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What a designer can change: a proposal for a categorisation of artefact-related aspects

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Abstract: This paper proposes a categorisation of artefact-related aspects that in different ways set people's preconditions for acting with technology. The categorisation can serve as a starting point for discussing which aspects are relevant to consider from a Design for Sustainable Behaviour perspective. The categorisation sorts these aspects into different layers: from the over-arching layer of enabled activity, through artefact type(s), operative functions, interactive functions, and finally communicative functions. Using examples from research studies, and a selection of theory and methods, we argue for an increased focus on all artefact-related aspects. Moreover, it is essential to move between layers to ensure a consistent design that in every layer provides preconditions for sustainable behaviour. The paper also discusses benefits of redesigning the artefacts people use in their everyday activities, instead of designing artefacts that stimulate new types of conservation activities.

Keywords: Design for Sustainable Behaviour; Behaviour change; Interaction Design; Design for Sustainability

1. Introduction

Design for Sustainable Behaviour (DfSB) has emerged as an important field of research and practice. DfSB addresses sustainability challenges related to people's use of products, services, and systems (Bhamra and Lilley 2015). In DfSB, design is used to encourage and enable new ways of doing and interacting with the world that in turn contribute to a sustainable society (Clune 2010; Lilley 2007; Lockton, Harrison and Stanton 2008). The number of articles and research projects exploring DfSB has exploded and now includes new topics and addresses gaps in the current state (Bhamra and Lilley 2015). In a review of 70 DfSB papers published between 2002 and 2014, Coskun and colleagues (2015) identified a number of common topics: choice and effectiveness of behaviour change strategies,

development of tools for idea generation, the contribution of different theoretical directions from other fields to the DfSB field. Based on their review, they recommend future studies to identify areas where better design can have significant impact, as well as which behaviour change strategies that have the most profound and lasting impact on people's behaviour. We believe that to follow these recommendations, DfSB research first needs to focus on the artefacts. We reason that it is not possible to assess the effectiveness or impact of strategies without basing the discussion on an artefact, its intended use, and how specific strategies have been implemented in the design of the artefact. Therefore, we suggest moving away from the appropriated tradition of designing interventions to trigger certain behaviour changes, towards designing everyday products that mediate sustainable activities. It is vital to remember that one cannot design behaviour, one can only influence people's preconditions for acting with technology by (re-)designing artefacts; designing for behaviour.

When designing such everyday products, it is necessary to consider several aspects, as different aspects influence preconditions for interaction in different ways. For instance, the introduction of a gearshift indicator on the dashboard of a car sets different preconditions for mobility compared to the introduction of a car-sharing service. Similarly, the preconditions for less water-intensive body washing can be provided in different ways: a new concept like Splashing presents a new alternative to showering (Kuijer 2014), a technical concept with closed water cycles enables savings without behaviour change (Orbital Systems 2015), and different feedback functions in the shower enable water use tracking, such as the Shower Calender (Laschke, et al 2011), or disappearing pattern tiles (Backlund, et al 2006). To address the different aspects that set preconditions it is relevant to first question what purpose a particular artefact may serve. Next, designers should consider the artefact's functionality and how it is to be designed, covering everything from main technical principle to details in the form.

A system perspective on people's interaction with artefacts would help designers to both question the purpose of a particular artefact and consider all aspects. For instance, a systematic overview of artefact-related aspects would be valuable in the DfSB design process. Such an overview should provide a breakdown of the full range of artefact-related aspects that influence people's preconditions to reduce their resource consumption in distinctly different ways. As the aspects together form one whole – the artefact – it is also valuable to clarify the interconnection between the different aspects as the parts all have interdependent effects on the whole (cf. Ackoff 1981). Finally, to be practically applicable, the overview should be simple yet theoretically sound (cf. Bødker and Klokmose 2011). To start a discussion about which aspects that are relevant to consider from a DfSB perspective, this paper proposes a tentative categorisation of artefact-related aspects. The objective of the categorisation is to describe in what ways a designer can influence people's preconditions for acting with technology.

The paper will first discuss current classifications for describing artefacts and then introduce the new categorisation. Subsequently, we will relate the categorisation to theories,

methods, and tools used in design processes. The paper concludes by discussing the value of the proposed categorisation for the DfSB community.

2. Proposed categorisation of artefact-related aspects

A search for an overview of design related aspects affecting people's preconditions for acting with technology was conducted. The search uncovered a range of different system models and functional classifications of artefacts. Models and classifications were selected for further review, see Figure 1, based on whether or not they contained a system description of artefacts, included a hierarchical structure, and to some degree included the users in the system.

