Designing ultra-personalised embodied smart textile services for well-being

7

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7.1 Introduction

Smart textiles are a type of smart material that have the capability to sense their environment or external stimuli and can respond to these events by adapting their behaviour to it while maintaining some of the intrinsic properties of traditional textiles (Cherenack and van Pieterson, 2012). Technological developments in textiles and technology make it possible to augment the existing qualities of textiles with sensing capability (e.g., measuring touch, stretch, movement, light, and sound) and actuation capabilities (e.g., changing heat, colour, light, and shape). The development of smart textiles has traditionally been pushed by technologically driven disciplines. Now that the field is maturing a point has been reached at which non-technological challenges related to societal and commercial adoption are becoming increasingly important to focus on (Schwarz et al., 2010). Because of the interactive nature of smart textiles properties can be added to an application to further personalise it to each customer. By combining intangible properties from services (e.g., the ability to measure and store data or change the functionality of a material over time) it becomes possible to tailor smart textiles to individual users. We consider an application a smart textile service when an interactive physical component (the smart textile) is combined with a business model that emphasises the intangible component over the physical product. Applications such as these go beyond a material and often imply connections between the whole vertical textile chain: from production to end user. The combination of services and smart textiles can enable the textile and clothing industry to create value propositions with increased personal meanings and product attachment for the user (Niinimäki and Hassi, 2011).

Smart textiles benefit from intrinsic properties of textiles such as flexibility to conform to the body, comfort to touch, softness, wearability, and the familiarity of the textile (Black, 2007). This offers tremendous opportunities for applications on and close to the body, for example, in well-being and medical contexts such as rehabilitation. Embodiment plays an important role in these contexts; the textile industry revolves around materiality and health care practitioners strongly emphasise the bodily abilities of their clients (physical rehabilitation, movement). However, when services

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are being connected there is a tendency to disconnect the body and materiality from the service design process (for example, resulting in sensor devices that track physiological data without reciprocal interaction with the body).

To illustrate an embodied take on service design, this chapter shows the research done in the Smart Textile Services Project (STS) part of the Dutch Creative Industry Scientific Program (CRISP). The aim of this research project is to investigate how to design, develop, and deploy services based on smart textiles locally in The Netherlands. In STS, Dutch textile producers, engineering companies, elderly care service providers, creative hubs, and academia (Bhömer et al., 2012) work collaboratively to integrate existing knowledge from the separate domains of textile (soft materials), technology, and services.

7.2 Designing embodied smart textile services

To realise embodied smart textile services it is necessary to implement a tight coupling between digital data and the human body and put focus to the context of the application. Examples of smart textiles for close-to-the-body applications include directions such as measuring movement and providing auditory feedback during rehabilitation, using textile material and interactive vibratory triggers to aid in communication during dementia care, and vibratory massage of pressure points to improve self-healing of patients. In our approach we try to address the role of the body and the context in which the applications are located, by focusing on customised and localised solutions. Further, we emphasise the role of prototypes to develop and discuss, but also test, the embodied services in their context.

7.2.1 Designing with the body, for the body

In current interaction design practices there are more and more methods emerging in which the body is taken as the point of departure in the design process (Loke and Robertson, 2013). For example, the design movement approach (Hummels et al., 2007) aims to support and inspire designers to design for movement interactions by using the body as a creative material. In the discipline of somaesthetics the body is taken as the centre of our experiential existence to realise interactions that cultivate ourselves (Lee et al., 2014). Body-centred technologies can provide more meaningful and trustable feedback and thus allow us to perform more effectively and enhance our quality of life (Nunez-Pacheco and Loke, 2014). There have been ideas for investigating how these principles can be applied in services from the perspective of providing better bodily experiences (Sundström et al., 2011). In these embodied services an important issue is how digital information is linked to our perceptual-motor skills. To acquire bodily data there are a range of possibilities, for example, the use of physiological sensors to measure information such as heart rate, skin temperature, and muscle tension. On the other hand, proprioceptive sensors can measure dynamic movement such as orientation, position, and speed of joints or the whole body. In addition to the acquisition of bodily data, embodied services will also be able to feed data back to the bodily sensorimotor system to trigger action: information for action. The Frogger framework aims to provide guidelines that help with the couplings between a person's action and the product's function through the use of inherent and augmented information (Wensveen et al., 2004).

