting: what it is and why it's like that. But, many think: 'OK, [size 1 tooling]'s not too bad in terms of battery capacity'. But then the duty cycle is cripplingly low.
Designer:
What it should be? If we think of the markets, what kind of work [do the users need to do]?
Product manager:
I see this being used. It's very much a maintenance machine. That's what it's going to be used for. So, what type of applications do you need for a maintenance machine? Certainly [size 2 tooling] would be used. But, if you're in an agricultural environment and you've got to repair a large gate or a tractor bucket or something like that, [size 2 tooling] is almost useless in that type of environment. So, if you want to do some hard servicing or you want to do a repair [...] then, for example, the other day, up at the golf range, no balls came out of the machine because the tractor was broken down. The bit of the machine that picks the balls up from the golf range […] had broken. Typically, this is the type of machine that you'd have […]. And probably, in that situation, [size 1] capacity would probably get you out of trouble.
Designer:
With one or two [tooling sets deployed]?
Product manager:
With one. And then you haven't got to have a power generator: you haven't got to have ... You [just] take this [machine] anywhere with you, and bingo! There is your solution. But I'm thinking that in an agricultural environment, the capacity is a little bit on the light side. And I see the ...
Designer:
And you always have a water bucket [to cool the device].
Product manager:
But then you always have … But you just need to make sure it's close by. But then you maybe have the capacity, if you have the capacity for one [size 2 tooling].
Engineer:
Sounds a little …
Product manager 2:
Also, there are some applications in the industry for example where you need to [work similarly]. Let's say you are installing some water pipeline, and there're some supports.
Product manager:
Ventilation.
Product manager 2:
Whatever ...
Product manager:
Hanging brackets.
…
Designer:
One session, one … attachment or whatever. And (when) they move and move all the stuff and go ...
Engineer:
This [duty cycle] is enough.

Here we see how the demand for portability, underscored by the key user representations, eventually trumps over the received wisdom in

the industry regarding what is a plausible duty cycle for a device and leads to relabelling ProjectND as designing a 'maintenance machine' that only needs a fraction of the capacity of a machine that could be used in 'production' of any kind. This characterization of the product is then considered against the implications arising to it from two central user representations: farmer, DIY person and industrial maintenance person (implied by man in the mast). This decision is one of the most differentiating decisions taken by the design team in contrast to competitor solutions, and in this example we see how well-articulated user representations can occasionally go as far as to settle a key design decision.

Noting this, we want to underscore that many tensions and uncertainties about design remain regardless of how well articulated user representations may be – their capacity should perhaps be best seen as one of guideposting issues of the desirability and customer value amidst for instances technical and business considerations.

Discussion and conclusions

In the course of this article we have analysed a case where none of the project's user representations were derived from a first-hand user study or user collaboration designated for this new-to-the-world device. Instead, the user representations originated from and were refined on the basis of accumulated information in the company and on the basis of the experience of in-house users and designers. The user representations could not be tested with prospective external users prior to market launch either. The designers were thus left to deal with the designing of usage only by indirect means, and they constructed a small array of user representations to help them do so. This allows us to make two sets of inferences about what user representations provide for designers that are at once anchored in the case project and also have wider implications to designing usage more generally.

Firstly, it may initially seem that the trade secrecy in the ProjectND resulted from a kind of representational practice that was targeted at the early critique of user representation that replaces real users with developers' imagination of them (see, e.g. Akrich, 1992, 1995; Oudshoorn et al., 2004). Yet, what these user representations did in the design process was exactly what the early critique hoped technology developers would do, that is, it systematically countered casting the user as 'everybody' or conjuring the images of users from designers' poorly scrutinized imaginations (Akrich, 1992; Oudshoorn et al., 2004). ProjectND's array of user representations was developed on the basis of a wealth of earlier direct engagements with users and it was used by designers in order to focus and justify a finite set of the target groups, their work practices and the usages to which they would put the device, leading to designing a novel 'repair' machine rather than a 'production' machine. We are thus inclined to join Johnson (2007) and Mäkinen et al. (2019) who insisted that it is not user research or user collaboration in design that renders design work accountable but the nature of representational practice regarding the prospective users and usages. As was the case with the company studied by Johnson (2007, 2013), the user representations in ProjectND and CompanyIM were the result of many years of studying users and communicating with the users and customers. Indeed, there appears to be a practical application for human-centred design visible in the analysis: pursuing user representation carefully can be seen as an effective *alternative* strategy to first-hand study and engagement with users in cases in which there are sufficient organizational and professional starting points to build deeply considered representations of prospective users. The real difference is thus based on the grounding and carefulness of the knowledge that goes into building user representations and the carefulness with which this is done, not on whether or not there has been direct contact with users.