While the existing classifications were found to be useful for their respective purposes, they fail to meet all the demands set up in the introduction; a model that is simple yet theoretical sound, provides a breakdown of the full range of artefact-related aspects, as well as clarifies the interconnection between the different aspects. Primarily, neither of the surveyed classifications covers the full range of artefact-related aspects. Some contain the detailing necessary in the lower layers, such as Warell (2001) and Muller (2001), whereas others cover the top layers, including Roozenburg and Eekels (1995) and Brezet and colleagues (2001). Additionally, several classifications focus solely on form aspects – only a few, Bødker and Klokmose (2011) and Hekkert and van Dijk (2011), focus on use or interaction, which is central to DfSB.

Since none of the existing classifications met the demands, a new categorisation was developed with appropriate detailing on all relevant layers and with focus on use and interaction. The limit for the lower levels was chosen to equal the most detailed of the reviewed classifications, that is the levels proposed by Muller (2001) and Warell (2001). The limit upwards in the hierarchy was set, not only to include the complete artefact, but also to include the main reason for the artefact's existence, i.e. the need it should help fulfil. Unless the purpose of the artefact is clarified, it is impossible to appropriately decide on its form or functions. In the development of the new categorisation, the range of reviewed classifications served as inspiration for organising and structuring relevant concepts. Some concepts, such as Warell's interactive and communicative functions and Muller's practical functions, were adopted into the proposed classifications, while others were adapted into new categories to cover the wider range of aspects necessary to be useful to DfSB, see Figure 1.

The proposed categorisation presents artefact-related aspects that set preconditions for acting with technology, according to the structure depicted in Figure 2. We imagine the aspects as different layers of influence in the design of the artefact. The layers of design are in order of increasing detail: *enabled activity, artefact type(s), operative functions, interactive functions,* and *communicative functions*. An expanded explanation of the layers follows.

Overview of system models and functional classifications of artefacts
– in relation to layers of the proposed categorisation