7.2.2 Ultra-personalisation

One characteristic of embodied services is the strong link with the context in which it is positioned. It is the context that will give meaning to the embodied action performed by the user. This interaction moment between the service itself and the end user (provider and client) is often characterised as an exchange mediated by a material artefact and is also known as the service interface (Secomandi and Snelders, 2011). In embodied services, the service interface can be customised through digital applications and innovative use of data and personalised by means of tailored textiles, thus creating ultra-personalised embodied smart textile services (Smart Industry, 2014). This customisation can enable the user to create personal meanings and form attachments to products (Niinimäki and Hassi, 2011). Examples of ultra-personalisation in the field of smart textiles for health care applications point to the potential of mass customisation of textiles and clothing (McCann, 2009).

7.2.3 Prototyping embodied services

To design, develop, and deploy ultra-personalised embodied smart textile services it is important to involve stakeholders in a value network and maintain shared ownership during the process (Bhömer et al., 2012). The dynamic character of the embodied service makes it difficult to deal with this process otherwise. Prototypes can help to form bridges between stakeholders, reflect on specific decisions, and find new directions for future developments. They will enable stakeholders to use their skills when discussing and experiencing current services and envision future ones (Ehn, 1992). Material properties, data-gathering options, and added functionality can be experienced in a holistic manner by means of interacting with the prototype. Interactions with a prototype such as pointing and manipulating, demonstrating its function, and imitation through body movement and gesture (Bhömer et al., 2013a) add an extra layer of depth and richness to the conversation. For example, to judge the value of the embodied service, the service needs to be evaluated in a context together with stakeholders and end users. In each evaluation cycle the prototype plays an important role in the valuation of the embodied service. To test the embodied service in context it is required to create prototypes, or experiential artefacts (Sundström et al., 2011), which will enable the stakeholders to experience the service as if it were real.

7.3 Exploring embodiment in smart textile services for well-being

To better understand the relation between the smart textile component and the added services we present an overview of smart textile services currently on the market (in Table 7.1). The overview was created by first selecting applications in the areas

Table 7.1 **Overview of propositions that can be considered smart textile services from the Vandrico Wearable Tech Market database (Vandrico Solutions Inc., 2015)**

Name	Smart textile	Service
Adidas miCoach http://micoach.adidas.com	Portfolio of various physical products, such as the X_cell (module that attaches to shirt and tracks heart rate, acceleration, and body movement), Fit Smart wristband (heart rate tracking), and Smart Ball (integrated sensors that measure speed, spin, trajectory, and strike point).	The hardware modules all connect to an online software platform; this platform offers coaching feedback, pre-planned workouts, and goal setting. The data are stored in the miCoach platform and can be shared and accessed by third-party applications.
OMsignal http://www.omsignal.com	The OMsignal smart shirt reads biological and physiological information such as breathing (respiratory rate and volume), activity intensity, and ECG. The OMsignal platform delivers a wide variety of physiological data directly to a user's smartphone or tablet via an application.	OMsignal is building a platform in which a collection of biometric smart wear plays an important role. Initially the OMsignal platform will be used to inform the wearer about his or her emotional well-being. Later, this platform will be opened up to third-party developers and users.
Owlet Smart Sock https://www.owletcare.com	A sensor-lined sock for babies monitors vital signs such as skin temperature, heart rate, blood oxygen levels, sleep quality, and movement. The data are transmitted to a smartphone app or Internet-based device via Bluetooth.	As a monitoring tool rather than a medical or diagnostic device, the smart sock aims to help parents be more aware of potential health-related danger signs. The service alerts the parent if the baby's vitals signs are outside the norm.