This leads to our second point, which is what user representations can do in design depends on the effort that has gone into constructing them. It was the designers' capacity to compile and arrange the accumulated user information that allowed them to produce in-depth notions of the users and their usage environments. Our study supports the now many studies that show that most present-day companies are not lacking information on users – as was implied in the early sociology of user representation – but operate with many user

representations derived from several formal and informal directions (for similar findings on the multiplicity of user representations, see Kotro, 2005; Williams et al., 2005; Wilkie, 2010; Johnson, 2007, 2013; Mozaffar, 2016; Benker, 2019). The array of user representations in ProjectND helped them to keep the differences and similarities of prospective users at the forefront in the project's discussions and to directly affect several requirements for the product's technical specifications and features. User representations were also contrasted with other design representations (of competitors, of parallel technologies, of viability and of markets) in the development of technical solutions and in the specification of the device's requirements. In this capacity, user representations act as safeguards against falling short of user needs and desires because of technical conveniences or economic prospects (Hyysalo, 2010).

To conclude, product development can be done without contact to prospective users and can be based on user representations and still retain the accountability associated with human-centred design. However, this requires careful anchoring of the user representations to the previously cumulated information on users and usages and their reflexive use as a guiding design resource. The sociology of user representation continues to be a vital and practically relevant strand of study in the intersecting areas between S&TS, design research, human–computer interaction and information systems and one that continues to provide relevant new insights despite what is soon 30 years of work in the area. The actual sources of user knowledge and particularly the variety of accountable representational practice are wider than could be anticipated in earlier academic literature. There remains ample room for further research on detailed studies of the practices of user representation as well as attempts to grasp the overall contours of how users are represented in different development contexts. Particularly interesting would be studies that would examine in-detail the situations where trade-offs or other mutually exclusive design choices are made between valid but mutually conflicting user representations.

References

Akrich M (1992) The description of technological objects. In: Bijker WE and Law J (eds) *Shaping Technology – Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press, pp. 205–224.

Akrich M (1995) User representations: Practices, methods and sociology. In: Rip A, Misa TJ and Schot J (eds*) Managing technology in society*. London: Cassel Publishers Ltd, pp. 167–184.

Akrich M and Latour B (1992) A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies. In: Bijker WE and Law J (eds) *Shaping Technology – Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press, pp. 259–265.

Benker A (2019) *Embrace Thy Users: Practices of User Knowledge Utilization in Innovation*. Espoo: Aalto University.

Cooper A (1999) *The Inmates Are Running the Asylum*. Indianapolis, IN: Sams.

Earthy J (1998) Usability maturity model: Human centredness scale. *INUSE Project Deliverable D* 5: 1–34.

Goodman LA (1961) Snowball sampling. *Annals of Mathematical Statistics* 32(1): 148–170.

Hyysalo S (2004) *Uses of Innovation. Wristcare in the Practices of Engineers and Elderly.* Helsinki: Helsinki University Press.

Hyysalo S (2010) *Health Technology Development and Use: From Practice Bound Imagination to Evolving Impacts*. New York, NY: Routledge.

Hyysalo S, Jensen TE and Oudshoorn N (2016) *The New Production of Users: Changing Innovation Collectives and Involvement Strategies*. London: Routledge.

Hyysalo S and Johnson M (2015) The User as Relational Entity: Options That Deeper Insight into User Representations Opens for Human-Centered Design. *Information Technology & People* 28(1): 72–89.

Hyysalo S and Johnson M (2016) User Representation: A Journey Towards Conceptual Maturation. In: Hyysalo S, Jensen TE and Oudshoorn N (eds) *The New Production of Users: Changing Innovation Collectives and Involvement Strategies*. New York: Routledge, pp. 75-100.

ISO 9241- 210 (2010) *Human-Centred Design for Interactive Systems.* Geneva, Switzerland: International Organization for Standardization.

ISO/TR 16982 (2002) *Usability Methods Supporting Human-Centred Design*. Geneva, Switzerland: International Organization for Standardization.

Jensen TE (2012) Intervention by invitation: New concerns and new versions of the user in STS. *Science & Technology Studies* 25(1): 13–36.

Jensen TE and Petersen MK (2016) Straddling, betting and passing: The configuration of user involvement in cross-sectorial innovation projects. In: Hyysalo S, Jensen TE and Ourshoorn N (eds) *The New Production of Users: Changing Innovation Collectives and Involvement Strategies*. New York: Routledge, pp. 136–159.

Johnson J/Latour B (1988) Mixing Humans with Non-Humans: The Sociology of a Door-Closer. *Social Problems* 35(3): 298–310.

Johnson M (2007) Unscrambling the 'average user' of Habbo Hotel. *Human Technology* 3(2): 127–153.

Johnson M (2013) *How social media changes user-centred design-cumulative and strategic user involvement with respect to developer–user social distance.* Academic dissertation, Aalto University, Department of Computer Science and Engineering.

Konrad K (2008) Dynamics of type-based scenarios of use: opening processes in early phases of interactive television and electronic marketplaces. *Science Studies* 21(2): 3–26.

Kotro T (2005) *Hobbyist Knowing in Product Development – Desirable Objects and Passion for Sports in Suunto Corporation.* Academic dissertation, National Consumer Research Center, Helsinki, and University of Art and Design Helsinki.

