Characteristics of Smart PSSs: Design Considerations for Value Creation*

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This article draws the attention of design academics and practitioners to a new type of market offering: Smart Product-Service Systems (Smart PSSs). Smart PSSs integrate smart products and e-services into single solutions, bringing the potential to create innovative interactions between consumers and providers. The article outlines six defining characteristics of Smart PSSs: *Consumer empowerment, individualization of services, community feeling, service involvement, product ownership and individual/shared experience*. Furthermore, the article discusses the implications for designers and design managers who are confronted with the creation of Smart PSSs. Our findings add to the discussion on what special design considerations must be taken when integrating products and services. Specially, knowledge is provided that can aid designers in the creation of Smart PSSs that bring the appropriate value and experience to consumers.

INTRODUCTION

Product-service systems (PSSs) are market offerings that combine products and services, and present them as single solutions to consumers (Goedkoop et al., 1999). In contrast to the traditional services attached to products (e.g., warranty), the service in a PSS significantly adds value to the experience of the consumer with the market offering. Launderettes are an example found in the existing literature (e.g., Mont and Plepys, 2007). This PSS is composed

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of washing machines (the products) that are made readily available to consumers for attended and unattended self-service purposes (the service). Consumers can access the launderette at any time of their convenience. Furthermore, many launderettes offer additional services, such as the folding of laundered clothing, which add value to the laundry experience.

In this paper, we focus on the so-called Smart PSS, an emerging type of PSS that is targeted to individual consumers. New technological advances have made it possible to combine products and services in innovative ways. Today, many traditional products can be equipped with information technology, which enables them to connect to the Internet. For instance, Laundry View has brought launderettes to a new level (http://www.laundryview.com). Laundry View is an Internet application that serves as a communication channel between the provider of the launderette and individual consumers. Laundry View allows consumers to check the availability of washing machines, view an estimated time of availability, and set notifications when a required machine becomes available. Because of this, consumers can save time by avoiding unnecessary visits to the launderette.

We refer to these PSSs as smart because they "contain information technology (IT) in the form of, for example, microchips, software and sensors and that are therefore able to collect, process and produce information" (Rijsdijk and Hultink, 2009, p. 25). In contrast to smart products, Smart PSSs integrate an e-service with the product to jointly address specific needs of consumers. 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., web platform) that consumers can access to: 1) store the personal data that was measured during the day, 2) access descriptive graphs of their chronological progress, and 3) get in touch with health experts for professional advice.

From a design management perspective, the integration of product and services has different implications. First, designers are accustomed to creating products and services separately. However, the product and service in a Smart PSS are so deeply intertwined that a distinction between the two may not be possible. Similarly, consumers may no longer see the difference between product and service and evaluate the PSS as a whole. Designers may thus need to adopt new tools and methodologies that facilitate the effective integration of products and services (Morelli, 2002). Moreover, designers will require a better understanding of how the product and the service complement each other, to create and communicate value to consumers. Our research aims to address these growing needs by outlining the defining characteristics of Smart PSSs. Our findings can help designers to attain a better understanding of the features that consumers will expect in Smart PSSs, manage such expectations, and create solutions that bring the appropriate value and experience to consumers. Furthermore, our insight can be used in the creation of new tools and methodologies to equip designers in the creation of Smart PSSs.

From Smart Products to Smart Product-Service Systems

Smart products are market offerings characterized by the high content of IT technology, and their ability to process and produce information (Rijsdijk and Hultink, 2009). 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 and Botkin, 1994). Several conceptualizations for the smartness of products have been proposed before (e.g., Maass et al., 2008, Rijsdijk and Hultink 2009). For example, 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 degree, 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. For example, Direct Life is an autonomous Smart PSS because the sensor measures movement unobtrusively throughout the day while consumers continue with their daily routines. Direct Life is adaptable because it bases its measures on personal information, such as age or weight. Thus, the data and advice provided by the Smart PSS adapts to the personal conditions of individual consumers. Finally, Direct Life is able to cooperate with other devices because the data collected through the day must be transferred to a computer to access it.

An important difference between Smart PSSs and smart products is that the first integrates a service with the product to jointly address the needs of consumers. Many of these PSS have e-services that deliver value to consumers through electronic means (Stafford, 2003). For instance, an important characteristic of e-services is their capacity to support a two-way dialogue between consumer and service provider (Rust and Kannan, 2003). Through the course of this dialogue, providers can collect relevant and specific information about consumers, which facilitates the creation of customized services to satisfy their individual needs. Furthermore, self-service technologies have been reported to provide a sense of control to consumers who can handle their transactions any time they want (Meuter et al., 2000). In this respect, 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 transaction. We argue that Smart PSSs are such technology-enabled innovations, which create new dynamics in the interactions between the service provider and the consumer, and can add value to the experience of consumers.

