ASSESSING SMART TEXTILE SERVICES USING BODILY KNOWLEDGE OF TANGIBILITY

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ABSTRACT

When combining the tangible properties of Smart Textiles (such as the hand of the fabric) with the intangible properties from services (such as dynamic properties and business models) the result can be considered as a Smart Textile Service. Practitioners in a healthcare context are used to an embodied approach to examine and improve the bodily abilities of their clients, therefore developing the intangible components of Smart Textile Services for healthcare can introduce difficulties in a participatory design process. In this article we investigate how embodied interactions with the prototypes of service interfaces help to assess not only tangible but also intangible aspects of Smart Textile Services. The analysis concerns a design meeting that took place during the multi-stakeholder process to develop the smart cardigan and service "Vigour" for people with dementia. During this meeting the current state of the development of the Smart Textile Service is assessed by two physical therapists, a manager of the eldercare organisation and two designers. One of the main findings is that the validation of assessments takes place by relating the body to tangible objects, imagined tangible objects, imagined future tangible objects and imagined intangible objects. We argue that bodily behaviour provides the basis for participants to agree on favourable/non-favourable tangible and intangible aspects of a design.

INTRODUCTION

Intrinsic tangible properties that define the "hand" of the fabric such as softness, comfort to touch, flexibility to conform to the body, wearability and familiarity. Smart textiles have the capability to dynamically adapt their behaviour to the environment and other external stimuli (Schwarz et al. 2010). Therefore, existing qualities of textiles can be further extended with sensing capabilities (e.g. measuring touch, stretch, movement, light and sound) and actuation capabilities (e.g. changing heat, colour, light and shape). These material qualities are especially fit for applications in wellbeing and medical context such as rehabilitation (Black 2007). Healthcare practitioners strongly emphasize the bodily and social abilities of their clients, for example during physical rehabilitation exercises or medical examinations. These corporeal, social and contextual elements are important aspects within the concept of embodiment, and allow for the creation, manipulation, and sharing of meaning (Dourish 2001). The Smart Textile Services project (STS) part of the Dutch Creative Industry Scientific Program (CRISP) aims 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) worked collaboratively to integrate existing knowledge from the separate domains of textile (soft materials), technology and services.

According to traditional marketing literature services are considered intangible and, therefore, “cannot be touched, tried on for size, or displayed on a shelf.” (Shostack 1977). However, the relations between providers and clients are based on the materiality and embodiment of their interfaces (Secomandi & Snelders 2011). The combination of these separate fields introduces a challenge between the tangible and embodied characteristics of textiles and healthcare on one side, and the intangible nature of services on the other side.

An example of a Smart Textile Service developed in STS is "Vigour", a smart cardigan for people with dementia that motivates the people to move more using sound. In “Vigour”, a dynamic tangible textile garment is combined with an embodied implementation within physical therapy and a business model that emphasizes the intangible components. To realize this application, which goes beyond physical products, connections between the whole vertical textile chain were needed, from production companies to end-users. This approach required the involvement of a wide group of stakeholders to collaborate in a participatory innovation process. Although intangible components played an important role, the actual service is actualized through a service interface (in this case a cardigan) that is available for bodily perception. As we will show, even when considering an intangible aspect of the design, stakeholders in their interactions still rely on embodiment as a main principle for validating the design in a design meeting - either by manipulating or pointing at the prototype or by using gesture or other bodily movements to mimic, explain or point out possible usage scenarios. Experiential prototypes of service interfaces could be evaluated by stakeholders and end-users (Bhömer, Brouwer, et al. 2013a).

These prototypes were used for referring to service aspects during discussions by pointing, touching, demonstration and even simulating demonstration (Brouwer & Bhömer 2013). In our current investigation we are interested in how these embodied interactions with the prototypes of service interfaces exactly helped to assess certain tangible and intangible aspects of Smart Textile Services. In this paper we will show an analysis based on an assessment meeting that took place during the development of the Vigour smart cardigan for people with dementia.