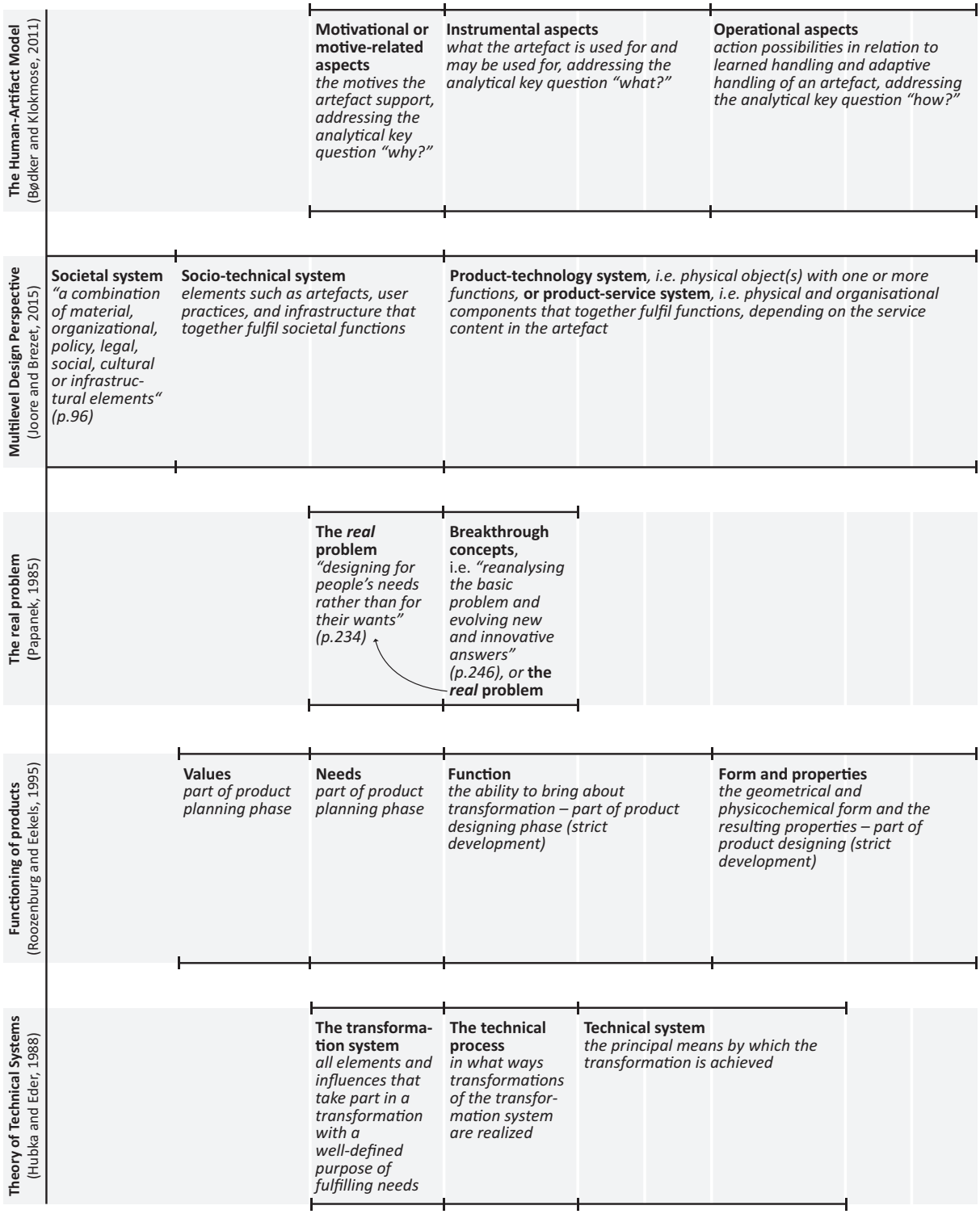

Figure 1 Reviewed system models and functional classifications compared to each other and to the proposed categorisation. Note: approximations of layer boundaries and overlaps have been made based on the intended use of the proposed categorisation.

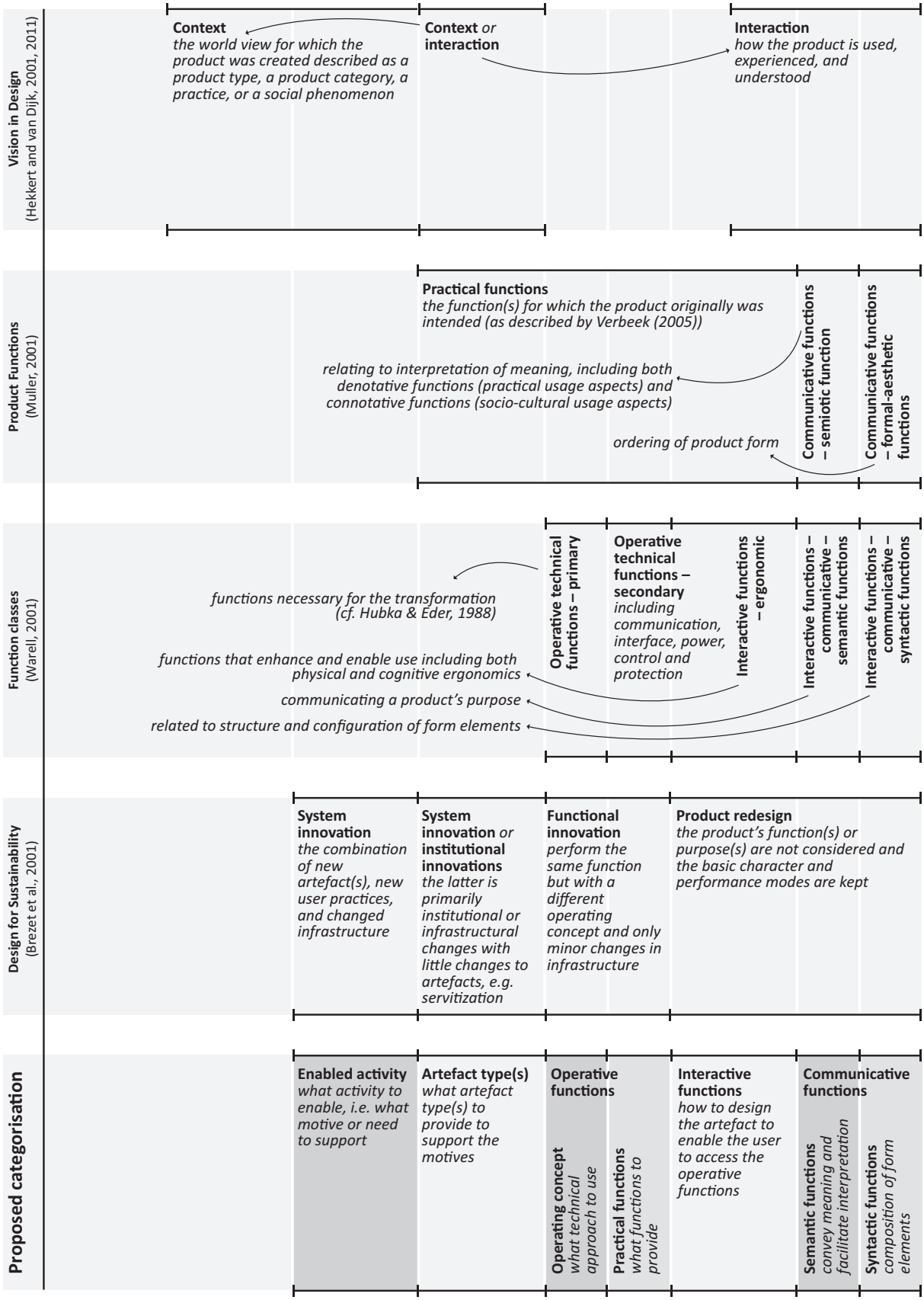

Figure 1 continued.