Sensoria http://www.sensoriainc.com	Body-sensing wearable devices with integrated e-textile sensors such as a Fitness T-shirt, Fitness bra (with integrated heart monitor), and Fitness socks. The proprietary software is aimed at fitness and health applications.	All the data from the products are collected in a fitness hub. The goal is to help patients and caregivers by providing systems and services that enable monitoring of patients remotely, reduce costs and readmissions, and provide better quality care to patients.
T.Jacket http://www.mytjacket.com	A jacket simulates the feeling of a hug using air pressure to provide comfort, calm, and control to both people with sensory processing challenges and their caregivers (parents, teachers, therapists, etc.). Built-in sensors measure and automatically record user activity levels (seated, walking, jumping, running).	The product's cloud service allows the data gathered by the jacket to be charted over time and can generate custom notification alerts based on that information. It is possible to control the air pressure directly from an app or to choose a pressure that suits the needs from the automated pressure programs.
Zoll LifeVest http://lifevest.zoll.com	This wearable defibrillator continuously monitors the patient's heart using dry, non-adhesive sensing electrodes to detect life-threatening abnormal heart rhythms. If a life-threatening heart rhythm is detected, the device releases gel over the electrodes and delivers a treatment shock to restore normal heart rhythm.	Through an online patient management system clinicians can monitor patient data from the LifeVest. This gives them the possibility to assess long-term arrhythmic risk and make appropriate plans. The data visualisation and notifications can be tailored to the patient. Further, the LifeVest is covered by most health plans in the United States.

of lifestyle and medical. This selection was then further specified by filtering with the criteria of containing both a smart textile and a service component. The resulting examples are then discussed through the lenses of (1) the level of embodiment and (2) the level of personalisation to provide insights into the value that an embodied approach can bring.

Looking at the overview in Table 7.1 based on the level of embodiment, we can conclude that a large part of the services are based on proprioceptive data measured by the smart textile component, for example, all the applications (except for Zoll LifeVest) measure movement activity. Some applications also measure complex physiological data. The OMsignal shirt can extract breathing information and ECG measurements and the Owlet Smart Sock measures skin temperature and oxygen level. From all the examples it is clear that there are new services emerging because of the tremendous amounts of sensor data that can be collected from our body and our environment.

Current methods to process and represent these complex data are often based on visual representations (applications, Web sites) and therefore rely mainly on cognitive process. All the smart textile service examples include platforms in which data are stored and visualised for the user. These data are in some cases, such as OMsignal and Owlet Smart Sock, communicated back to the user through a smartphone application. These cognitive processes do not directly relate to the inherent goal that these close-to-the-body applications have. Some of the examples extend the data and link back to the body of the wearer. The Zoll LifeVest uses shock treatment to react to a life-threatening heart rhythm and the T.Jacket uses air pressure to simulate the feeling of a hug. Linking our body with the digital world (and thereby with the services that are possible) through perceptual–motor skills can help to maintain a direct link with our body. With this focus on the body we can achieve certain sensitivity in interaction; however, we need to consider the material qualities of the tangible parts of the service. To give an example: do we really need a massage manual to be able to perform a pressure-point massage? Wouldn't it be much better if the instructions for performing this massage could be presented through the garment itself?

In relation to the level of personalisation, an aspect we notice in the previous examples, other than the T.Jacket, Owlet baby sock, and Zoll LifeVest, is that the context of application is less considered. The business models of smart textiles are still based on traditional business models, in which mass production is preferred over small-scale personalised business proposals. Owing to value chain thinking, production and servicing are often outsourced to facilities elsewhere in the world. When taking the context in mind, local groups of stakeholders can collaborate and tailor their products and services specifically to a certain market. By doing this, not only can margins increase as profit moves to the services behind the product, but also it will become possible to customise the service to the skills and identity of the particular user and stakeholders. For example, in the case of the Zoll LifeVest the visualisation style can be tailored to the specific patient. The air pressure programs of the T.Jacket can be personalised through an accompanying mobile phone application, to provide the most comfort and reduce stress for people with sensory modulation difficulties. Allowing one to personalise the air pressure programs opens the door for a new kind of service. Wouldn't it be better if these air pressure programs could be co-developed between practitioners, families, and users as part of the caregiving process?

7.4 Case studies

Since 2012 we have been working within the CRISP STS project on cases to demonstrate an embodied smart textile services design approach. Among these are *Tactile Dialogues*, *Vigour*, and *Vibe-ing*. To understand how these were designed we will describe for each project the goal, its main collaborators, and the value of the embodied service. To go more deeply into the service element we describe the customer journey through a table (Tables 7.2, 7.3, and 7.4) and a description. In these tables the different rows show the exchanges between client and provider (the service interface). Finally, a critical reflection will give more depth on how the body and ultra-personalisation play a role in the embodied smart textile service.