VIGOUR SMART TEXTILE SERVICE

Vigour consists of 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. This cardigan is one of the services interfaces of a Smart Textile Service for geriatric patients, their family, physiotherapists and other people involved in caregiving. It enables all stakeholders to gain more insight in the patient’s exercises and their progress. Besides wearing the garment during daily activities to gather activity information, Vigour can also be worn when executing rehabilitation exercises. Feedback is given to the wearer through the sound coming from an iPad application. This sound helps to motivate patients to do their exercises and achieve an increase in their bodily awareness. For example: the further an arm is moved upwards, the higher the pitch of the piano, or an increase of volume of the voice in a song which is determined by the end-user. The sensitivity and activation of each sensor surface can be controlled using the interface on the iPad application. The project advances ways of communication between geriatric (Alzheimer) patients and their therapists and encourages interaction and movement.

Figure 1: Evolution of the Vigour Smart Textile Service

Three iterations of prototypes of the cardigan have been developed, together with an eldercare organization (De Wever), electronics engineering company (Metatronics), textile producer (TextielMuseum TextielLab) and a fashion designer (Pauline van Dongen). To evaluate the prototypes and discuss new ideas regular meetings were organized. With the first prototype (shown in figure 1a) the direction was set-out, as described in (Bhömer, Tomico, et al. 2013b). Then, an improved prototype was developed which implemented the idea of manipulation through sound (shown in figure 1b). In a previous article we analysed a meeting where physiotherapists reflected on the prototype (Bhömer, Brouwer, et al. 2013a). Here it was concluded that participants used bodily interactions with the prototype for explicating design issues by gazing (with pointing, touching or manipulating), demonstration or demonstration by imitating the interaction. In this article we will build further upon this analysis, by focussing on a meeting about the same project, which occurred in succession of the meeting described in 1b. In the meeting shown in figure 1c a new prototype of Vigour and the accompanying iPad application were assessed.

During the development of this prototype the main focus was on improving the aesthetics and material qualities, to reach especially a less stigmatizing medical appearance. The goal of the meeting was to 1) evaluate the current prototype (both the cardigan and the application), 2) to understand the participants' positive and negative associations with the iteration of the Smart Textile Service, 3) to brainstorm about the ideal future Smart Textile Service, and 4) to establish mutual agreement about the next steps to take. This could include for example who to involve, how to set-up a test with the clients of the eldercare organization, or how to design the sounds that reacted to body movement.

ANALYSIS

The participants of the meeting (figure 1c) were the following: two physiotherapists (F and E) from an eldercare organization, an dementia expertise centre manager of the same eldercare organization (C), an interaction designer (D) who was responsible for the design and development of the iPad application and the design researcher who was in charge of the design of the prototype (B). The duration of the meeting was 2 hours and 54 minutes. An initial coding was used to select excerpts where the stakeholders used their body when assessing certain aspects of the Vigour Smart Textile Service. In this initial coding the meeting was coded based on three variables. The first variable described how the participants were interacting with their body (e.g. a coding of 1.4 means a participant would demonstrate a certain feature using their body). The second variable is used to indicate to what the participants are referring to (e.g 2.1 would refer to the prototype of the Vigour cardigan). The third variable is used to indicate why the people were referring to a certain object (e.g. a coding of 3.2 would mean the participants are referring to a feature in future tense, not there being there yet at that moment). The first variable was derived from our previous findings about prototypes in design meetings (Bhömer, Brouwer, et al. 2013a). The second and third variables emerged when coding the video recordings.

