The Design of Smart Product-Service Systems (PSSs): *An Exploration of Design Characteristics*

Ana Valencia *, Ruth Mugge, Jan P. L. Schoormans, and Hendrik N. J. Schifferstein

Delft University of Technology, Delft, the Netherlands

Smart Product-Service Systems (Smart PSSs) integrate smart products and e-services into single solutions. Smart products make use of information and communication technology (ICT) to collect, process and produce information, while e-services are web portals, apps and means alike, which facilitate the communication between service providers and consumers. Smart PSSs are relatively novel in the market but their presence and relevance for consumers is increasing. However, there is limited available information that can help designers be prepared for this new task of integrating products and services. In this article, we extend this knowledge by outlining seven important characteristics of Smart PSSs: *consumer empowerment, individualization of services, community feeling, service involvement, product ownership, individual/shared experience and continuous growth.* These characteristics were identified by means of two studies. In Study 1, individual in-depth interviews with 16 industrial designers were conducted. During the interviews, participants were asked to analyze 29 commercially available Smart and non-smart PSSs, and to classify them according to their perceived similarities. In Study 2, stakeholder checks were conducted by means of 10 in-depth interviews with professionally experienced designers of Smart PSSs. In this paper, we exemplify the ways in which these characteristics are being implemented, we discuss the potential value of Smart PSSs both for consumers and companies, and we discuss the challenges designers are likely to face when designing this type of offerings.

Keywords **–** Consumer Experience, Product Design, Product-Service System, Service Design, Value Creation.

Relevance to Design Practice **–** Our results can help designers to create Smart PSSs that convey the appropriate value and experience for consumers. Moreover, our insights can be used as a tool in the design of Smart PSSs, or as the basis for new tools and methodologies for the effective integration of products and services.

Citation: Valencia, A., Mugge, R., Schoormans, J. P. L., & Schifferstein, H. N. J (2015). The design of smart product-service systems (PSSs): An exploration of design characteristics. *International Journal of Design, 9*(1), 13-28 .

Introduction

Product-service systems (PSSs) are market offerings that combine products and services, and present them as single solutions to consumers (Goedkoop, Van Halen, Te Riele, & Rommens, 1999). In contrast to traditional services attached to products (e.g., warranty), the service in a PSS significantly adds value *in use* to the consumer. For example, when buying a washing machine, a consumer may have access to a service warranty. However, this warranty does not particularly influence the interaction between consumer and the machine or his/her experiences with it. In contrast, when using a PSS both product and service are (jointly) part of the solution, and thus central to the interactions and experiences of the consumer with it. Launderettes (i.e., shared laundry facilities) are an example of a PSS found in the existing literature (e.g., Mont & Plepys, 2007). This PSS is composed of washing machines (the products) that are made readily available to consumers for self-service purposes (the service). Benefits of this PSS for consumers include the avoided cost of purchasing professional machines, but also the access to in-site services such as the ironing and folding of clothes by the service employees. Thus, in assessing the experience with the PSS, consumers will rely on aspects of the product, such as performance, but also on aspects of the service, such as employee friendliness, general atmosphere in the laundry room, and the quality of the end result (Bitner, 1992).

In this paper, we focus on an emerging type of PSS that is targeted to individual consumers. New advances in information and communication technology (ICT) are bringing PSSs to a new level. For instance, Laundry View (http://www.laundryview.com) connects washing machines to the Internet, allowing consumers of launderettes to check or be notified about the availability of the washing machines. Furthermore, consumers can report incidents or give comments/suggestions to the service provider. Thus, Laundry View serves as a communication channel between the provider and individual consumers, and enhances their experience by, for example, enabling them to visit the launderette only when convenient.

We refer to this type of PSSs as Smart Product-Service Systems. We call them smart because they make use of ICT, such as microchips, software and sensors, which allows them to connect, collect and process information (Rijsdijk & Hultink,

Received December 6, 2013; **Accepted** October 1, 2014; **Published** April 30, 2015.

Corresponding Author: A.M.ValenciaCardona@tudelft.nl.

2009). For example, the washing machines in Laundry View are smart because the ICT in them helps to transmit relevant information to consumers. Thus, Smart PSSs integrate a smart product with an e-service to jointly address the needs of consumers. The ICT embedded in the product plays an important role in the implementation of Smart PSSs, because it facilitates the generation and transmission of relevant information, and guides the creation of e-services around the product. Consequently, the integration of smart product and e-service opens up an array of opportunities for designers, who can implement new interactions or touchpoints, and strengthen the relationship between consumers and service providers.

Smart PSSs are relatively novel offerings in the market place but their presence and relevance for consumers is growing. For designers, this could imply an increase in Smart PSSs-related projects, and the need to adjust their best practices to the design of these offerings. Although designers have long been acknowledged for their role in the design of products and services (e.g., Kimbell, 2011; Sleeswijk Visser, 2013; Valtonen, 2005), the design of Smart PSSs may call for special attention to the practicalities of integrating smart products and e-services. This research aims to address this pertinent question by exploring the defining characteristics of Smart PSSs, which are relevant in the creation of meaningful user experiences and interactions. Understanding how Smart PSSs can create meaningful interactions is important, because it can support the development of Smart PSSs that foster long-lasting relationships between service providers and consumers. Consequently, our research objective is to bring forward knowledge that can help designers make more informed decisions around the design of Smart PSSs. Understanding the characteristics of Smart PSSs can lead to the creation of such market offerings with increased value for consumers, especially over time.

Ana Valencia is a PhD candidate at the faculty of Industrial Design Engineering, Delft University of Technology. She received her MSc in Strategic Product Design from the same university. Her research focuses on the design of Smart Product-Service Systems (PSSs); on understanding the special considerations of the design process, as well as the value they can bring to consumers and companies. Through qualitative research, she aims to generate guidelines for design practitioners, which can lead to the development of Smart PSSs with durable value to consumers, companies, and society at large.

Dr. **Ruth Mugge** is Associate Professor of Consumer Research in the Faculty of Industrial Design Engineering at Delft University of Technology. Her main research focus is on understanding consumer response to product design at purchase and during ownership. She has published her research in such journals as *Design Studies*, *Journal of Engineering Design*, *Journal of Product Innovation Management*, *Applied Ergonomics*, *the Design Journal*, and *International Journal of Design*.

Jan P. L. Schoormans earned his PhD from Tilburg University and is a Professor of Consumer Research at Delft University of Technology, The Netherlands. He has published on the role of consumer behavior in new product development in several academic journals, such as *International Journal of Design*, *Design Studies*, *Journal of Product Innovation Management*, *International Journal of Research in Marketing*, *the Design Journal*, *Journal of Engineering Design*, *Design Management Review*, and *CoDesign*.

Rick (H. N. J.) Schifferstein is Associate Professor at the Faculty of Industrial Design Engineering of Delft University of Technology. His topics of interest include (multi)sensory perception, experience-driven innovation, and food design. He contributed to more than 60 papers in international scientific journals, including *Acta Psychologica*, *Food Quality and Preference, Chemical Senses*, *International Journal of Design*, and *Journal of Experimental Psychology: Human Perception and Performance*. He is co-editor of the books *Food, People and Society* (2001), *Product Experience* (2008), *From Floating Wheelchairs to Mobile Car Parks* (2011), and *Advanced Design Methods for Successful Innovation* (2013). With his company Studio ZIN, he provides personal coaching and facilitates workshops that stimulate the innovative and creative powers of people and organizations.

Types of PSS

Three types of PSSs are generally acknowledged in the PSS research field: result-oriented, use-oriented and product-oriented PSSs (e.g., Baines et al., 2007; Tukker, 2004; Yang, Moore, Pu, & Wong, 2009).

In result-oriented PSSs, companies sell results or competencies rather than tangible products. A specific product may not be pre-determined by the service provider, and may consequently play a less noticeable role in how the solution is delivered (Tukker, 2004). The ownership is usually kept with the provider, who is responsible for the maintenance and good performance of the product. Launderettes, previously discussed in this paper, belong to this category. However, most examples cited in the literature relate predominantly to the business-to-business markets. One example would be managed print services, where companies (i.e., customers) have a temporary contract with a service provider to manage their printing activities (e.g., http://www.managedprintservices.com). In addition to delivering printers, service providers guarantee quality of printing, supplies and prompt maintenance. Customers, on the other hand, pay a fee depending upon the number of prints made and supplies used.