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 consumers. Our conceptualization focuses on the opportunities Smart PSSs offer to create new interaction between consumer and service provider. While the characteristics of PSSs have been previously discussed (e.g., Baines et al., 2007, Tukker, 2004), there is a gap in the literature concerning the characteristics of Smart PSSs in relation to the experience and/or benefits for consumers. Understanding these characteristics is pivotal for designers of Smart PSSs who want to manage the expectations of, and create value for consumers. We thus we set out to

gain a deeper understanding of Smart PSSs, and to provide designers with new knowledge that can help them create Smart PSSs more effectively.

METHOD

A classification task was created where participants grouped examples of Smart and non-Smart PSSs based on their perceived similarities. The goal of the classification task was to uncover the characteristics (i.e., criteria) used to group sets of Smart PSSs. 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 to avoid categorizations based on product features (e.g., shape, category). Furthermore, participants had the freedom to decide the number of groups and examples of PSS belonging to each group (Handelt and Imai, 1972).

Participants

Participants (n=16) were experts in industrial design engineering (with BSc degree), who are trained to understand how users experience and interact with products and services. Given the focus on Smart PSSs, it was particularly important to have participants capable to rationalize and explicate their grouping decisions in design-related terms.

Stimuli

Based on extensive Internet research and discussions with companies, a set of 29 existing PSSs was created. The selected PSSs differed considerably in the balance between product and service and the purpose of the offering or situations in which they are used. Moreover, examples of traditional PSSs that are often mentioned in the literature were included in the final list, with the purpose of obtaining insights in the differences between them that are important for the user experience.

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 service interactions with consumers. This resulted in 29 different product-service-user interaction diagrams. Then, the 29 individual storyboards were sketched by a graphic designer making use of professional software (Figure 1). The final storyboards were included in a booklet as sensitizing material for participants to learn about each PSS prior to the classification task. This 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 interrelate, 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

Participants were contacted two weeks before the classification task. A booklet was provided to each participant, which they were encouraged to read at their own time and pace. Before the task started, remaining questions regarding each PSS were answered. Furthermore, participants were verbally instructed on the procedure; a classification example was provided as part of the instructions, thereby ensuring that participants understood the task.

Individual cards were randomized and placed on the table facing up; this gave participants an overview of the total set of PSSs. Participants were instructed to take two cards and to group them based on perceived similarities. Participants were asked to think aloud to reveal the rationale behind their classification choices. Once a first set of two cards was classified, participants were instructed to continue with the remaining. Participants took one card at the time, adding them to the already created group or creating new ones. This procedure was repeated until the set of 29 cards was discussed and classified. Following, participants were asked to label every distinctive group using a name describing their classification criteria. Participants took 55-145 min to complete the task. All stimuli were categorized and labelled.

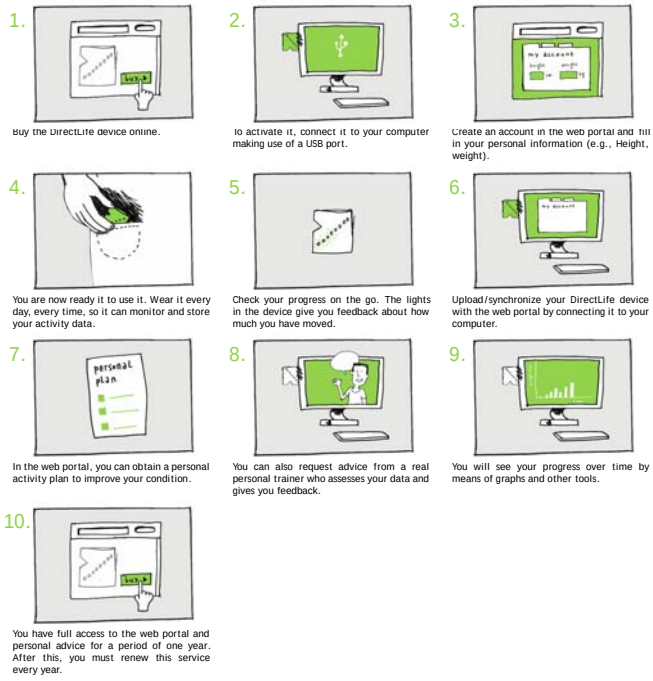

Figure 1. Example of a storyboard for Direct Life used in the final stimuli. The storyboard depicts product, service and user interactions in the PSS.