7.4.1 Tactile dialogues: keeping dementia patients in touch with their families

Tactile Dialogues is a textile object in the form of a pillow with integrated vibration elements that react to touch (Figure 7.1). To develop this embodied smart textile service, prototypes of the pillow were produced together with an elder care provider,

Figure 7.1 Person with dementia and a family member interacting with Tactile Dialogues. Photo: Wetzer and Berends.

an electronics engineering company, a textile producer, and a textile designer. These prototypes were used to test the pillow in the context in which the service takes place (Schelle et al., 2015). In addition to testing, the various iterations of the prototype also played an important role in discussions with all the involved stakeholders on how the service interfaces should be developed. The goal of the textile object is to enable a dialogue by triggering physical communication patterns between a person with severe dementia and a family member, spouse, or other caregiver, by a joint interaction with the product. The pillow provides various vibrotactile stimulus patterns and haptic sensations that, combined, encourage the patient to move and develop conversations in an alternative yet bodily way. The object can be used in spaces where two people are sitting, e.g., at a table, couch, or over the armrests of a wheelchair. The object consists of a textile with integrated vibration elements. When these elements are touched (by rubbing, stroking, or pushing) a soft vibration can be felt from multiple locations on the object. The vibrations in the pillow can be programmed to create specific vibratory behaviours. For example, when both sides are touched simultaneously, the vibration will increase. This stimulates small movements and social connection between the people using the pillow; it allows for a dialogue based on physical interaction to begin.

As presented in Table 7.2, the clients and providers involved in the service are the Tactile Dialogues company, the elder care company (manager, caregiver, and motivational therapist), the family members, and the person with dementia. Tactile Dialogues is demonstrated by a representative of the company, after which the care provider can decide to acquire and personalise the pillow (interface 1). When the Tactile Dialogues arrives in the care home a representative offers training to the caretakers involved and motivational therapists, and the pillow is configured to the infrastructure of the organisation (interface 2). The care provider will arrange introductions in which the use of the pillow is explained to the family members (interface 3); after this step the vibration patterns can be further personalised to the interaction patterns of family members and the person with dementia (interface 4). This personalised vibration pattern is further activated when the family member is visiting the person with dementia to support their interaction; this step can be repeated during every visit (interface 5). At certain intervals the motivational therapist will be present during the family visit to observe the visit and give advice (interface 6). The video recordings of these visits are evaluated together with experts from the care provider, which provides the opportunity to exchange knowledge about the dementia process (interface 7). In the case of damage a representative of the company will visit the care organisation and examine whether the repairs can be done on location (interface 8). The dirty pillowcases are exchanged for clean ones regularly by the company (interface 9).

During the demonstration visit (interface 1) the body is used as a way for the decision-maker to experience the effect of the vibrotactile stimuli and customise the fabric structure. Similarly, the family member has a chance to experience interaction with the pillow in an introduction session (interface 3). When the pillow is used during the visit (interface 5), the exploration of the bodily somaesthetic qualities opens up opportunities for social interaction. Further, the vibrotactile stimuli patterns and haptic sensations have a direct relation to the movements of the body. This principle makes it possible for even people with limited cognitive capabilities to still have an activity

Table 7.2 **Overview of Tactile Dialogues service interface during the customer journey**

Front end				Back end		
User profile	**What the user can do**	**Interaction supported**	**Service interface**	**Interaction provided**	**What the provider offers**	**Provider profile**
Elder care manager (decision-maker)	Experience service value and better decision	Try, ask questions, personalise, and buy	**1.** Representative visits care home	Setup demonstrator and convince customer	Dementia knowledge and technical support	Tactile Dialogues company
Caregiver or motivational therapist	Understand benefits, guide configuration	Test pillow, configuration for specific organisation	**2.** Tactile Dialogues delivery	Deliver pillow, configuration, and training	Technical knowledge and training for staff	
Multiple families of people with dementia	Decision whether to use pillow during visits	Try, ask questions about own situation	**3.** Tactile Dialogues information meeting	Explain about pillow, demonstrate usage	Information about product and service	Elder care provider
Family of person with dementia	Understand benefits of pillow and personalise	Experience pillow and converse with staff	**4.** Introduction during coaching session	Demonstrate pillow and personalise vibration	Knowledge about family member to personalise	Caregiver or motivational therapist