In use-oriented PSSs, products have a more prominent role. Unlike result-oriented PSSs, providers of use-oriented PSSs sell the accessibility and use of specific products. Providers maintain the ownership of products while their goal is to maximize their use and lifespan (Baines et al., 2007). Examples in this category include shared, leased, and pooled products (Tukker, 2004). In tools sharing programs, for instance, consumers pay to make temporary use of professional tooling for gardening, construction, and other purposes. Service providers make tools available through different service hubs around cities (e.g., http://www.boels.com). A consumer may thus select a hub based on a preferred location. After use, the tools are returned to their pick-up location where other consumers can make use of them. The service in tools sharing typically includes the maintenance of the tools, insurance, and assistance/information on how to operate the professional machinery (Mont, 2004). Consumers pay to access the tools easily but are responsible for cleaning the tools, returning them on time, and reporting any damages.

Finally, in product-oriented PSSs, a tangible product is sold and its ownership transferred. Additional services are then offered to guarantee the correct functionality and durability of the product (Baines et al., 2007). Examples in this category include after-sales services (such as maintenance) needed during the use-phase of the product, or advice on how to operate the product (Tukker, 2004). Most examples provided in the literature relate to business-to-business transactions, where products are often described as parts of 'package' deals (e.g., including installation, maintenance, advice) and, as expressed by Tomiyama (2003),

"a means to deliver services" (as cited in Yang et al., 2009, p. 225). For consumer goods, however, this product-oriented classification implies the use of conventional services that add limited value to the experience with the offering. For example, the purchase of a laptop computer may include a guarantee for reparations, replacement of parts, and so on. These guarantees are, nevertheless, standard for many electronic products and rarely influence the value in use of the product.

The above typology is mainly used by the sustainable design and sustainable production communities, who have acknowledged the potential of PSSs to create more eco-efficient solutions, for example, by reducing product ownership and by maximizing the lifespan of products. While eco-efficiency is an important topic in the existing PSS body of knowledge, our discussion transcends this scope. Furthermore, we see two important limitations of the existing literature for the design of Smart PSSs. First, the above typology is highly focused on business models around PSSs. While this information on business models is important in the design of PSSs, designers can also benefit from insights regarding user experiences and interactions. Product-Service Systems are complex solutions whose design require the consideration of multiple aspects, such as technology, development actors, users and context (Morelli, 2002). It is the interaction between those elements that can create meaningful experiences and added value during the use phase of the PSS. Second, important differences between traditional PSSs and Smart PSSs (e.g., the ICT in the product) may result in new and critical opportunities for designers. Thus, for designers of Smart PSSs, it is important to understand how the combination of smart products and e-services can lead to new types of interactions, improve the relationships between the stakeholders involved in the Smart PSS (i.e., users, employees, community, companies at large), and enhance the perceived value of the system over time.

In the following section, we provide a conceptualization for Smart PSSs. We explain the transition from smart products to Smart PSSs, and start identifying the opportunities that smart products as well as e-services bring to providers and consumers.

Smart Product-Service Systems

Smart products are market offerings characterized by the high content of information technology, and their ability to collect, process and produce information (Rijsdijk & Hultink, 2009, p. 25). For instance, automatic lawn mowers (e.g., Robomow, http://www.robomow.com) can be considered smart versions of the traditional lawn mowers. These machines are equipped with sensors that allow them to function with limited human intervention. Furthermore, contrary to traditional lawn mowers, the smart lawn mowers can be programmed to work at predefined times, and to automatically connect to the charging unit whenever needed.

Smart PSSs are 'smart' because they carry some of the characteristics of smart products, such as the capacity to transform data into knowledge that can help consumers perform more effectively (Davis & Botkin, 1994). Several conceptualizations for the smartness of products have been proposed before (e.g., Maass, Filler, & Janzen, 2008; Rijsdijk & Hultink, 2009). According to Rijsdijk and Hultink (2009), the smartness of a product is determined by the extent to which it possesses, to a greater or lesser extent, one or more of the following dimensions: autonomy, adaptability, reactivity, multifunctionality, the ability to cooperate with other devices, the human-like interaction of the product, and personality. Consequently, these dimensions may also apply to a greater or lesser extent to Smart PSSs. For example, Philips' Direct Life (http://www.directlife.philips.com) is a Smart PSS designed to improve the health of consumers. The product in Direct Life is a small sensor that consumers can carry with them to measure their movements. This sensor is coupled with an e-service (i.e., a web platform) that consumers can access in order to 1) store the personal data that were measured during the day, 2) access descriptive graphs of their chronological progress, and 3) get in touch with health experts for advice on how to use the data to improve their health. Thus, Direct Life is an autonomous Smart PSS because the sensor measures movement unobtrusively throughout the day while consumers continue with their daily routines. Data are automatically transferred to the web platform. Direct Life is adaptable because it bases its measures on personal information, such as age or weight. Hence, the data and advice provided by the Smart PSS adapt to the personal conditions of individual consumers. Direct Life is also able to cooperate with other devices, because the data collected through the day must be transferred to a computer to access it. Finally, Direct Life is reactive, because its sensor has embedded lights that light up according to how much consumers have moved; the more consumers move, the more lights will light up.

An important difference between smart products and Smart PSSs is that the latter integrates a service with the product to jointly address the needs of consumers. Most of these services are e-services that deliver value to consumers electronically (Stafford, 2003). Thus, for the automatic lawn mower to become a Smart PSS, it would have to be coupled with an e-service that would generate added value in use to the consumer, for example, by allowing him/her to check the status of the lawn, the sharpness of the blades, or get in touch with service providers remotely.

Several benefits of implementing e-services for consumers have been reported. One important benefit is their ability to support a two-way dialogue between consumer and service provider (Rust & Kannan, 2003). This dialogue allows providers to collect relevant specific information about consumers, which facilitates the creation of customized services to satisfy their individual needs. Furthermore, self-service technologies reportedly provide a sense of control to consumers who can handle their transactions any time they want (Meuter, Ostrom, Roundtree, & Bitner, 2000). To make optimal use of the benefits of e-services, Rust and Kannan (2003) predicted an increase in technology-enabled innovations, capable of supporting the delivery of e-services to consumers, which allow consumers to experience a high level of control over their transactions. We argue that Smart PSSs are such technology-enabled innovations, which will create new dynamics in the relationship between the service provider and the consumer.

To conclude, we define Smart PSSs as the integration of smart products and e-services into single solutions delivered to the market to satisfy the needs of individual consumers. While there is substantial knowledge regarding the characteristics of smart products and e-services, we lack understanding of the opportunities, in terms of interactions and value in use for consumers, resulting from the integration of smart products and e-services. While the characteristics of PSSs have been previously discussed, the characteristics observed were highly focused on business models and business-to-business solutions. Thus, with this study, we aim at broadening the existing knowledge on PSSs, by providing insights into the characteristics of Smart PSSs that can influence the experience of individual consumers.

In the following sections, we report on two research activities that were conducted to identify the characteristics of Smart PSSs. Study 1 had an exploratory character, and aimed at identifying a first set of characteristics of Smart PSSs. To this end, examples of Smart PSSs were discussed with industrial designers holding a bachelor's degree by means of a classification task. Study 2 aimed to validate and extend the findings of Study 1, by discussing them with a group of designers who have experience with the design of Smart PSSs.

Study 1

Method Study 1

In-depth interviews were conducted with industrial designers who held a bachelor's degree in industrial design ($N = 16$). Our group of participants was composed of recently graduated and second-year master's students of industrial design. Consequently, participants were well trained to understand how users experience and interact with products and services. Because of their professional experience and education, participants had taken part in various real-life project scenarios that granted them a critical view of user needs and general product/service requirements.

During the interviews, participants were asked to analyze 29 commercially available smart and non-smart PSSs and to classify them according to their perceived similarities. The goal of this classification task was to uncover the characteristics (i.e., criteria) used to group similar sets of market offerings (Mugge, Schoormans, & Schifferstein, 2009). Given the focus on Smart PSSs, it was particularly important to enroll participants who were capable of rationalizing and explaining their grouping decisions in design-related terms. To elucidate design characteristics, participants were encouraged to group stimuli on aspects related to the user interaction and/or experience. Establishing this mindset was important in order to avoid categorizations based on more general product features, such as shape and category. Participants had the freedom to decide the number of groups and examples of PSSs belonging to each group (Handelt & Imai, 1972).