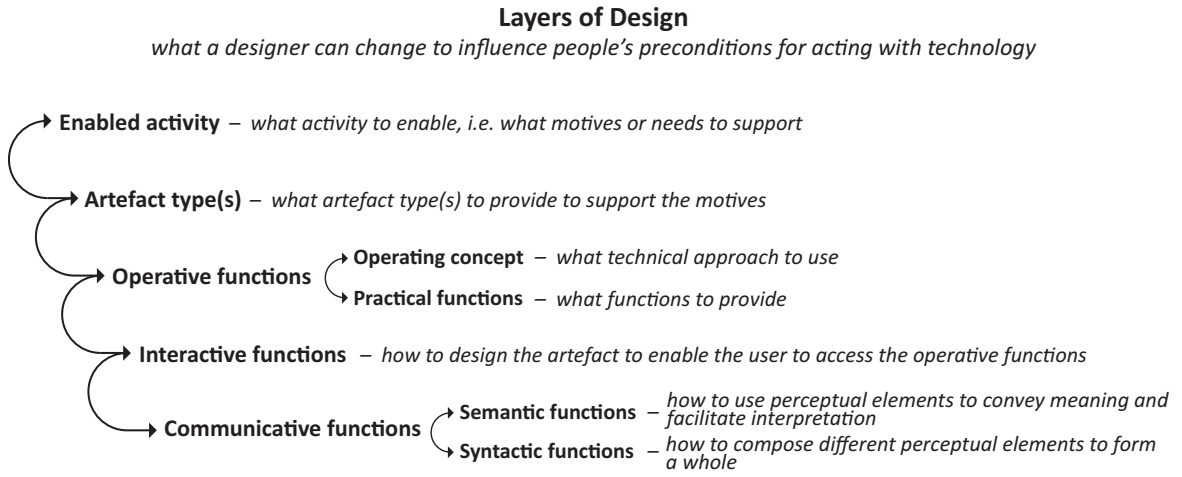

Figure 2 The proposed categorisation of different artefact-related aspects that affect people's preconditions for acting with technology.

2.1 Enabled activity

As mentioned, the top layer of the categorisation concerns the key question of why the artefact is designed in the first place (cf. Bødker and Klokmose 2011), that is, which motives or needs that the artefact should support. In the illustrated example in Figure 3, which exemplifies the layers using the example of a freight bicycle, the enabled activity – transporting oneself between places – addresses the need for mobility. Design decisions at this layer steer which activities people can perform with the artefact. Depending on which artefacts are made available in society, preconditions are set for which activities that are possible to engage in. Moreover it determines whether there are one or more artefacts available that allow people to accomplish their goals. To address this layer, a designer could ask: "which needs are relevant to address?" and "which activity should be enabled?".

2.2 Artefact type(s)

The second layer addresses the key question of what type of artefact to design. In the illustrated example, the artefact type is a freight bicycle but the activity could equally have been enabled by a car or an innovative mobility-as-a-service. The layer concerns making types of artefacts available that enable different ways of performing an activity, so that people can find ways that suit them and their requirements. In relation to sustainability, that means whether there is an artefact available that would allow for the activity to be carried out with less environmental impact. For the designer, relevant questions are "what type of artefact can mediate the activity?" and "which types allow for less resource intensive mediation?".