Continued

Table 7.2 Continued

Front end				Back end		
User profile	**What the user can do**	**Interaction supported**	**Service interface**	**Interaction provided**	**What the provider offers**	**Provider profile**
Person with dementia	Responding to interaction with the family	Look at pillow, feel, stroke, hug, throw, etc.	**5.** Interaction session during family visits	Opportunity to use pillow during visit	Trigger physical and emotional response	Family of person with dementia
Person with dementia and family	Finding different ways to use pillow	Use pillow during visit, ask for feedback	**6.** Interaction session, guided by expert	Observe interaction and converse with family	Provide pillow and assistance during visit	Caregiver or motivational therapist
	Evaluate session and understand dementia	View video of session and ask questions	**7.** Evaluating with care professional	Analyse video and instruct family	Evaluate client and involve family	
Elder care manager	Receive a working pillow	Explain problems with pillow to maintenance	**8.** Maintaining and recycling Tactile Dialogues	Remove and replace broken parts	Small maintenance on location	Tactile Dialogues company
	Give dirty pillowcases away	Pick up dirty pillowcases from (care) home	**9.** Washing Tactile Dialogues	Wash pillow when dirty or repair when broken	Pillow is picked up and returned	

together with a visitor. The motivational therapist has an important role to evaluate these bodily qualities during the evaluation meeting (interface 7). Through ultra-personalisation the textile and appearance of the pillow are further adapted to the needs of the person with dementia and family member, since the reactions to the tactile stimuli that the pillow provides might be completely different. The service provider offers a coaching process in which the family member and the person with dementia are instructed together in using Tactile Dialogues and also co-create the vibration patterns together. The standard vibrotactile behaviour is the mirroring behaviour: touch on one end of the pillow is mirrored with vibrations on the other end. An example of a tailored vibration is a game in which the people have to move their hands to find where the vibration is coming from.

7.4.2 Vigour: a knitted cardigan that keeps people active

Vigour is a knitted long-sleeve cardigan with integrated stretch sensors made of conductive yarn and an accompanying iPad application, which monitors the movements of the upper body and can give sound feedback (Figure 7.2) (Bhömer et al., 2013c).

Figure 7.2 Vigour as it is used by a patient and a family member.
Photo: Wetzer and Berends.

During the development of the Vigour embodied smart textile service, two iterations of the cardigan were designed together with an elder care provider, electronics engineering company, textile producer, and fashion designer. After tests with the first prototype we designed the later prototype with much more focus on the aesthetics and material qualities and hence a less stigmatising medical appearance. This cardigan is a piece of wearable technology for geriatric patients that would enable the physiotherapist to gain more insight into the patient's exercise and progress. The garment can be worn all day and thereby gather a lot of data. Next to this the garment can be worn when executing rehabilitation exercise and give feedback to the wearer by making sound (on an iPad application) or optionally also vibrate to encourage the wearer. For example: the farther a particular sensor is stretched, the higher the pitch of the piano or the increase in volume of the voice in a song. The sensitivity of the sensors and the activation of each sensor surface can be controlled using the interface displayed on the iPad application. The project has a high social value, since it advances ways of communication between geriatric (Alzheimer) patients and their therapists and encourages interaction and movement.

The overview of the service interfaces of Vigour (Table 7.3) shows exchanges between the clients and the providers involved in the service; these stakeholders are the Vigour company, the insurance company, stakeholders involved in the caregiving process (physician and physiotherapist), the family members, and the geriatric patient. Vigour is recommended by a physician to the geriatric patient in a new treatment plan after a checkup (interface 1). The other parties involved, such as family and insurance company, are also informed (interface 2). The patient can start to customise the size, colour, and sensor locations of the cardigan alone or together with family and the help of a physiotherapist (interface 3). The personalised cardigan is knitted by the Vigour company and delivered to the home of the patient (interface 4). During a first introductory session together with the physiotherapist the cardigan is tested and a training program is made (interface 5). This training program is executed when the patient is performing the exercises individually (or with help from a family member) at home (interface 6). The exercises and sounds that link to the movements are personalised and adapted together with the physiotherapist (interface 7) and the progress of the rehabilitation process can be followed using the application (interface 8). Vigour can be washed at home after the electronics are removed from the integrated pockets; however, repairs may be necessary when the cardigan does not work anymore (interface 9). Finally, Vigour will be picked up by an employee of the Vigour company after the product finishes its life cycle (interface 10).