Stimuli

Based on extensive Internet research and discussions with companies, a set of 57 existing PSSs and PSS concepts (smart and non-smart) was created. To keep the classification task manageable for the participants, the initial set of PSSs examples was reduced by focusing only on PSSs that are commercially available in order to increase the study's realism. Furthermore, PSSs that provided similar benefits to consumers were eliminated, resulting in a final set of 29 PSSs. The selected PSSs differed considerably in the balance between product and service, the purpose of the offering, and the situations in which they were used (see Appendix A). Moreover, examples of traditional PSSs that are often mentioned in the literature were included in the final list, in order to obtain insights about the differences between smart and non-smart PSS that are important for the user experience. A pilot test demonstrated that although the classification task was manageable, further extending the number of stimuli would make the interview tedious and tiring for the participants.

The development of the final stimuli consisted of different phases. First, a storyboard for each PSS was created. In order to create the individual storyboards, the main researcher diagrammed the process followed by consumers in each PSS, from purchase to use, depicting the main product and all service interactions. This resulted in 29 different product-service-user interaction diagrams, which were subsequently discussed with a professional interaction designer, in order to enhance their completeness. Then, the 29 individual storyboards were sketched by a graphic designer making use of professional software. The final storyboards were included in a booklet that was used as sensitizing material. Participants studied all PSSs prior to the classification task (see Figure 1). The booklet contained: an image of the PSS taken from the official website, an extensive description of the product and the service in the PSS and how they interrelated, the storyboard, and a notes section for participants to write comments or questions to be addressed prior to the session. Finally, individual cards showing each PSS at a glance were made to facilitate the classification task. The individual cards contained the name and picture (as shown in the booklet) of the PSS, and the storyboard.

Procedure

We contacted participants two weeks before the classification task. A booklet was provided to each individual, which they were encouraged to read at their own time and pace. Before the task started, the interviewer answered any remaining questions regarding each PSS. Furthermore, participants received instructions on the procedure, including a classification example, to ensure their understanding of the task.

Individual cards were randomized and placed on the table facing up to give an overview of the total set of PSSs. Participants were instructed to take two cards and to group them in one or two groups, based on perceived similarities. We asked participants to think aloud to reveal the rationale behind their classification choices. Once a first set of two cards was classified, participants continued with the remaining cards. Participants took one card at the time, adding them to the already created groups or creating new ones. This procedure was repeated until the entire set of 29 cards was discussed and classified. Subsequently, participants labeled every distinctive group using a name describing their classification criteria. Throughout the process of classifying and

labeling stimuli, participants were instructed to group stimuli on aspects related to the user interaction and/or experience. Some examples of grouping labels used by participants include "measuring and keeping track", "feeling in control", "personalize it to fit your daily life", "feedback product allows socializing", "rent and return" and "people-people interaction". Participants took 55-145 minutes to complete the task, and all participants completed the task satisfactorily.

Data Processing

All interviews were recorded and fully transcribed. The data were analyzed using the software program Atlas.it. Because of the exploratory nature of Study 1, the data processing was inductive; it did not begin from a preconceived set of themes, and our findings emerged directly from the data that were collected (Thomas, 2006). Transcribed interviews were coded looking for patterns and interesting themes in the data. This process was followed interview by interview until no significant number of codes was added to the list, resulting in an initial set of over 100 codes. This set of codes was discussed with the main and secondary researchers, identifying codes with similar meanings, and main subjects in the data. For example, the codes "managing content" and "updating content/data" were merged into the code "controlling content", because of their similar implications for the experience of the end-user. Another example relates to the codes "feedback", "user feedback", "personalized feedback", and "product preview", which were merged into the code "type of feedback" because they explain the different ways in which information is presented to end-users. The process of merging similar codes allowed us to reduce the list to a total of 55 codes distributed among 15 themes. Identified themes related to different aspects, such as the smart product (e.g., data), the e-service (e.g., feedback), the benefits for the end-user (e.g., control), but also to aspects of how the Smart PSS is brought and implemented in the market place (e.g., business model). Once the list of codes was refined, the remaining interviews were transcribed. Additional codes were identified as overlapping with the existing ones, and classified in one of the identified themes. Even though the point of saturation had already been reached by the fifth interview, the remaining 11 interviews were coded in order to ensure that the full richness of the data was present in our findings. New characteristics were however not found. A final session with the research team was conducted to discuss the resulting list of 35 codes and 10 themes, and to establish their relevance in relation to the research objective (Thomas, 2006). Finally, selected themes were further classified into six characteristics, which we will present below. Appendix B presents an overview of the final 35 codes and 10 themes related to our findings, as well as the relations between themes and characteristics.

Findings and Discussion Study 1

Study 1 led to the identification of six highly interrelated characteristics of Smart PSSs, based on the interaction and value in use for the consumer: *consumer empowerment, individualization of services, community feeling, service involvement, product ownership and individual/shared experience.* Importantly, some characteristics can be manipulated directly by designers, while others need to be discussed at a more strategic level (for example by the management) to assure their correct implementation. Furthermore, the characteristics may vary in their dominance

Figure 1. Example of pages in the sensitizing booklet for Direct Life.

according to the context for which the Smart PSS is developed. Hence, the characteristics are not, by definition, present in all Smart PSSs. In this chapter, we present each characteristic and discuss the implications for designers.

Consumer Empowerment

Consumer empowerment is a characteristic of Smart PSSs that most participants recognized during the interviews. Smart PSSs empower consumers by giving them the necessary tools to make decisions or take action on their own terms. We identified two main sources of empowerment in Smart PSSs: delivering feedback to consumers, and enabling consumers to select their own content.

Feedback is relevant information that consumers can use to assess a specific situation, and take action accordingly. Different features of Smart PSSs facilitate the delivery of feedback to consumers. First, Smart PSSs enable consumers to *measure their own data* at a specific moment in time. Because this information is usually stored online, this grants service providers access to relevant input on consumers' states and activities. By having access to data related to individual consumers, service providers can create personalized overviews of the measured data, thereby enabling consumers to *track their progress over time.* Furthermore, data are transformed into *graphs, diagrams and other pictorial representations* that consumers can understand easily. This type of feedback was often associated with Smart PSSs that facilitate the achievement of goals. For example, the WiFi Body Scale (http://www.withings.com) provides real-time feedback by displaying the weight and BMI of the consumer on the scale's screen when the Smart PSS is used. Furthermore, it provides long-term feedback by automatically sending these measurements to a web portal, which creates illustrative graphs of these over time. Together this information will empower consumers, because consumers who want to lose weight can use such feedback to understand how their eating habits affect the achievement of their goals. As expressed by one participant:

> This is all about measuring, measuring and keeping track […] there is some aspect of life, like your movement, about pressure, or whatever, or something that for whatever reason is important for you. For example, with Fiat it's about not having a too big impact on the environment, and this one [WiFi Body Scale] has to do with health, […],you don't really need to do this unless you want to do it […]. And it's focusing on longer periods, […], but you can also look back at the data, it's really about the process of improving or not, and it's also really about the specific data, it's really qualitative information, it is really about understanding what is happening…

Next to the capacity to track one's progress in a certain activity, Smart PSSs enable consumers to *track the status of products*, such as their availability and location. For example, Laundry View is a Smart PSS that enables consumers to check the availability of (specific) washing machines. Laundry View empowers consumers by helping them to take control over the process, for example, by visiting the laundry room only when a laundry machine is available:

> Laundry view is about getting information on the moment you want it, without having to do all the walking, it's about easily obtaining short-term information, information that you need right now, it also makes life easier for you, you can plan more easily, you can set the alarm when the washing machine is available.

Smart PSSs provide feedback by *delivering relevant information regarding product features or content* prior to purchase. Such is the case with smart phones and app stores (e.g., iPhone and iTunes, http://www.apple.com), which provide descriptions, images and free trials of applications, but also enable consumers to give feedback to each other about the quality of the apps (see *Community Feeling*). Thus, this type of feedback empowers consumers by providing relevant information to make a purchase decision:

> I think it's more about going online to see what exactly you want to have before you purchase or rent anything. So I think it's about online selection, there's a lot of information and options. There's way more than when you go to your shop on the corner of the street. Then it has maybe two types of Christmas trees or three and also with designer bags and stuff. They don't have everything and with the Laundry View it's also about, you get more information when you go online. I think it's about online information and selection before purchase or rent.

Finally, Smart PSSs can empower consumers by enabling them to *select their own content*, and have an experience that fits their individual needs. For example, Amazon's Kindle (https://kindle.amazon.com) is an e-book reader that consumers can use to read, buy and store e-books. Using the Kindle Store, which is the Kindle's e-service, consumers can browse and purchase a wide range of content, including e-books, e-magazines, e-news and games. Because of the wide range of options Kindle provides, consumers can select content that fits their individual taste or mood. Furthermore, enabling consumers to select their own content was associated with *service availability*; a service that can be accessed at any time and is always available to them:

> Basically what the device does for you is that it allows you to download something. Then you can use it as you want [..] in the Kindle: you can look back and forward in the pages, so you always have an online database through which you can find information for you to use.