Bodily interactions	**Objects**	**Referencing to**
1.1 Gazing and pointing	*2.1* Vigour cardigan	*3.1* Existing use
1.2 Gazing and touching	*2.2* iPad application	*3.2* Future use
1.3 Gazing and manipulation	*2.3* Previous Vigour	*3.3* Questioning
1.4 Demonstration with the body	*2.4* Service element	*3.4* Emphasizing
1.5 Demonstration with prototype		*3.5* Side activity
		3.6 Testing & evaluation
		3.7 Explanation

Table 1: Overview of the initial coding used to analyse the meeting

After this initial coding ethnomethodological conversation analysis (CA) was used to understand better how the participants use their body to reach understanding and agreement during such assessments. The next sections introduce assessments in general, go deeper into validating assessments, and analyses the role of the body in relation to the object that is referenced (tangible objects, imagined tangible objects, imagined future tangible objects and imagined intangible objects).

ASSESSMENTS

One of the major tasks which participants in a design session face is to assess ideas, objects, mock-ups and the like and share those assessments with each other so that they can accomplish agreement. CA literature on assessments in interaction reveals that, and how, assessments occur in everyday and institutional settings, and can be seen as a recurrent and recognizable phenomenon. According to Pomerantz (1984) assessments encompass ascribing *value terms* to a *referent*. The following excerpts present some of the different ways this is being done.

1B	Ja *yes*
2	(0.4)
3B	Zoiets inderdaad [of een] trektouwtje:: eh trektouwtje is niet ideaal *Something like that indeed or a pulling cord eh pulling cord is not ideal*

Excerpt 1 (YT1:56)

A	Verschrikkelijke muziek. *Terrible music*

Excerpt 2

1B	Der is veel rekening gehouden met eh (0.4)
	A lot of consideration was made with eh
2(F?)	(hhh)
3B	extra plooien der in te brengen om de lichaamsvo(h)rmen (h)e(h)e
	placing extra pleats in order to make the body form
4	wat eh makkelijker [te maken er] in te passen
	fit in a better way
5F	[nou wat goed]
	wow how great

Excerpt 3: YT1 - 00:26

Figure 2: All eyes on the prototype while F utters: How great

1F	Het ziet er wel al heel mooi uit zeg.
	It really looks quite beautiful already

Excerpt 4: YT2:40

Figure 3: Everybody's gaze on the prototype and several hands touching it

It is an interactional task for the participants to establish the referent that they are making an assessment about. This can be done by naming the referent in the same turn at talk, as in Excerpt 1, where 'pulling cord' is the referent, and 'not ideal' the value term; and in Excerpt 2, the referent being 'music' and the value term 'terrible'. In both cases, the referent and the assessment are produced through talk by the same speaker.

However, establishing the referent may be done by one participant, while another participant makes the assessment about it as in Excerpt 3. Here, B establishes the referent through talk, the making of pleats in the cardigan, while A asserts the value term 'good'. Establishing the referent may be supported by bodily behaviour as well - as demonstrated in Excerpt 3, there is handling of the prototype in order to establish joint attention, ie. participants' gaze, to the pleats. In Excerpt 4, the referent of the assessment is indicated by a pronoun, understandable as the object that all participants are looking at, and several are touching it - the value term is 'quite beautiful'. The referent of the assessment can thus be established interactionally by way of pointing, gazing at or manipulating the tangible object or aspects of it, thus establishing joint attention.

VALIDATING AN ASSESSMENT

As pointed out in Fasulo and Monzoni (2009), assessments within evaluative activities, such as a design session, can be seen as central features of the overall activity. The assessments in this meeting are to some extend systematically solicited in planned activity, and the objective seems to be to achieve agreement. Central for such evaluative activity may be, then, that the assessments are validated or substantiated (Isaksen & Brouwer 2015), in the course of working towards agreement. One such validation is seen in the continuation of Excerpt 1.