Since Vigour is a wearable product, the body plays an important role during the whole service journey. During the standard checkup the physician will mainly focus on the physical well-being of the patient (interface 1). The body is measured to adapt the garment measurements, also the sensor locations have to be carefully matched to the individual characteristics (interface 3). When Vigour is delivered and tested for the first time the patient is focused on the bodily experience to judge the comfort and the effect of coupling the sound feedback to their body movement (interfaces 5 and 6). Finally, during the actual use of Vigour (interfaces 7 and 8) the link between the bodily movements and the digital data is made. Movements such as lifting the arms and

Table 7.3 **Overview of Vigour service interfaces during the customer journey**

Front end				Back end		
User profile	**What the user can do**	**Interaction supported**	**Service interface**	**Interaction provided**	**What the provider offers**	**Provider profile**
Geriatric patient	Undergo the checkup	Describe physical problems	**1.** Patient visiting physician	Check physical well-being of patient	New treatment plan for cure and prevention	Physician
Family of geriatric patient	Agree on treatment plan, take next steps	Family receives information	**2.** Physician informing other parties	Examine treatment report	Financial support for patient	Insurance company
Geriatric patient (could be together with family)	User interface to change parameters	Customise size/ fit, colour, male/female	**3.** Customising the Vigour cardigan	Load parameters of patient into platform	Web platform to configure cardigan	Physiotherapist
	Wear the cardigan, test the fit to the body	Receiving cardigan at home	**4.** Delivering Vigour cardigan	Cardigan is knitted based on parameters	Production on demand	Vigour company and production partners
	Test personalised experience and comfort	Ask questions and perform exercises	**5.** Testing Vigour cardigan	Introduce cardigan and training program	Check sensors and personalise sounds	Physiotherapist

Continued

Table 7.3 **Continued**

Front end				Back end		
User profile	**What the user can do**	**Interaction supported**	**Service interface**	**Interaction provided**	**What the provider offers**	**Provider profile**
	Sound feedback motivates and provides awareness	Manipulate sound by body movement	**6.** Performing exercises with Vigour cardigan	Tailored training program for patient	Involvement of patient in treatment and self-control	
	More motivation because of adaptation	Indicate progress training	**7.** Adapting training and sound feedback	Adapt training and select sound together	More effective rehabilitation	
	Get insight into the exercise progress	View visualisation of treatment	**8.** Using application to follow treatment	Feedback and advice based on analysis	Analyse the visualisation over time	
Physical therapist	Broken cardigan is given away	Pickup from physical therapy location	**9.** Maintaining Vigour cardigan	Repair cardigan when broken	Cardigan is picked up	Vigour company
	Cardigan is given away	Dispose of cardigan	**10.** Recycling Vigour cardigan on disposal	Pick up cardigan after life cycle	Cardigan is picked up	

bending the back are translated into sounds such as piano chords or musical instruments, which fade in and out. Vigour is ultra-personalised by adapting its physical appearance to the body and preferences of the patient who will be wearing the cardigan (interfaces 2 and 3). This means that the back end of the service is aimed at producing individual customised pieces, rather than mass-produced high volumes. The patient and physiotherapist have tools available (by using the iPad application) to adapt the sensor sensitivity and sound feedback according to the actual exercise and physical and cognitive capabilities of the patient (interfaces 6 and 7). Through this end-user programming procedure the garment can be personalised further.

7.4.3 Vibe-ing: a self-care tool for personal well-being

Vibe-ing is a self-care tool in the form of a garment, which invites the body to feel, move, and heal through vibration therapy (Figure 7.3) (Bhömer et al., 2013b). By developing this prototype we aim to inspire a multidisciplinary audience,

Figure 7.3 Vibe-ing is a therapeutic self-treatment care tool.
Photo: Wetzer and Berends.

bridging the disciplines of fashion, technology, and health care. By developing a prototype together with a textile development lab and an electronics company we integrated textile and vibration for self-care services at home or even in everyday activities. Using a fully fashioned manufacturing technique it becomes possible to customise the garment to the preferences of an individual body. The merino wool garment contains knitted pockets embedded with electronic circuit boards that enable the garment to sense touch and vibrate specific pressure points on the body. By integrating vibration actuators in textile pockets the design enables programming of the exact areas and the type of stimulation on the body depending on the specific person's need for rehabilitation and healing. For example, one of the stimulation patterns is based on a ripple pattern (similar to a wave in the water or sound travelling through air). A vibration starts in the pocket touched by the person wearing the garment, and the vibration slowly transfers to the surrounding pockets, until it fades away after a certain period.