Design for empowerment is clearly a topic of interest for designers. The role of design practices such as do-it-yourself (DIY) solutions and co-design, both of which give consumers a sense of authority in the design of traditional products, has been previously discussed (Mugge et al., 2009; Wolf & McQuitty, 2011). Furthermore, it has been suggested that e-services and technology-based self-service options provide consumers with a sense of control (e.g., Dabholkar, 1996; Rust & Lemon, 2001). Smart PSSs offer innovative opportunities to combine these and thus the challenge for designers lies in combining e-services with tangible products in new ways to empower consumers. Above, we presented different features in the integration of products and services that facilitate consumer empowerment. However, this is

not an exhaustive list and other ways of providing control and authority to consumers may be viable. Furthermore, past research has suggested that feeling in control of the process of service delivery has a positive effect on consumers' evaluations of such process and quality (Dabholkar, 1996). Although we presume that the above-mentioned features empower consumers, their effect on consumers' perceptions of control and consumers' attitudes towards Smart PSSs is still unknown. Thus, future research on the features enabling empowerment, and their influence on consumers' perceptions towards Smart PSSs, can provide designers with more accurate advice on the design of such systems.

Individualization of Services

Smart PSSs make consumers feel important by addressing them as individuals. Smart PSSs individualize their services for consumers in different ways. First, because of their digital nature, Smart PSSs make use of *user accounts to identify consumers*. E-services support the two-way communication between service providers and consumers (Lagrosen, 2005; Rust & Lemon, 2001). Through this communication, and by identifying consumers, service providers can collect specific data and create more personalized solutions to satisfy their needs (Rust & Lemon, 2001). For example, Green Wheels (https://www.greenwheels.com) makes cars readily available to consumers for specific periods of time. Upon registration, consumers receive a personal e-card and pin code, which grants them access to the vehicles. Because Green Wheels has personal information about the consumers, such as their locations and demand, they can adjust they offer accordingly. Regarding the effect of using personal accounts, and personalized services, a participant said:

> Because the Green Wheels, of course it is not your own car, but it feels a bit like your own car I would say, because you have your own account, you have your own card, you can make your own reservation while the coffee machine and the multi-laundry room is just there and that you can use it is not personalized at all…

Closely related to user accounts, Smart PSSs make use of *virtual servicescapes* to communicate with consumers (Vilnai-Yavetz & Rafaeili, 2006). Servicescapes have been defined as the environment where the interaction between service provider and consumer takes place. Servicescapes are composed of the several elements that facilitate the interaction and influence the experience of consumers, such as furniture, symbols and personnel (Bitner, 1992). For Smart PSSs, the servicescape is "virtual" because the interaction between service provider and consumer primarily takes place through the e-service instead of the physical world.

Virtual servicescapes are an important touchpoint to implement tactics in the individualization of consumers. While some Smart PSSs make use of web portals accessed from computers, others allow consumers to access the virtual servicescapes directly through the product. Amazon's Kindle is a Smart PSS that provides both options. Consumers can access the Kindle Store to buy content directly through the e-reader, or access it through the Internet making use of a separate computer. Because consumers are identified with a personal user account that is needed to access the virtual servicescapes in both instances, purchased content is linked to the individual consumers, stored, and automatically synchronized through all virtual servicescapes. Furthermore, in many instances virtual servicescapes are the only means through which consumers communicate with providers, making them an important element to focus on in the design of Smart PSSs:

> That you buy a physical product, this is the first step, then you have to connect it with an Internet platform, then you have to use it for a certain time or not, just use it once. Then you [go] to the platform again and you update your personal profile and data you have, and then it gives you feedback on your progress on how well or bad you are doing. So it's a really typical product but then the experience after you use the product is really personalized.

Finally, Smart PSSs vary in the human-like interaction (Rijsdijk & Hultink, 2009), or *way of approaching consumers*, by the service provider. Some Smart PSSs make use of real people to interact with consumers. For example, Philips Lifeline (http://www.lifelinesys.com) is a Smart PSS for the elderly, which consumers can use in case of emergency. When consumers are in a life-threatening situation, they can press the button in the Lifeline collar they wear, and an emergency call is automatically placed to a Philips representative. The Philips representative will then communicate with the consumer via an intercom, assess the situation, and send medical help when needed. Other Smart PSSs make use of artificial means (or automated responses) to communicate with consumers. For example, Nike+ is a Smart PSS that enables consumers to track their progress during running workouts. The product in Nike+ measures data, such as burned calories, distance and trajectory. The service in Nike+ (http://www.nikeplus.com) is a web platform that gives consumers access to graphs and overviews of the data related to their workouts. Nike+ encourages consumers to exercise by awarding them with trophies and other achievement-related prizes. When consumers reach a goal (e.g., 10 kilometers running), they receive pre-recorded cheering messages from celebrity athletes. Thus, Nike+ communication towards consumers is automated, human-like, and linked to the specific development of individual consumers. The need to implement a more or less human-like interaction, depends on the goal and context of the Smart PSS. As expressed by one participant:

> In these two products [Philips Lifeline and PT/INR Self Testing] you come into contact with a person. With the others you can exchange information with other people, but it's not something that you need or it's not an emergency. This [Philips Lifeline and PT/INR Self Testing] is something that you need [to be] attended by a person, and you feel like you want to be attended by a person. I don't feel that they would be as successful if, for example, with the Philips Lifeline you would have a platform. That would be impossible because you wouldn't be able to be attended as you need, so I think that is the main difference.

The abovementioned features are examples of how Smart PSSs address and individualize their services for consumers. These, however, may not be the only tactics designers can implement to create a more personal experience with Smart PSSs. The integration of products with services poses great opportunities for designers. The perceptions towards the service can be greatly influenced by the tangible evidence that surrounds it (Bitner, 1992). Because the product in Smart PSSs is central to the consumer experience, designers have the opportunity to strengthen the individual value of the service through the physical characteristics of the product. In this respect, designers must have a good understanding of the message companies want to communicate to consumers. Past research has suggested that the integration of services and products with a congruent meaning can have a positive effect on consumers' attitudes towards the offering (Valencia, Mugge, Schoormans, & Schifferstein 2011). Thus, the challenge for designers is to bring the service closer to consumers while safeguarding the overall value of the Smart PSS offering. Consequently, creating individuality in the service through the product is a task which should involve other important stakeholders in the development of the Smart PSS; it is a task that requires alignment between different functional areas to ensure that the correct value is communicated to consumers.

Community Feeling

Community feeling refers to how Smart PSSs *facilitate the communication between consumers*. This communication typically takes place through *social media*. Consumers give feedback to each other, share and exchange information regarding the Smart PSS. For example, Wattcher (https://www.wattcher.nl) is a Smart PSS developed to make consumers more aware of their energy consumption at home. The product in Wattcher is a sensor that measures and displays the consumed energy. The service is a web portal where consumers can store their measured data and track their development over time. An important feature of this web portal is an Internet forum that consumers can use to talk to each other, to compare measured data, and share advice on how to reach energy consumption goals. Other types of social media that are typically implemented in Smart PSSs include the evaluative rating of content by consumers, *connecting and sharing of information* through social networks, such as Facebook, and the possibility of sharing information via email.

> For example, for the Wattcher you can talk with other people that also use it and see how they are doing, so yeah.
>
> I think the consumer experience of this, the Wattcher, is similar to the Nike+ and the Blood Pressure Monitor group, […], in the same sense that you can socialize through it.

Thus, through the use of social media, Smart PSSs enable consumers to share their opinions about, and personal experiences with the product and service. A good implementation of these communication channels could have significant implications for maintaining momentum in the use of Smart PSSs. Internet facilitates the rapid dissemination of word-of-mouth. Companies experience reduced control over the opinions of consumers, which could lead to negative repercussions for the adoption of market offerings. For example, the rapid dissemination of negative opinions by consumers could result in a slow adoption of the market offering. However, by implementing social media as complement to their communication strategies, companies can engage consumers, communicate directly, provide targeted information, and shape and monitor their opinions (Mangold & Faulds, 2009). Thus, designers need to be aware of the important role that social media play in the adoption of Smart PSSs, and their relevance in bringing such services closer to consumers. Moreover, the implementation of social media in Smart PSSs may be an important expectation of consumers. Thus, future research could set out to define the instances in which these communication channels are desired, and how they create value for consumers (e.g., Is the communication expected to take place directly through the product? How does communicating through the product influence consumers' perceptions of the Smart PSS? Does it increase perceptions of empowerment?). Finally, because social media also supports two-way communication between consumers and service providers (as previously discussed), creating a feeling of community may be an important way of individualizing and bringing the service closer to consumers. How the product in the Smart PSS can be used to support this communication, and for which touchpoints in the provider-consumer interaction, are interesting avenues for future research.