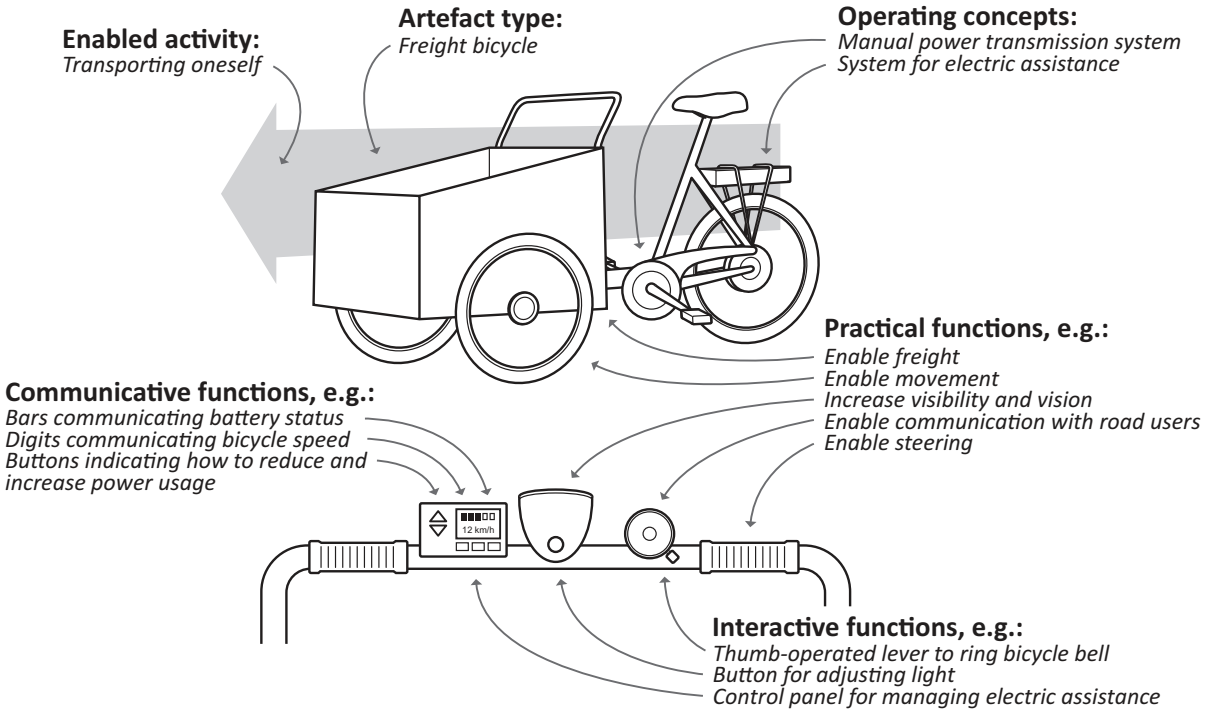

Figure 3 Examples of design features for the different layers.

2.3 Operative functions

The third layer concerns an artefact's operative functions. It addresses what should be designed, but in more detail than artefact type. This layer has been divided into two sublayers, *operating concept* and *practical functions*, in order to highlight two complementary aspects of the artefact's design at this level.

The operating concept addresses how the artefact should deliver its main function(s), i.e. which technical approach is taken to provide the function. An example of different operating concepts in the same artefact type is whether a car is powered by electricity or petrol. Another example is induction cooktops versus regular electric cooktops. The operating concept sets preconditions for resource consumption, in relation to both type and amount of resources and pollution. It also affects preconditions for use. For example, an electric car can be charged at home instead of being fuelled at a gas station and the "fuel" is paid for through the electricity bill. Looking instead at cooktops, induction cooktops use the same resource as conventional ones but the amount needed is reduced and the preconditions for use are slightly different as not all kinds of pots and pans can be utilised.

The practical functions determine what the user should be able to do with an artefact. Here, the target is to deliberately set the preconditions for use, contrary to operating concept where the preconditions for use follow from the operating concept selected. Practical functions include all things the artefact may be used for, from the main functionality (e.g. carry people from A to B), to necessary support functions (e.g. the ability to stop the vehicle using for example brakes), to delighters (e.g. a cheerful sounding bell). Here a designer asks

"what should the user be able to do with the artefact?", "what does the user need to be able to benefit fully from the main functionality?", and "what does the user need for the artefact to fit the activity?". Asking such questions from a DfSB perspective may provide inspiration to, for example, add eco-feedback to make users aware of their behaviour (Lilley, Lofthouse and Bhamra 2005; Wever, Kuijk and Boks 2008) or offer compartmentalised cold storage to decrease energy use and food waste compared to ordinary refrigerators (Selvefors, et al 2012). It is often practical functions that determine if people are able and willing to use an artefact, as the fit between functionality and user needs is what makes the product possible to adopt into everyday life (Strömberg 2015).

2.4 Interactive functions

The fourth layer, interactive functions, concerns users' possibilities for physically interacting with the artefact. This layer deals with the key question of how the artefact should be designed so that the user can access the functionality. To address this layer a designer could ask "how should the user interact with and control the artefact?" or "how should the user be given access to the functions?". For the user, the design of interactive functions sets the preconditions for how easy it is to use the artefact and gain full benefit of its functions – whether the user is able to control and interact with the product in less resource intensive ways. Examples of design decisions connected to this layer include how interaction sequences should be structured, which level of user control to apply, which types of interaction elements to provide (e.g. buttons, displays, or sensors), and their placement. A woodstove case can exemplify how a redesign with improved interactive functions can support more sustainable use (Daae 2014). Users had problems working the stove's two separate levers in a correct way according to recommendations for a clean burn. When the two levers for controlling air intake were combined into one lever with three positions, it became easier for users to achieve good burning.