The customer journey of the Vibe-ing self-care service (Table 7.4) presents the exchanges between the patient and the various stakeholders involved, such as family doctor, medical sportswear shop, and the Vibe-ing company. After a patient decides, together with his/her family doctor, to apply for an annual health checkup (interface 1), the patient is introduced to the self-care tool by the physician who proposes a change in lifestyle to improve the general health condition (interface 2). Consequently, the patient visits the medical sportswear shop, where a physiotherapist first measures the body and looks for pressure points that could be treated (interface 3). In the same medical sportswear shop a specialist applies test vibration points on these pressure points to personalise the location and intensity of the vibration, by creating vibration patterns (interface 4). After a certain amount of time the personalised Vibe-ing garment is produced and delivered back to the medical sportswear shop, where the patient picks the Vibe-ing up and, after an initial test procedure, starts to use the garment at home (interface 5). Once the patient starts using the garment the Vibe-ing platform is made accessible, with which experiences and questions can be shared with other Vibe-ing users and experts can be consulted (interface 6). After a longer period of time using the garment, an appointment with a physiotherapist is made to analyse the progress, discuss the treatment, and prescribe potential adjustments of the self-care treatment (interface 7). After the vibration elements are removed, Vibe-ing can be washed at home, but for repairing damage external service is still necessary (interface 8). A pick-up is also included in the service for when the garment reaches the end of its life cycle (interface 9).

Vibe-ing allows practitioners to offer a therapeutic non-invasive treatment method to support both the physical and the psychological well-being of the patient (interface 2). By introducing to the patient what pressure points are, and how to locate them on his or her own body, it becomes possible to discover which vibration locations and vibration intensities are most efficient (interface 3). This body awareness is further developed when the vibration patterns are customised in the final garment to best match the treatment expectations (interface 4). Whenever the patient is in need of comfort on his or her body, the garment can be touched or massaged by the patient or a family member (interface 5). The Vibe-ing platform offers the possibility of sharing body-specific knowledge that the various users have built up through the usage of the garment (interface 6). The

Table 7.4 **Overview of Vibe-ing service interfaces during the customer journey**

Front end				Back end		
User profile	**What the user can do**	**Interaction supported**	**Service interface**	**Interaction provided**	**What the provider offers**	**Provider profile**
Senior patient	Receive information, purchase service	Ask questions about service	**1.** Buying annual medical checkup	Answer questions about care service	Personalised health care support	Family doctor
	Change lifestyle for recovering health	Discuss current health problems	**2.** Visiting hospital for medical checkup	Medical examination	Prescribe the self-care treatment	Physician in hospital
	Indicate preferences during measuring	Finding specific body pressure points	**3.** Visiting medical sportswear shop	Analyse body shape and movement	Personalised treatment	Physiotherapist
	Test performance of electronics on body	Determine adequate vibrations for the body		Analyse effect of vibrations on body	Placement of sensors and vibration motors	Medical sportswear shop
	Test garment performance and comfort	Receive the user's manual for the garment	**4.** Receiving personalised Vibe-ing	Garment is handed over to user	Customised vibration patterns	

Continued

Table 7.4 **Continued**

Front end				Back end		
User profile	**What the user can do**	**Interaction supported**	**Service interface**	**Interaction provided**	**What the provider offers**	**Provider profile**
	Comfort and conscious about body	Self-care treatment at home during daily life	**5.** Usage of the Vibe-ing self-care product	Instruction on how to find pressure points	Memo-log for health check to report progress	Physiotherapist
	Connecting with people through the product	Find other people and discuss experiences	**6.** Connecting with other people in community	Access to platform with other users and experts	Platform and experts to answer questions	Vibe-ing company
	Therapeutic non-invasive self-treatment	Discuss progress and analyse treatment	**7.** After-use service for Vibe-ing	Prescribes adjustment of self-care treatment	Health service monitoring	Physiotherapist
	Broken garment is given away	Give garment away	**8.** Maintenance of Vibe-ing	Repair garment when broken	Garment is picked up	Vibe-ing company
	Garment is given away	Dispose of garment	**9.** Recycling Vibe-ing on disposal	Pick up garment after life cycle	Garment is picked up	