Service Involvement

Service involvement refers to the nature of the relationship between consumer and service provider. As described in the preceding sections, Smart PSSs promote the *recurrent interaction* between providers and consumers. This recurrent two-way interaction facilitates the deeper understanding of consumers, prolongs the relationship between consumer and provider, and allows the provision of more targeted solutions to consumers. For example, consumers of Kindle may access the Smart PSS several times in one month, reading and participating in user reviews, or simply buying Kindle content. Every time consumers access Kindle, Amazon can register, follow up their preferences, and learn from them. In contrast, other types of PSSs (including those with lower or no content of IT technology) focus on particular stages of the consumer journey and involve fewer interactions between consumers and service providers. In tools sharing, for instance, consumers pay to make temporary use of professional tools for gardening, construction, and other purposes (Mont, 2004). After being used, the tools are returned so other consumers can make use of them. Thus, unlike with Smart PSSs, the interaction between service provider and consumers is virtually non-existent during the use of the product use, and between rental periods. Furthermore, because the product has no ICT in it, it does not connect the service to the product, making it more vulnerable to market replacements. Smart PSSs, on the contrary, have the unique potential to recurrently link product, service and

consumers, which could translate into benefits for consumers (e.g., personalized solutions, prompt reaction to consumers' needs). An often-mentioned way of promoting the recurrent interaction between the consumer and the service provider is by adding (e.g., downloading, buying) new content, which can renew the experience of consumers with the Smart PSS. For example, iMarker is a digital pen for children that functions in combinations with an application developed for iPad. With iMarker, consumers can select from a wide range of (digital) drawing, and choose from a variety of strokes and textures to draw. Because the application is updated periodically, consumers get access to new content (i.e., drawings) which keeps their interaction with the Smart PSS active:

> Because it evolves, all those things evolve around a physical object which improves your life or something of your life, like driving or creative coloring for kids […] so if you like something and you can download more or if you are interested in specific animals to draw, you can probably download a whole lot of animals. And if you are interested in some kind of app then you can download a whole lot of them or improve those apps […] So the fact is that you actually don't buy a complete device in the first moment, although you pay the most for that, but later on you can actually buy little parts to improve that device.

For designers, it is important to understand the level of involvement that service providers aim to attain with their consumers, and vice versa. This understanding can be used as a framework in the developing Smart PSSs that support the correct level of interaction. Having Smart PSSs that involve consumers extensively, but without the correct infrastructure to support it, may be detrimental for their adoption. Establishing an accurate level of involvement could lead to more congruent Smart PSSs, where product and service features are in balance.

Product Ownership

The characteristic of product ownership has implications for the business model of the Smart PSS and is linked to prior classifications (i.e., types) of PSSs (e.g., Baines et al., 2007; Tukker, 2004). First, the tangible product in the Smart PSS can be sold to consumers and its ownership transferred to them. In that case, consumers are responsible for the maintenance of the product. Maintenance includes installing software updates developed by the service provider, to guarantee the correct functionality of the Smart PSS. In Smart PSSs, consumers buy the product to gain access to and obtain value from the service. Owning the product grants consumers unlimited access to the PSS, unless restricted by other business-model related aspects, such as monthly fees to access the service. Examples of Smart PSSs where the ownership is transferred to consumers include Nike+, Wattcher and Kindle.

Second, the ownership of the product can be kept with the provider, who is responsible for maintenance and functionality of the products. In this case, consumers have limited access to the PSS, typically for specific periods of time. Different to those Smart PSSs where the ownership is transferred, consumers interact with service providers to gain access to the tangible products. Examples of Smart PSSs where the ownership is kept with the provider include Green Wheels and Laundry View.

> Coffee Vending Machine, this is about having a big expensive machine which you rent, and which gives you what you want, and which is maintained by other people, which takes away some responsibility of your own and some risk …and it was similar to the Multi Laundry room where you also all share, it is supervised by someone else and they take care of it as well. It's very nice if you don't have the money to buy some for yourself.

> So with the rental I will just put "rental" because I believe that they just rent things, that is different for the user because you give things back and that is yet another step and you don't own the product. It is also a different thing, if you own the products then you have to think of how to get rid of it as well.

Individual/Shared Experience

Individual/shared experience relates to the extent to which consumers' experiences with the Smart PSS are shared with other users. This characteristic can vary among Smart PSSs. For example, Direct Life is owned by consumers and used on an individual level. Although the system facilitates the communication between different consumers, the product as well as the service in Direct Life are used and experienced on an individual level. Differently, Nike+ encourages groups of friends, who all own Nike+, to compete with each other in reaching common goals. Their experiences are linked through the service, which connects consumers by depicting, for example, performance rates among competing friends. Because each consumer makes use of Nike+, the individual experience with the Smart PSS is maintained. However, the idea of goal sharing, and the simultaneous use of the Smart PSS, creates a shared experience between users of the Smart PSS. Finally, when talking about shared experience, participants used words such as fun and games, suggesting "gamification", defined as the use of gaming elements in non-gaming contexts (Deterding, Dixon, Khaled, & Nacke, 2011, http://gamification.org), as an appropriate strategy to promote the shared experience among consumers. To illustrate this point, consider what a participant said about Poken and Sifteo Cubes (https://www.sifteo.com), a Smart PSSs that allows consumers to play digital games in the physical world:

> …I guess the fun part, the most fun part about it for me, it would be to share it with other people and the Sifteo Cubes is the same because you can also play games on your own with the interactivity and stuff, but I think it's most fun to play with other people, and Poken is not very much fun if you do it alone and it is about the sharing as well, sharing the activity or the information or whatever.

Other Smart PSSs are shared by different consumers, while the experience is to a large extent individual. For example, the cars of Green Wheels can be used by different consumers in a sequential manner. Although different consumers share the cars throughout the day, their experiences with the system remain individual. By contrast, in Laundry View consumers share the laundry facilities with others, and their experiences (may be) greatly influenced by the interactions among them.

Designers ought to be aware of the desired level of shared experience, because it may lead to important differences for the definition of Smart PSSs. For example, in designing shared experiences, designers may need to consider technical features that support the interconnection of the products (e.g., Nike+), or devise ways to control for environmental aspects likely to influence the individual, yet shared, experience of consumers (e.g., the potential noise, messiness found at shared laundry facilities). Similarly, designers need to be aware of all the aspects surrounding the individual experience of products. For example, a product that is owned and experienced by an individual may require decisions on product aesthetics that are particularly focused on satisfying personal needs of consumers, such as the need to express their identity and/or associate themselves with social groups (Crilly, Moultrie, & Clarkson, 2004). Alternately, designing experiences for shared Smart PSSs may require more general considerations on the aesthetics on the product, turning the focus of designers to creating uniqueness and individuality for the consumer via the service of the PSS.

Conclusion Study 1

Study 1 has led to the identification of six characteristics of Smart PSSs. As may be evidenced in the large number of codes associated to consumer empowerment, this characteristic seems to play a particularly important role in the definition of Smart PSSs and in the creation of meaningful experiences/interactions for consumers. More generally, the identified characteristics can help designers to attain a better understanding of the possibilities emerging from the combinations of smart products and e-services in terms of interactions and experiences for consumers. The analysis of a large set of PSSs helped to achieve depth in our descriptions of each characteristic. Consequently, our findings could guide the work of designers in the design of Smart PSSs, help them to define the experience they want to create around the system, and to make more informed decisions throughout the design process.

An important limitation of Study 1 arises from the type of participants used in the study. Although participants had a background in industrial design, their experience designing Smart PSSs was limited. Thus, Study 1, excludes the professional expertise of an actual Smart PSS design process, which can lead to the prioritization of specific characteristics, and the identification of new ones. To counter these limitations, we set out to validate our findings with Study 2, by discussing the characteristics we identified in Study 1 with experienced professionals involved in the design of Smart PSSs.