2.5 Communicative functions

The last layer, the artefact's communicative functions, includes both semantic and syntactic functions. Semantic functions comprise functions that describe purpose and mode of operation, express properties, exhort reactions, and identify a product, its origin, kinship, location, nature or category (Monö 1997). Syntactic functions include the ordering of product form, and how to compose perceptual element to form a whole (cf. Muller 2001). The communicative functions set the preconditions for the users' perception of the artefact, including the perception of the interaction, such as understanding its purpose and how to use it, perceiving its properties, as well as reactions to interaction ("it's comfortable", "it's heavy"). It also concerns the perception of the artefact as such, of wanting and having the artefact and time-related aspects such as emotional bonds with the artefact. At this layer, the designer asks "how should the user perceive the artefact?" or "how do I want the user to feel when using the artefact?".

3. Design theories and methods in relation to the layers

Many different theoretical frameworks, methods and practical tools have been highlighted in literature for their contribution to the DfSB field and the possibilities they provide for supporting the design of everyday products. They originate from various research fields with different theoretical backgrounds and they all contribute with different perspectives. For instance, some theories are useful for understanding human behaviour and the use of technology, while others discuss, and present tools for, the concretization of artefacts. Thus, one framework, method, or tool rarely supports design work on all layers. Instead, they are often relevant to consider in relation to one or a couple of layers. If looking at the multitude of different frameworks, methods, and tools presented in literature, it is evident that there exist plenty of contributions which combined have the potential to support design work on all layers. However, while some are frequently discussed and applied in DfSB literature, some are rarely mentioned even though they contribute with important perspectives essential for design. As the theories, methods, and tools are different in character, and address different layers, they may inspire different types of solutions that change people's preconditions for acting with technology in different ways. This section will therefore briefly highlight a selection of theories, methods, and tools, in relation to the different layers, that could be beneficial to make use of when aiming to design for sustainable behaviour.

Turning first to the layer enabled activity. To identify opportunities for new innovative products that may enable people to go about their everyday activities in a less resource intensive way, it is essential to try to understand what people want to achieve in their everyday lives, and why. There are several theories that can provide a fuller understanding of people's needs and doings in everyday life. For instance, Activity Theory provides a framework for understanding the dialectical development between human needs and artefacts and highlights artefacts' mediating role in relation to human action. By taking activities as a unit of analysis, one may gain an understanding of how people's motives and goals during everyday activities influence their actions and use of artefacts (Bødker and Klokmose 2011; Kaptelinin and Nardi 2006). Moreover, Social Practice Theory can be adopted in a design perspective to explore opportunities for changes in practices by taking practices as a unit of analysis. By studying how people currently perform a particular practice, how the practice has evolved historically, and if similar but less resource intensive practices exist, designers may gain an understanding of which opportunities for desirable change that exist and identify which element configurations that work (Kuijer 2014). Regardless of what theoretical direction is favoured, it is essential to acquire user insights from potential users in order to identify what motives and needs to support.

When dealing with the actual design of the artefact it is relevant to first determine the artefact type(s) as this choice determines which operating concepts and functions that can be considered. Aspects such as users' needs, the potential for significant changes in resource consumption, and the business model can be considered when deciding on a suitable artefact type. To guide this work, methods and tools from the two related fields of Product-

Service System (PSS) and Service Design can be used. (See Tukker (2015) for an overview of PSS literature and Stickdorn and Schneider (2011) for service design thinking and tools.) When choosing operating concepts and establishing an artefact's functionality, many of the traditional engineering and design methods are essential. Methods such as Concept Classification Tree (Ulrich and Eppinger 2003, p. 112), Product Function Analysis (Baxter 1995, p. 210; Cross 2008, p. 78; Ulrich and Eppinger 2003, p. 102), and Concept Combination Tree (Ulrich and Eppinger 2003, p. 114) are very useful for identifying independent solutions to the problem and managing the choice between possible alternatives.

Once the operative functions have been established, the interactive and communicative functions can be decided on. A multitude of theories can be considered to form an understanding of which functions that would be suitable to both enable and support less resource intensive interaction. For instance, behavioural and environmental psychology provides a broad theoretical basis for discussing factors that influence how people behave in different contextual and social settings (Jackson 2005; Steg and Vlek 2009). It can, for example, inform different DfSB strategies related to an artefact's interactive and communicative functions (Zachrisson and Boks 2012). Knowledge gained from these types of theories is essential when aiming to design artefacts that are to be easily understood and intuitive to use in a less resource intensive way. The usability of artefacts is also vital in order to design user-friendly products that can be used in an efficient, effective, and satisfying way (Jordan 1998; Nielsen 1994). Jordan (1998) highlights important components such as guessability and learnability and describes several principles of usable design such as consistency, consideration of user resources, visual clarity, and explicitness that are relevant to take into consideration when deciding on an artefact's interactive and communicative qualities. Norman's Affordances (1999, 2013) highlight real and perceived affordances and discusses how artefacts can be designed in such a way that the user perceives possible actions to be meaningful, be useful, and result in known outcomes. Moreover, Norman (1999) highlights the concept of constraints and argues that artefacts can be design to be physically restricting, logically guiding, or fit with culturally learnt ways of interacting. Similarly, the concept of scripting has been discussed in DfSB literature as a way of designing products that trigger sustainable use by either creating obstacles for unsustainable use or by making sustainable use easy and intuitive (Jelsma and Knot 2002; Lilley, Lofthouse and Bhamra 2005; Wever, Kuijk and Boks 2008).