Löwgren J, Stolterman E (2004) *Thoughtful Interaction Design: A Design Perspective on Information Technology*. Cambridge, MA: MIT Press.

Mäkinen S, Hyysalo S and Johnson M (2019) Ecologies of User Knowledge: Linking User Insight in Organisations to Specific Projects." *Technology Analysis & Strategic Management* 31(3): 340-355. https://doi.org/10.1080/09537325.2018.1502874.

Mallard A (2005) Following the Emergence of Unpredictable Uses? New Stakes and Tasks for a Social Scientific Understanding of ICT Uses. In: Haddon L, Mante E, Sapio B, Kommonen KH, Fortunati L and Kant A (eds) *Everyday Innovators. Computer Supported Cooperative Work*, vol 32. Springer, Dordrecht, pp. 39-53.

Mallard A (2012) Developing Uses, Qualifying Goods: On the Construction of Market Exchange for Internet Access Services. *Consumption Markets & Culture* 15(2): 191–211.

Marchand R (1998) Customer research as public relations: General Motors in the 1930s. In: Strasser S, McGovern C and Judt M (eds) *Getting and Spending: European and American Consumer Societies in the Twentieth Century*. Cambridge, UK: Cambridge University Press, pp. 85–110.

Martin D, Rooksby J and Rouncefield M (2007) users as contextual features of software product development and testing. In: *Proceedings of the 2007 international ACM conference on supporting group work (GROUP'07),* November 4–7, 2007, Sanibel Island, FL, USA. Association for Computing Machinery, New York, NY, USA, pp. 301–310.

Mozaffar H (2016) User communities as multifunctional spaces: Innovation, colective voice, demand articulation, peer informing and professional identity (and more). In: Hyysalo S, Jensen TE and Oudshoorn N (eds) *The New Production of Users: Changing Innovation Collectives and Involvement Strategies*. New York: Routledge, pp. 219–248.

Oudshoorn N, Rommes E and Stienstra M (2004) Configuring the user as everybody: Gender and design in information and communication technologies. *Science, Technology & Human Values* 29(1): 30–63.

Prahalad CK and Ramaswamy V (2004) *The Future of Competition: Co-Creating Unique Value with Customers*. Boston: Harvard Business School Press.

Preece J, Rogers Y and Sharp H (2002) *Interaction Design – Beyond Human Computer Interaction*. Hoboken, NJ: John Wiley & Sons.

Robertson S and Robertson J (2006) *Mastering the Requirements Process,* Second Edition. London, UK: Addison-Wesley.

Rohracher H (2005) *User Involvement in Innovation Processes. Strategies and Limitations from a Socio-Technical Perspective*. München und Wien: Profil Verlag.

Sharrock W and Anderson B (1994) The user as a scenic feature of design space. *Design Studies* 15(1): 5–18.

Silvast A, Williams R, Hyysalo S, Rommetveit K and Raab C (2018) Who 'Uses' Smart Grids? The Evolving Nature of User Representations in Layered Infrastructures. *Sustainability 10* (10), 3738.

Silverstone R, Hirsch E and Morley D (1992) Information and Communication Technologies and the Moral Economy of the Household. In: Silverstone R and Hirsch E (eds) *Consuming Technologies: Media and Information in Domestic Spaces*. London: Routledge, pp. 115–31.

Steen M (2011) Tensions in human-centred design. *CoDesign* 7(1): 45–60.

Stewart J and Williams R (2005) The wrong trousers? Beyond the design fallacy: Social learning and the user. In: Rohracher H (ed) *User Involvement in Innovation Processes: Strategies and Limitations from a Socio-Technical Perspective*. München undWien: Profil Verlag, pp. 195-221.

Strauss A and Corbin J (1990) *Basics of Qualitative Research*. London: Sage.

Welch S (1975) Sampling by referral in a dispersed population. *Public Opinion Quarterly*, 39(2): 237–245.

Wilkie A (2010) *User Assemblages in Design: An Ethnographic Study.* Academic dissertation, Goldsmiths, University of London.

Wilkie A and Michael M (2009) Expectation and mobilisation: Enacting future users. *Science, Technology, & Human Values* 34(4): 502–522.

Williams R, Slack R and Stewart J (2005) *Social Learning in Technological Innovation – Experimenting with Information and Communication Technologies*. Cheltenham: Edgar Elgar Publishing.

Woolgar S (1991) Configuring the user: The case of usability trials. In: Law J (ed) *A Sociology of Monsters: Essays on Power, Technology, and Domination*. London: Routledge, pp. 58–99.

Notes

1 The original data is in Finnish, a Fenno-Ugric language. It does not translate into English anywhere near as neatly as an Indo-European language (particularly in its spoken form), the translations of which readers may be accustomed to, based on having read translations from other Indo-European languages into English. We have sought to foremost retain meaning in the translation but also seek to retain the form of expression whenever we can, yet this results in a some 'imperfect English' that does not pretend to be transliterated to English and has to be accompanied with somewhat more clarificatory detail, provided in square brackets, when compared to translations of Indo-European languages into English.