Study 2

Method Study 2

Study 2 was carried out with two objectives. First, to validate the findings in Study 1 by checking their trustworthiness with experienced professionals (Thomas, 2006). Second, to obtain new knowledge from professionals involved in the design of Smart PSSs. In this paper, we limit our reports to aspects related to the characteristics of Smart PSSs.

Interviews were conducted with 10 professionals from six different companies. Companies had different backgrounds and the Smart PSSs they developed were intended for different use contexts. Participants were contacted via research partners or personal contacts. Besides different types of designers (e.g., interaction designers, product designers, service designers), they included other professionals involved in the creation of Smart PSSs (e.g., problem owners). This varied group of participants, with ample experience in design, helped to ensure the trustworthiness of the identified characteristics. Furthermore, it permitted us to make use of multiple new Smart PSS cases related to business-to-consumer solutions to reflect on the characteristics and/or identify new ones.

Procedure

In-depth, semi-structured interviews were conducted with all participants. To reflect on the characteristics, participants were asked to choose a specific Smart PSS project they had contributed to. The interview guide was divided into two sections. After a short introduction about the purpose and content of the interview, participants were asked to describe the Smart PSS project they had chosen. It was important for them to describe the Smart PSS in their own words, objectively and without preconceptions of the characteristics to be discussed. The goal was to verify that the Smart PSS being discussed could be labeled as such and to create the opportunity to identify new characteristics to be added to the list. The last section addressed the characteristics of Smart PSSs identified in Study 1 in a direct manner. Characteristics were introduced and discussed one-by-one. To guide the introduction of the characteristics, illustrative cards depicting keywords and examples of existing Smart PSSs were developed for each characteristic. Questions included: To what extent does this characteristic apply to the Smart PSS you developed? How important is this characteristic for the adoption of the Smart PSS? To answer these questions, participants primarily reflected on the Smart PSSs they had helped develop. The interviews concluded by asking participants about relevant characteristics/information missing in our list of characteristics. Interviews lasted between 50 and 105 minutes, which varied according to the time availability of respondents, and their level of detail while explicating concepts.

Data Processing

All interviews were recorded and fully transcribed. Interviews were analyzed making use of the software Atlas.ti. The data processing was both inductive and deductive. The analysis initiated from the characteristics identified in Study 1. However, we paid close attention to possible new concepts emerging from participants' explanations of the Smart PSS.

The data processing approach was as follows. First, a set of five interviews was fully coded by the main researcher, generating an initial set of 30 codes related to the characteristics of Smart PSSs. This initial set of codes was discussed with the other researchers, taking into account quotes of different participants to assure the correct interpretation of the data. Twenty-five codes

were identified as directly related to any of the characteristics of Smart PSSs identified in Study 1. The remaining five codes (i.e., "continuous growth", "ecosystems", "evolution = not changing entire system", "gamification", and "clear roadmap of offering") led to the identification of an additional characteristic of Smart PSSs: *continuous growth*. Subsequently, the remaining five interviews were coded, adding three new codes to the list, which belonged to any of the already identified characteristics.

Findings and Discussion Study 2

The main objective was to validate the characteristics of Smart PSSs, as identified in Study 1. This objective was met satisfactorily. Each participant identified several characteristics as relevant to the Smart PSS project(s) he had contributed to. Whether a characteristic was perceived as more relevant depended on the goal for which the Smart PSS was developed. These variations helped to validate our idea that the characteristics of Smart PSSs are context dependent, and not necessarily generalizable across all types of Smart PSSs. This context dependency of the characteristics is exemplified by the following statement, in relation to a Smart PSS developed for the taxi market, which connects individual consumers with taxi drivers:

> I don't see the goal for our consumers to communicate [i.e., community feeling] with each other and say, yesterday I had this great taxi, maybe tomorrow I will try this one. On the driver's side I see more of a community […] they are individual drivers and they can say, hey we work always together so give us a name and they can kind of create a virtual taxi company within our system […] So driver's side yes, so they can do their work better. Consumer's side no.

Some characteristics of Smart PSSs were acknowledged more prominently than others. In this regard, consumer empowerment, providing consumers with feedback and meaningful information, was perceived again as particularly important for creating value around the Smart PSSs. One participant had the following to say about empowerment, in relation to the Smart PSS he helped design, which was intended to help consumers to reduce their electricity consumption at home:

> This is crucial. This is the core, you know?, it's giving you this information that before you couldn't have […] The information that people had was [available] once a year when they received the bill. It's impossible to change your behavior based on that, because it doesn't contain any information. Actually, it's just an amount of money. This doesn't give you any information that can help you think about: What can I do to lower this amount of money?.

Another characteristic often mentioned by participants was the individualization of services; approaching individual consumers through digital means in a meaningful and user-friendly way. This characteristic was considered relevant, because it can bring important challenges for the design process, such as the creation of high-quality interactions that positively influence the experience of consumers with a system (Valencia, Mugge, Schoormans, & Schifferstein, 2014).

Furthermore, participants considered service involvement, and in particular the recurrent interaction between providers and consumers, an important characteristic of Smart PSSs. To deepen this topic, we now proceed to introduce the seventh characteristic of Smart PSSs identified in Study 2.

Continuous Growth

Continuous growth relates to how Smart PSSs are in a *continuous state of development*, adapting or changing their value proposition over time. From a user experience perspective, the goal of implementing continuous growth (evolution) is to keep the market offering relevant, thereby maintaining their engagement (i.e., recurrent interaction) with the Smart PSS. Furthermore, by keeping the Smart PSS relevant for consumers, the perceived value of the system to the company can also be sustained over time. As explained by participants, digital technologies are developing fast and consumers are becoming comfortable around them. While consumers may place high value on a Smart PSS that is novel, such novelty may diminish over time as consumers' expectations of the Smart PSS change:

> I have talked to a lot of people about it; for a while they kind of [perceived] it like they don't think it provides any more meaning or any more value to them, so they stop using it. So there is sort of a direct correlation between the meaning that it's providing for my life over time. So in the beginning there is a lot of meaning and then after a while it sort of goes down.

Different tactics were mentioned as a way of leveraging the continuous growth of Smart PSSs. For example, to widen the offer of the system (and thus the options for consumers), companies can *periodically introduce new content or functionalities* via the e-service. Amazon's Kindle, for example, expands its content with the introduction of new content, such as books or games. Kindle has also grown by expanding the functionality of its product and software. In the early days of Kindle, it was only possible to read Kindle's e-books through a Kindle device. Nowadays, Kindle has expanded its functionality, allowing consumers to read e-books through multiple touchpoints, including PCs and mobile devices. Another tactic is the option to *open the system to other companies (or individuals*) who may want to implement services through the smart product. This is a tactic used by companies providing smartphones and other mobile devices, which allows independent developers to create applications to be distributed through their digital servicescapes (e.g., iTunes). Consequently, these companies have a wide range of new contents/functionalities available for their consumers, which facilitates the individualization of the Smart PSS, and answers to the changing needs of consumers over time. Finally, companies may also *open the system to consumers*, allowing them to co-create the system, thereby increasing their feelings of ownership towards the Smart PSSs. Although the participants in Study 2 had not developed a Smart PSS implementing this type of feature, some mentioned it as an important trend in the development of Smart PSSs. This interesting concept progresses the traditional views on ownership, by placing the value on the 'intangible' aspects of the Smart PSS.

> I think that that's a common thing right now, maybe what will even go into the future, will be to add design skills in normal people so that they could get involved as a community in the design and manufacturing of their products and services […] And of course, manufacturers will stay manufacturers, and designers will still have their design expertise, but there will be a new design skill for anybody to also design and to also manufacture. And that will bring of course the community feeling even more, and not only the community feeling but also the ownership of the products and services.

For designers, continuous growth may be a fundamental aspect of Smart PSSs, primary to creating long lasting relationships between service providers and consumers. As discussed, available technologies and market standards change fast, and consumers' expectations of Smart PSSs may change rapidly as they grow adapted to new technologies. Smart PSSs that do not address the needs and expectations of consumers may result on shorter lasting interactions between service providers and consumers. Thus, continuous growth can counter this possible issue by developing a system that adapts to its context.

As the Smart PSS is in a constant state of change, the design of Smart PSSs is an enduring activity too. The long-lasting nature of the design of Smart PSSs may pose several opportunities and challenges for designers of Smart PSSs (Valencia et al., 2014). Because of the recurrent interaction between service providers and consumers, companies can obtain consumer insights that can guide the further development of the system. As new features/content are being introduced, companies can obtain direct feedback from consumers (related to the relevance of the implemented changes), and fine-tune their development activities. Furthermore, the continuous growth of the system typically occurs through the e-service, which reduces the alterations needed in the smart product, hence, lessening the amount of resources needed to improve the system. Challenges in the implementation of continuous growth relate to the need to foresee important required technology in the smart product, which can facilitate the implementation of future interactions/functions through the e-service. Consequently, the design of Smart PSSs can benefit from the involvement of professionals with a keen eye for market trends, whose input can help manage the design process, for example, by defining the development steps guiding the growth of the Smart PSS.