Another theory that is relevant to address when deciding on interactive and communicative functions is semiotics, the study of meaning formation, signification and communication (Monö 1997). It can provide deeper insights about people's interpretation of product characteristics and how material artefacts interact with humans (Vihma 2010). Theories of cognitive psychology (e.g. Levitin 2002) and theories of visual perception (see overview by Gordon, 1989), such as information processing (e.g. Wickens and Carswell 2012), gestalt theory (Koffka 1935), and perceptual constancy (Walsh and Kulikowski 1998), can also aid in the understanding of how people perceive and understand information, objects and visual forms. In their Design with Intent toolkit, Lockton, Harrison, and Stanton (2010a) have

compiled a set of patterns with inspiration from, among others, semantics, semiotics, and gestalt theory to provide designers with practical examples of how they may influence how users perceive patterns and meanings as they interact with artefacts.

Depending on the project scope and aim, it might not always be possible to address all layers during a specific product development process. If the aim is to re-design existing products to make incremental improvements, there is often not room for questioning decisions related to the higher layers (Roozenburg and Eekels 1995). There is however a risk of sub-optimizing when focussing too narrowly on designing a function on a particular layer, when it might be better to make changes on a higher layer of generality (cf. Cross 2008). Both Jones (1992) and Cross (2008) argue that if aiming for radical new design, capable of creating new patterns of behaviour and demand, one must question the artefact and its essential functions in order to identify favourable alternatives. We agree with this perspective and believe that it is essential to address all layers from a DfSB perspective as the artefact-related layers influence preconditions for acting with technology in different ways. In addition, decisions on all layers influence people's use and adoption of the artefact and thus the potential to support less resource intensive activities. If some of the layers are left unaddressed, DfSB designers risk both limiting the potential solution space and failing to create artefacts that have potential for supporting radical yet accepted changes.

4. Discussion

As was stated in the introduction, this paper proposes a tentative categorisation of artefact-related aspects a designer can change to influence people's preconditions for acting with technology. The categorisation implies a stronger artefact focus which highlights the design part of "Design for Sustainable Behaviour", shifting the debate away from sustainable behaviour and which theoretical frameworks on behaviour to use.

4.1 Mediating sustainable activities?

In many research studies, including our own, the goal of fulfilling of everyday needs has been overshadowed by the ambition to change behaviour. This behaviour change intention has resulted in products that in different ways enable the activity "be sustainable", instead of products that support everyday needs. However, people use products, services, and systems to fulfil everyday needs – not solely to "be sustainable". Designing for the activity of being sustainable often results in the user engaging in a new, additional activity and therefore does not fundamentally change the environmental impact of other everyday activities. This phenomenon was evident in the case of the energy feedback system Eliq Online (Selvefors, Karlsson and Rahe 2013), which supported the activity of "reducing domestic energy use". As a result, the active users of Eliq Online introduced a short-lived new conservation activity, but did not change their everyday behaviours in other activities to any higher extent. Similarly, an evaluation of the Power-Aware Cord (Löfström 2008) showed that the cord invited people to experiment, thus engaging in a new activity of "playful learning about appliances' electricity use". Unfortunately, the interest for engaging in such

learning and conservation activities often fade with time (Selvefors 2014). Thus, we argue the need to design products that mediate people's activities in less resource intensive ways while still allowing them to fulfil everyday goals. This option of mediating activities in new ways appears to have slightly slipped away from attention within the field of DfSB.

4.2 Working on each and all of the layers of design

The categorisation highlights the necessity of working through all layers of an artefact. Going upwards ensures the effectiveness of the chosen solution. The higher up, the higher the potential for resource savings (Brezet, et al 2001). Going downwards helps to create one coherent whole where the layers reinforce each other and facilitate comprehension and adoption. The importance of reinforcement was demonstrated by a subscription based mobility-as-a-service concept, UbiGo, through which users were provided access to a wide range of transport modes through a smartphone app. When opening the app to purchase a trip, the user was presented with a list of transport options – all at the same level of readiness. Thus, the users considered more options before deciding on the most appropriate one (Strömberg 2015). The communicative functions of the artefact, i.e. the design of the list in the app, reinforced the artefact type, i.e. mobility-as-a-service.