All interviews were recorded and fully transcribed. The data was analysed using the software program Atlas.it. Transcribed interviews were coded looking for patterns and interesting themes in the data. This process was followed interview by interview until no significant amount of codes was added to the list, resulting in an initial set of 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. This process allowed reducing the list to a total of 55 codes. Once the list of codes was refined, the remaining interviews were coded.

FINDINGS AND DISCUSSION

We identified six highly interrelated characteristics of Smart PSSs, which can have an effect on how consumers perceive Smart PSS: Consumer empowerment, individualization of services, community feeling, service involvement, product ownership and individual/shared experience. In this chapter, we will present each of these characteristics 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 in 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 can be used by consumers to assess a specific situation, and take action accordingly. 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. Service providers can create personalized overviews of the measured data, thereby enabling consumers to track their progress. Furthermore, data is transformed into graphs, diagrams and other pictorial representations. 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 in 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 can use such feedback to understand how their eating habits affect the achievement of their health goals.

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 have control over the process, for example, by visiting the laundry room only when a laundry machine is available. Moreover, 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. Thus, this type of feedback empowers consumers by providing relevant information to make a purchase decision.

Finally, Smart PSSs can empower consumers by enabling them to select their own content, and have an experience that fits closer to their individual needs. For example, Amazon's Kindle (https://kindle.amazon.com) is an e-book that consumers can use to read, buy and store e-books. Through the Kindle Store, consumers can browse and buy from a wide range of options, and 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.

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, for giving consumers a sense of authority in the design of traditional products, has been previously discussed (Mugge et al, 2009, Wolf and 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 and Lemon, 2001). However, Smart PSSs offer innovative opportunities to combine these. Thus, the challenge for designers lies in this specific combination of e-services with tangible products, and how these new combinations create new ways to empower consumers. Above, we presented different features in the integration of products and services that facilitate consumers' empowerment. However, these features are not exclusive and other ways of providing control and authority to consumers may be viable. Moreover, designers ought to be aware of the features enabling empowerment, and how they influence consumers' evaluations of the Smart PSSs' quality. This suggests a more wide-ranging role for designers, who should go far beyond the traditional product-design related manipulations, to account for consumers' evaluations towards a system.

Individualization of Services

The individualization of services refers to how Smart PSSs make consumers feel important by addressing them as unique individuals. Smart PSSs individualize their services for consumers in different ways. First, 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 and Lemon, 2001). By identifying consumers, service providers can create more personalized solutions to satisfy their individual needs (Rust and Lemon, 2001). For example, Green Wheels (https://www.greenwheels.com) makes cars readily available to consumers, for specific periods of time, in a convenient way. Upon registration, consumers receive a personal e-card, which grants them access to the vehicles. Cars can be located and booked through a web platform or mobile phone. Because Green Wheels has personal information about the consumers, such as their locations and demand, they can adjust their offer.

Closely related to user accounts, Smart PSSs make use of virtual servicescapes to communicate with consumers. These virtual servicescapes are the main communication

channel between consumers and service providers, and thus 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, purchased content is linked to the individual consumers, stored, and synchronized through all virtual servicescapes.

Finally, Smart PSSs vary in the human-like interaction (Rijsdijk and Hultink, 2009) of the service provider. Some Smart PSS 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 a consumer is in a life-threatening situation, he/she can press the button in the Lifeline collar he/she wears, and an emergency call is automatically placed to a Philips representative. The representative will then communicate 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+ (http://www.nikeplus.com) enables consumers to track their progress during running workouts. The product in Nike+ measures data, such as burned calories, distance and trajectory. The service is a web platform that gives consumers access to graphs and overviews of the data. Nike+ encourages consumers to exercise by, for example, awarding them with trophies and other achievement-related prizes. When a consumer reaches a goal (e.g., 10 kilometers running), he/she receives 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 above-mentioned 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. Because the product in a Smart PSS is central to the experience of consumers, designers have the opportunity to strengthen the individual value of the service through the physical characteristics of the product. Past research has suggested that the integration of product and service could have an effect on the overall meaning associated with the PSS, and the attitudes of consumers towards the offering (Valencia et al., 2011). Thus, the challenge for designers lies in bringing the service closer to consumers while safeguarding the overall value of the Smart PSS. Consequently, creating individuality in the service through the product is a task for which other important stakeholders in the development of the Smart PSS should be involved; it is a task that requires the alignment from different functional areas to ensure that the correct value is communicated to consumers.

Community Feeling

Community feeling refers to Smart PSSs that facilitate the communication between their 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 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 evaluative rating of content, connecting and sharing of information through social networks.