Overall Discussion and Conclusion

Our research objective was to provide designers with new knowledge that can aid the design of Smart PSSs. In particular, our objective involved the understanding of Smart PSSs with an emphasis on user experience/interactions (i.e., value in use), which can foster long lasting relationships between service providers and consumers. To achieve this, we set out to conduct two studies with young and experienced design professionals. These studies helped us to examine multiple Smart PSS cases, and to capture the thoughtful reflections of design professionals around the characteristics of Smart PSSs. Accordingly, these studies led to the identification of seven characteristics of Smart PSSs, summarized in Table 1.

Table 1. Summary of characteristics of Smart PSSs: Definitions and examples.

Characteristic	*Description*	*Example*
1. Consumer empowerment	Enabling consumers to make decisions or take action on their own terms. Enabled by: − Providing feedback (i.e., relevant information) to consumers: • Transforming data into information. • Information regarding product/service status • Information about product/service features prior to purchase − Providing them with options.	− Showing graphs that allow consumers to track development over time. − Using time estimates to indicate availability and/or maps to show location. − Product/service descriptions and/or user reviews. − Implementing extensive libraries with content, which consumers can explore.
2. Individualization of services	Making consumers feel important by addressing them as unique individuals.	− Identification of consumers. − Use of digital servicescapes to communicate directly with consumers. − Using a human-like 'tone' when communicating with consumers.
3. Community feeling	Facilitating the communication between consumers.	− Enabling social media platforms, such as blogs, Facebook, or email to share content/information.
4. Individual/shared experience	Enabling a shared experience (with other consumers) through the Smart PSS.	− Encouraging consumers to simultaneously use the Smart PSS (e.g., game) and share experiences.
5. Product ownership	Defining who is responsible for the product over time.	− Rented product. − Product owned by consumer. − Product owned by consumer but shared with others (e.g., car pooling).
6. Service involvement	Facilitating/promoting the recurrent interaction between consumer and service provider.	− Encouraging daily or weekly interaction with gaming strategies. − Renewing the experience of consumers through content.
7. Continuous growth	− Facilitating the growth/evolution of the system. − Maintaining the Smart PSS and its perceived value relevant over time.	− Introducing new content/functionalities periodically. − Opening the system to independent developers to create functionalities/services around the smart product. − Providing tools to consumers to facilitate the development of their own content.

The characteristics of Smart PSSs outlined in this paper provide a first overview of the opportunities in terms of value creation that arise from the integration of smart products and e-services. Importantly, Smart PSSs promise to be an important means of empowering consumers. The benefits of e-services in providing consumers a sense of control have been previously discussed (Meuter et al., 2000). However, when combined with smart products, designers (and companies) are presented with new opportunities to collect rich data about consumers, and to translate that into meaningful, highly individualized services (i.e., interactions and experiences), which can elevate consumers' sense of control. Similarly, such levels of individualization can lead to important benefits for the design process. Market feedback received through the Smart PSSs enables companies to follow the changes in consumers' preferences closely. Companies have the opportunity to react/adapt more rapidly to the market, and stay relevant for longer periods of times. Furthermore, although Smart PSS are not necessarily designed with eco-efficiency as the underlying goal, we see a potential link between Smart PSSs and the eco-efficiency described in the traditional PSS literature. As Smart PSSs become highly individualized, consumers place less relevance on the tangible product, and give more value to the information/digital content/services deriving from the system. Moreover, the characteristic of continuous growth favors the maximization of changes in the system through the e-service, potentially increasing the lifespan of the smart product.

Despite the recognizable advantages deriving from the integration of smart product and e-service, designers should be cautious in the design of Smart PSSs. In a recent study, the authors identified *the definition of the value position* as one significant challenge for designers of Smart PSSs (Valencia et al., 2014). As with traditional services (Polaine, Løvlie, & Reason, 2013), Smart PSSs can be complex offerings, involving multiple and different types of users, touchpoints and use contexts. Consequently, the relevance of the outlined characteristics can vary considerably across contexts. The effective implementation of the characteristics of Smart PSSs requires the thorough understanding of the user, the company and their context, in order to create Smart PSSs that are of value to individual consumers and organizations. Regarding this challenge, informal discussions with practitioners have indicated that the discussed characteristics could be used as a goal-setting tool, in terms of intended user experience, and to help communicate design goals among members of the design team. In combination with other design tools, such as customer journeys and written scenarios (see e.g., Polaine et al., 2013; Stickdorn & Schneider, 2010; Van Boeijen, Daalhuizen, Zijlstra, & Van der Schoor, 2013), the characteristics of Smart PSSs could become a relevant tool in identifying the appropriate level of interaction to be implemented in the system. Furthermore, the characteristics of Smart PSSs could be used to cross-check design goals with outcomes throughout the entire design process, and to better understand how such design goals change as the system grows. Finally, although the characteristics we identified are based on Smart PSSs, and intended for designers of Smart PSSs, we believe some may be transferable to other design contexts, such as the design of digital services.

There are different research opportunities that can strengthen our findings. First, the characteristics we have outlined can be implemented at various levels of a spectrum (e.g., high vs. mid, vs. low community feeling), according to the context for which the Smart PSS is developed. Consequently, future research should set out to explore how consumers experience Smart PSSs in different use contexts, and the perceived value associated to the characteristics. This new information can help define the appropriate level of implementation for different scenarios, and help understand the role of the characteristics on the adoption and success of the Smart PSS. Furthermore, having this consumers' view can help fine-tune the characteristics of Smart PSSs, and help designers make more informed decisions during the design process. Second, because of the evolving nature of Smart PSSs, new characteristics may emerge in the future, which may be of relevance in the design of Smart PSSs. Thus, future research should aim to review the identified characteristics, and to assess them against emerging types of Smart PSSs. Such activity can lead to the inclusion of new characteristics, or the broadening of descriptions by, for instance, adding new ways of implementing characteristics.

Acknowledgments

This research is part of the Creative Industry Scientific Program (CRISP), which focuses on the design of product-service systems as a means of stimulating the continuing growth of the Dutch Design Sector and Creative Industries. The CRISP program is partially sponsored by the Dutch Ministry of Education, Culture, and Science. We would also like to thank our industry partners and other professionals, whose willingness to discuss our research outcomes made this work possible.

References

1. Baines, T. S., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard, J., . . . & Wilson, H. (2007). State-of-the-art in product-service systems. *Journal of Engineering Manufacture, 221*(10), 1543-1552.
2. Bitner, M. J. (1992). Servicescapes - The impact of physical surroundings on customers and employees. *Journal of Marketing, 56*(2), 57-71.
3. Crilly, N., Moultrie, J., & Clarkson, P. J. (2004). Seeing things: Consumer response to the visual domain in product design. *Design Studies, 25*(6), 547-577.
4. Dabholkar, P. A. (1996). Consumer evaluations of new technology-based self-service options: An investigation of alternative models of service quality. *International Journal of Research in Marketing, 13*(1), 29-51.
5. Davis, S., & Botkin, J. (1994). The coming of knowledge-based business. *Harvard Business Review, 72*(5), 165-170.
6. Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining gamification. In *Proceedings of the 15th Conference on International Academic MindTrek: Envisioning Future Media Environments* (pp. 9-15). New York, NY: ACM.