For adoption, the significance of lower layers was seen in an evaluative study of a plastic measuring cup for washing detergent. Inside the measuring cup, a frog sat on a stone and the frog's feet represented a suitable dose for most washes (Lidman and Renström 2011). The users that evaluated the frog cup all appreciated the practical functions it offered, i.e. dosing of detergent. Some users found the frog cute, while others disapproved of the frog because it was in the way when dosing. Thus, the communicative functions contributed to adoption for some, while the interactive functions of the frog ran the risk of contributing to rejection for others. It is noteworthy that if any layer is designed without intent there will be risks for rejections or weakening of other layers. Preconditions for behaviour are always designed, whether intended or not (Lockton, Harrison and Stanton 2010b).

4.3 Beyond the theoretical standpoints

The research regarding how design could be used for affecting sustainable ways of acting is currently characterised by a debate about which theoretical approach should be taken (Boks, Lilley and Pettersen 2015). A more established interaction-oriented approach, which includes the use of behaviour change strategies to alter well-defined interaction behaviours, is challenged by a social practice-oriented approach, which involves the creation of new material elements to reconfigure practices (Kuijer and Bakker 2015; Pettersen, Boks and Tukker 2013). The proposed categorisation and this discussion bring to light the role both approaches have in relation to the generality of the design problem and their relation to the different layers. The categorisation is able to open up the debate by opting for a different angle on the issue. That is, by focusing on the artefact's design, instead of which theory of behaviour that should serve as the starting point for the design. The new angle clarifies that the link between artefact-aspect and behaviour goes via the preconditions for acting that

the design of the artefact affords. It is only the preconditions for behaviour that can be designed, and not the behaviour (or practice) itself. Thus, as a designer you can work to make it easier or harder to act in certain ways, or make entirely new ways possible. In that work, different theories of understanding users can structure the gathering of insight in relation to the layers, i.e. serve as a unit of analysis. Artefacts can then be designed with the hope that they will affect behaviour in a certain direction, re-mediate an activity, or re-configure the performances of social practices. Nevertheless, a certain outcome cannot be guaranteed, as people will act in ways the designer can neither foresee or control when they appropriate the artefact into their everyday lives, if they are willing to use it at all.

When viewed from the angle of artefacts, the debate regarding theoretical standpoints starts to dissipate. It has been shown that in the pragmatic context of the creation of solutions, the tensions between the two perspectives become less apparent (Kurz, et al 2015). The two approaches are needed at different layers. Depending on your starting point in terms of freedom to define the scope of your design, or the level of problem to be addressed, you may need to focus on one or the other. In practice, any single perspective becomes limited in addressing sustainable behaviour (cf. Lopes, Antunes and Martins 2015). The design of a consistent artefact requires a range of theories and methods to be realised. Nevertheless, we do not argue for the debate to cease, as it is needed to advance the field. The debate also spurs discussion on important issues such as with whom responsibility for society's sustainability lies and which behaviours and practices are considered sustainable enough.

4.4 Future work

The categorisation is, as noted, tentative and has not been tested in practical cases. Currently, studies are being undertaken in which the categorisation serves as a tool for analysis and design, which may lead to a confirmation of the layers as well as elaboration of sub-aspects. Furthermore, we plan to undertake comparative studies to explore the effects of design decisions related to the different layers. If these studies show significant differences in environmental impact relating to the layers, the necessity of systematically considering each aspect when designing for sustainable behaviour will be enforced. Moreover, the proposed categorisation only covers one main enabled activity and one main artefact. Future work could relate the categorisation to what aspects are relevant when artefacts are used in combinations of activities, or in combination with other artefacts.

5. Concluding remarks

This paper proposes a categorisation of artefact-related aspects that is tailored for DfSB designers. With the categorisation, we argue for a strengthened focus on artefacts and their role in setting preconditions for acting with technology. Different layers in the categorisation outline essential design considerations: from the lowest level of perceptual influence, through the implementation of sustainable interaction strategies, supportive functions,

different operating concepts, and artefact type(s) up to the introduction of new ways of mediating activities.

When designing everyday artefacts, DfSB designers need to more systematically address all layers, as is common in traditional design practice. By moving upwards through the layers the potential for resource savings can be increased and radical changes are made possible. In contrast, moving downwards increases the potential for a consistent design that may facilitate user adoption and provide preconditions for sustainable behaviour in every layer.

The coupling of the categorisation with methods and theories shows that designers have means to address all layers. A range of theories and methods will be needed to support the design work as no theoretical framework covers all layers. Hopefully, the categorisation's coupling with methods and theories can facilitate exploration of design possibilities on all layers.

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