service includes a body checkup after a certain amount of time, in which a physiotherapist evaluates the health of the person to recommend further treatment or adaptations to the garment (interface 7). The garment can be ultra-personalised to the patient by using Knit and Wear flatbed knitting techniques. This enables the garment to be produced in smaller quantities and customised to the user's needs, body shape, and aesthetic preferences (interface 4). The garment is further personalised to the patient through the modular electronics system, which enables patients and caretakers to program the exact areas and the type of stimulation on the body depending on their need for rehabilitation and healing (interface 5). These programs can be later updated to match new treatment settings (interface 7).

7.5 Conclusions

From the examples of current smart textile services on the market (described in Section 7.3) it can be concluded that only the T.Jacket and Zoll LifeVest can be tailored towards the bodily capabilities of the wearer using the accompanying software component. The pressure sensitivity of the T.Jacket can be changed using an application to give the most comfort to the child, and the visual representation of the vitals of the person wearing the Zoll LifeVest can be personalised to the viewer. On reflection on the previous embodied smart textile services examples (described in Section 7.4), we noticed that there are more possible ways to personalise the service experience towards the bodily capabilities of the user. These personalised bodily interactions with the service interface can lead to ultra-personalised service experiences for the end user. We can distinguish three ways to ultra-personalise smart textile services: personalising the textile material properties, personalising the garment, and personalising the interaction with the garment.

7.5.1 Personalising the textile material properties

In Tactile Dialogues the fabric that is used to create the pillow is knitted specifically to trigger certain hand movements from the person with dementia. For example, arrow structures trigger the user to move his or her hand forward, stuffed rectangles act to trigger the person to use the fingertips to explore the fabric. Areas that are more filled have different tactile properties, allowing the person to pinch, stroke, and rub. In addition to the direct relation between the personalisation of the fabric and body behaviour, the programming of the textile material also has a relation to how the interactivity is later programmed. For example, the arrows knitted in the fabric material also allow the vibration motors in these arrows to make a haptic in the forward direction (alternating from one vibration to another). This haptic sensation can be used to personalise the interaction with the user. This personalisation through the material properties can also be seen in Vigour, in which the material properties of the textile define how the fabric can be stretched. In Vibe-ing, felting the merino wool transforms the textile into a denser and more pleasurable to touch fabric.

7.5.2 Personalising the design of the garment

In the case of Vigour, it is necessary to implement the movement sensors in the garment on exact locations on the body to be able to measure the movements of the rehabilitation exercises. By measuring the body shape of the person the sensors can be better customised to the person, and also the overall fit of the garment can be tailored specifically to the person. Ultra-personalising the garment also has advantages for the aesthetics of the garment; it enables the user to feel more connected to the design of the garment, for example, by selecting colour and materials. This level of ultra-personalisation could result in reducing textile waste compared to traditional mass production of textile garments. The textile needs to be produced only when it is necessary for certain applications. This personalisation in design of the garment and object can also be seen in Tactile Dialogues and Vibe-ing, for which digital fabrication methods in circular knitting and flatbed knitting are used to adapt the design to the person using it.

7.5.3 Personalising the programming of the interaction

In the Vibe-ing garment example the vibratory actuators can be programmed to create a dynamic sequence reacting to body movement. The personalisation on this level enables the embodied smart textile service to link to the senses of the person during the actual use. In the example of Vibe-ing, the personalisation of this interaction can even be further customised by the user or together with a family member or expert. This level of ultra-personalisation can also enable data from the service to be related more directly back to the senses of the user. The vibration patterns in Vibe-ing can also develop over time, as the expert changes the treatment. In the example of the Tactile Dialogues service it is possible to program different mappings depending on the reactions of the patient, such as the mirroring behaviour or the find the vibration game. With Vigour the user and therapist can choose between a direct mapping of sound (stretch to tone) or a more ambient volume feedback.

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