Internet facilitates the rapid dissemination of word-of-mouth. Companies experience reduced control over the opinions of consumers, which could imply diverse repercussions for the adoption of market offerings (Mangold and Faulds, 2009). 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 and Faulds, 2009). Thus, designers need to be aware of the important role that social media plays 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). In addition, because social media supports the two-way communication between consumers and service providers, 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. Smart PSSs promote the recurrent interaction between providers and consumers. This recurrent interaction facilitates the deeper understanding of consumers, and the provision of more targeted solutions to them. 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 learn from their preferences. In contrast, other non-Smart PSSs 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 tooling for gardening, construction, and other purposes (Mont, 2004). After being used, the tools are returned, so other consumers can make sequential use of them. Thus, different to Smart PSSs, the interaction between service provider and consumers is virtually non-existent during the

product use, and between rental periods. Furthermore, because the tools have no IT technology in them, they do not connect to the service, making the PSS 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 important benefits for consumers (e.g., personalized solutions, prompt reaction to consumers' needs).

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 development of 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

Product ownership is related to the business model of the Smart PSS and is linked to prior classifications (i.e., types) of PSSs (e.g., Baines et al., 2007, Tuker, 2004). First, the tangible product in the Smart PSS can be sold to the consumer and its ownership transferred to him/her. Then, 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 value from the service. Owning the product grants consumers unlimited access to the PSS, unless restricted by other business-model related aspects, such as the need of 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 the maintenance and correct 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.

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 PSS. 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 of the Smart PSS.

Other Smart PSS are shared by different consumers, while the experience is devised as individual. For example, the cars of Green Wheels can be used by different consumers on a sequential manner. Although different consumers share the cars throughout the day, their experiences with the system remain individual. Differently, 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. A product that is owned and experienced at an individual basis may require a high focus on product aesthetics. Differently, designing experiences for shared Smart PSSs, may turn the focus of designers on creating durable Smart PSSs, and to create uniqueness and individuality for the consumer via the service.

IMPLICATIONS FOR DESIGN MANAGEMENT

In this article, we have discussed six characteristics of Smart PSS, and their potential in creating unique value for consumers. Our insights can help designers to attain a better understanding of how variations in Smart PSSs can be created, and which benefits these can bring for both companies and consumers. Furthermore, our findings take a first step in understanding the characteristics that consumers will expect in Smart PSSs. As such, our finding can help designers to manage said expectations, and to create experiences for consumers that bring value to them.

From a design management perspective, the design of Smart PSSs poses different challenges. First, the integration of smart products and e-services implies a new product development (NPD) process where many more stakeholders are often involved. Strategic partners, governments, consumers, outsourced design agencies, diverse experts, may all be part of the NPD process and bring different visions on what the Smart PSS should deliver (e.g., Dougherty, 1992). Thus, at a project definition level, the effective communication between multiple stakeholders may be fundamental to achieve the well-rounded design brief of the Smart PSS; one that integrates the needs of, and creates value for all stakeholders involved. In this respect, the characteristics outlined in this paper can serve as a tool to stimulate the communication and discussions around the Smart PSS. Furthermore, at a project execution

level, design may have to interact with experts from multiple disciplines, who may not only have different visions on the project, but also speak a different "language" than designers (e.g., Gorb, 1986, Persson, 2005). In this respect, the capacities of designers to facilitate the communication between professionals from different disciplines, and integrate the demands of diverse stakeholders (Valencia et al., *in press*), could be particularly relevant for the design of Smart PSSs.

Second, past research has questioned the effectiveness of traditional design tools for the integration of products and services (Morelli, 2002). Our research provides a first insight into what benefits design tools should bring to the design process of these complex systems. Because of the complexity that Smart PSS bring to the new product development process (e.g., multiple stakeholders, multiple contexts, multiple users), designers could benefit from tools to reduce this complexity. Tools for stakeholders' analysis, for example, can help identify the different important parties to be involved in the design of the Smart PSS, and the value they expect to find in the system. Second, tools that help safeguard the coherence in the Smart PSS, and the value it conveys, could benefit the design process. In this respect, informal interviews with experienced Smart PSS designers have suggested that traditional visualization tools, such as storyboards, which can help visualize the interactions between consumer, service and product, could be of significance.

Finally, there are different research opportunities that can strengthen our findings. In particular, it is important to obtain a better understanding of the value that the Smart PSS can bring to consumers. For example, it is important to understand how the goal and context for which the Smart PSS is developed, can influence the relevance of certain characteristics. Furthermore, participants in our research were industrial design experts, who could more easily elucidate aspects related to technology and interactions. Thus, future research should set out to explore the value of the Smart PSS characteristics with consumers, so that designers have a more accurate know-how on how to design these offerings.

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