7. Goedkoop, M. J., Van Halen, C. J. G., Te Riele, H. R. M., & Rommens, P. J. M. (1999). *Product service systems: Ecological and economic basics. Hague, the Neherlands: Dutch Ministries of Environment (VROM)*. Retrieved September 30, 2014, from: http://teclim.ufba.br/jsf/indicadores/holan%20Product%20Service%20Systems%20main%20report.pdf
8. Handelt, S., & Imai, S. (1972). The free classification of analyzable and unanalyzable stimuli. *Attention, Perception, & Psychophysics, 12*(1), 108-116.
9. Kimbell, L. (2011). Designing for service as one way of designing services. *International Journal of Design*, *5*(2), 41-52.
10. Lagrosen, S. (2005). Effects of the internet on the marketing communication of service companies. *Journal of Services Marketing, 19(2), 63-69.*
11. Maass, W., Filler, A., & Janzen, S. (2008). Reasoning on smart products in consumer good domains. *Constructing Ambient Intelligence Communications in Computer and Information Science*, *11*(4), 165-173.
12. Mangold, W. G., & Faulds, D. J. (2009). Social media: The new hybrid element of the promotion mix. *Business Horizons, 52*(4), 357-365.
13. Meuter, M. L., Ostrom, A. L., Roundtree, R. I., & Bitner, M. J. (2000). Self-service technologies: Understanding customer satisfaction with technology-based service encounter. *Journal of Marketing, 64*(3), 50-64.
14. Mont, O. (2004). Institutionalisation of sustainable consumption patterns based on shared use. *Ecological Economics, 50*(1-2), 135-153.
15. Mont, O., & Plepys, A. (2007). System perspective on service provision: A case of community-based washing centres for households. *International Journal of Public Affairs, 3*, 130-151.
16. Morelli, N. (2002). Designing product/service systems: A methodological exploration. *Design Issues, 18*(3), 3-17.
17. Mugge, R., Schoormans, J. P. L., & Schifferstein, H. N. J. (2009). Incorporating consumers in the design of their own products. The dimensions of product personalization. *CoDesign, 5*(2), 79-97.
18. Polaine, A., Løvlie, L., & Reason, B. (2013). *Service design: From insight to implementation.* New York, NY: Roselfeld Media.
19. Rijsdijk, S. A., & Hultink, E. J. (2009). How today's consumers perceive tomorrow's smart products. *Journal of Product Innovation Management, 26*(1), 24-42.
20. Rust, R. T., & Lemon, K. N. (2001). E-service and the consumer. *International Journal of Electronic Commerce, 5*(3), 85-101.
21. Rust, R. T., & Kannan, P. K. (2003). E-service: A new paradigm for business in the electronic environment. *Communications of the ACM, 46*(6), 36-42.
22. Sleeswijk Visser, F. (Ed.). (2013). *Service design by industrial designers (1st ed.).* Delft, the Netherlands: Lulu.
23. Stafford, T. F. (2003). E-Services. *Communications of the ACM, 46*(6), 26-28.
24. Stickdorn, M., & Schneider, J. (2010). *This is service design thinking*. Amsterdam, the Netherlands: BIS Publishers.
25. Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation, 27*(2), 237-246.
26. Tomiyama, T. (2003). Service CAD. In *Proceedings of the 1st Conference of SusProNet (pp. 5-6)*. Amsterdam, the Netherlands: The Centre for Sustainable Design.
27. Tukker, A. (2004). Eight types of product–service system: Eight ways to sustainability? Experiences from SusProNet. *Business Strategy and the Environment, 13*(4), 246-260.
28. Valtonen, A., (2005). Six decades – and six different roles for the industrial designer. In *Proceedings of the Conference of Nordic Design Research (NORDES)*. Copenhagen, Denmark: Nordic Design Research.
29. Van Boeijen, A. G. C., Daalhuizen, J. J, Zijlstra, J. J. M., & Van der Schoor, R. S. A. (Eds.) (2013). *Delft design guide.* Amsterdam, the Netherlands: BIS Publishers.
30. Valencia, A., Mugge, R., Schoormans, J. P. L., & Schifferstein, H. N. J. (2011). Designing a product service system: Does congruity add value? In *Proceedings of the 1st Cambridge Academic Design Management Conference (pp. 1-14)*. Cambridge, UK: Institute of Manfacturing.
31. Valencia, A., Mugge, R., Schoormans, J. P. L., & Schifferstein, H. N. J. (2014). Challenges in the design of smart product-service systems (PSSs): Experiences from practitioners. In E. Bohemia, A. Rieple, J. Liedtka, & R. Cooper (Eds.) *Proceedings of 19th Conference of DMI: Academic Design Management Conference.* Boston, MA: DMI.
32. Vilnai-Yavetz, I., & Rafaeli, A. (2006). Aesthetics and Professionalism of virtual servicescapes. *Journal of Service Research, 8*(3), 245-259.
33. Wolf, M., & McQuitty, S. (2011). Understanding the do-it-yourself consumer: DIY motivations and outcomes. *AMS Review, 1*(3-4), 154-170.
34. Yang, X., Moore, P., Pu, J. S., & Wong, C. B. (2009). A practical methodology for realizing product service systems for consumer products. *Computers & Industrial Engineering*, *56*(1), 224-235.

Appendix

Appendix A. List of selected stimuli.

#	*Product-service system (in alphabetical order)*	*Source*
1	Albert Hein Self-Scanning	http://ahxlelandstraat.nl/zelfscan.html
2	AR.Drone and iPhone	http://ardrone.parrot.com
3	Avelle (also known as Bag Borrow or Steal)	http://www.bagborroworsteal.com
4	Blood Pressure Monitor	http://www.withings.com
5	Book Crossing	http://www.bookcrossing.com
6	iMarker and Color Studio HD App	http://www.griffintechnology.com/crayola-colorstudiohd
7	DirectLife	http://www.directlife.philips.com
8	DE CoffeeVending Machines (office)	http://www.douweegbertsprofessional.com
9	Fiat eco:Drive	http://www.fiat.com/ecodrive
10	Hema Photobooks	http://foto.hema.nl
11	Green wheels	https://www.greenwheels.com
12	Interactive TV Ziggo	https://www.ziggo.nl
13	Smartphones and apps (e.g., iPhone)	http://www.apple.com
14	Kindle	https://kindle.amazon.com
15	Laundry View	http://www.laundryview.com
16	Liftmaster® 8550 and Internet Gateway	http://www.liftmaster.com/lmcv2/products/introducingliftmasterinternetgateway.htm
17	Multi-laundry room	
18	Nike+	http://nikerunning.nike.com
19	Octopus Beats Watch	http://www.beats.com.hk
20	Philips Lifeline	http://www.lifelinesys.com/content/lifeline-products/auto-alert
21	Poken	http://www.poken.com
22	PT/INR Self Testing	http://www.inrselftest.com
23	Ray-Ban Virtual Mirror	http://www.ray-ban.com/usa/science/virtual-mirror
24	Sifteo Cubes	https://www.sifteo.com
25	Skinit	http://www.skinit.com
26	The Living Christmas Company	http://www.livingchristmas.com
27	The WiFi Body Scale	http://www.withings.com
28	TomTom	http://www.tomtom.com
29	Wattcher	http://www.wattcher.nl

Appendix B. List of resulting codes, themes and characteristics.

Code	*Theme*	*Relation to Characteristics*
1. Control over own progress 2. Control over shared content: Privacy 3. Controlling own experience 4. Controlling content	Control	Consumer Empowerment
5. Type of Feedback (user/personalized/preview/easy to understand) 6. Accuracy 7. Action-reaction	Feedback	Consumer Empowerment
8. Collecting data 9. Type of content 10. Measuring data	Data	Consumer Empowerment
11. Tracking (development/location/state)	Tracking	Consumer Empowerment
12. Encourage activities 13. Reducing tasks	Goal: Activity oriented	Consumer Empowerment
14. Create a personalized product/experience 15. Self expression 16. Trust 17. Risk (Reduced risk) 18. Empowerment	Goal: Consumer experience	Consumer Empowerment
19. Digital servicescape (Computer as interface) 20. Identifying (Account) 21. Service = 'They do something for you' 22. Service reaching consumer/real person/push notifications	Service	Individualization of Services
23. Connecting people 24. Easy access to information 25. Level of experience/group/individual 26. Consumers reaching other consumers/exchanging content/sharing 27. Transferring data	Connection	Community Feeling, Individual/Shared Experience
28. General procedures (ordering/payment/delivery) 29. Before/after purchase experience 30. Paying for extended experience 31. Service = dynamic, not static 32. Service = Someone is behind it	Business model	Service Involvement
33. Your own 34. Shared PSS 35. Temporary use	Ownership	Product Ownership
36. Continuous growth 37. Ecosystems 38. Evolution = Not changing entire system 39. Gamification 40. Clear roadmap of offering	Continuous Growth	Continuous Growth

Note: The table lists the 40 most relevant codes related to the characteristics of Smart PSSs. Code 1-35relate to the characteristics of Smart PSSs, as reported in Study 1. Codes 36-40 belong to "Continuous Growth", as identified in Study 2. Remaining codes have been deliberately excluded from the table. Even though they have helped to develop our theories, they relate to other aspects, such as definitions(e.g., PSS = product and service inseparable) and product requirements (e.g., data storage, portability), which do not directly relate to our research objective.