1B	Ja
	yes
2	(0.4)
3B	Zoiets inderdaad [of een] trektouwtje:: eh trektouwtje is niet ideaal omdat het
	Something like that indeed or a pulling cord eh pulling cord is not ideal because it
2D	[ja]
	yes
3	(0.8)
4	ja het moeilijk was eh om het er in te brengen
	yes it was hard to eh to get it in

Continuation of Excerpt 1

In this excerpt, the participants are discussing how best to get the cardigan fitting at the lower edge. A belt is considered and then B, in l. 1 considers a pulling cord. Just after, however, B assesses the pulling cord as not being an ideal solution. This is then followed by the reason for why this is not ideal, which can be heard as an account for such an assessment being acceptable for other participants as well. Such validation is seen throughout the data: Participants systematically provide reasons for their assessments being acceptable, and validated assessments tend to be reacted to with agreement from the other participants.

BY MEANS OF AN TANGIBLE OBJECT

Validation of an assessment (the account of why a positive or negative assessment was made) may be made by pointing at, touching or demonstrating it with the tangible object that is the referent of the assessment, rather than by solely explicating this with talk. In Excerpt 5 the design researcher (B) is gazing and touching (1.2) the physical prototype of Vigour on the table (2.1), while making an assessment about the existing use of a certain feature. B is making a negative assessment in lines 1-3. In line 4 and 5 he produces a validation of this assessment by reference through talk to parts of the prototype while explicating it further by gazing at, and tapping the part of the prototype he is talking about. His bodily actions can be seen to produce evidence for his point, which then again can be seen as a move towards agreement on this assessment on the part of the other participants.

Figure 4: Excerpt 5, l. 4: B tapping the prototype

1B	Ehm dan als negatief daar aan gelinkt (.)
	ehm then as a negative linked to this
2	dat (.) de integrat=van de stof nog niet (.)
	that the integration of the fabric is not yet
3	optimaal is. =
	optimal
4	=Dr zijn nog wat harde onderdelen in de casings die misschien niet heel
	There are still some hard parts in the casings which probably might not be
Bgaze	from paper up > prototype----------
Brighthand	reaches out to PT touches PT taps three types hearably on hard parts
5	comfortabel kunnen zijn.
	quite comfortable

Excerpt 5: YT3:15:29-15:39

BY MEANS OF AN IMAGINED TANGIBLE OBJECT

As shown in an earlier study (Brouwer & ten Bhömer, 2013) participants may make use of *earlier* handling of a tangible object when making a point about a design. This is achieved by mimicking the handling in their gesture, and grounding an assessment of that object based on their earlier handling. In such cases, the participants' bodies act with an imagined object when assessing it - and this may even be done when the object is in the immediate surroundings of the participants. It is not only the tangibility of a design object (prototype, mock-up, etc.) per se which affords for explicating design insights, but the *interaction of participants bodies with tangible objects*. These tangible objects may be physically present, but when not handled directly may also be 'imagined' on the basis of earlier bodily interaction with the object or similar objects. In other words, participants use their *bodily knowledge of tangibility* of the object in order to make their assessments about the design, and validate their assessment, simultaneously making the assessment both understandable and acceptable for other participants.

In Excerpt 6 the manager of the eldercare organization (C) is demonstrating a function with her body (1.4), this movement is referring to the physical prototype of Vigour lying on the table (2.1), and she is doing this to explain her opinion about a feature of the prototype (3.7). The more or less positive assessment of the collar is followed by first presenting a general validation for this being seen as positive ('you have done this to make it broader') but then followed by Cs *actual* validation of seeing it as positive. First then, it becomes clear that C moves towards agreement on seeing the collar as a positive point based on her reasoning rather than others' reasoning.

1C	De rits zit er heel mooi in en ik vind die kraag op zich [ook wel hè](.)
	The zipper is placed beautifully and I also think the colar as such is also, right
Chands	[mimics colar on body]
2	Dat heb je eh natuurlijk gedaan om t brejer te maken >maar<
	You did that of course in order to make it broader but
3	.hh [voor veel mensen is het wel]
	oude mensen is het prettig=
	for many people it is
	old people it is nice
4B	[e:::h ja: :::]
Brighthand	reaches over to touch the prototype
5C	=als ze een kraag hebben.
	to have a collar
6B	Okay.

Excerpt 6: YT3 10:56

Figure 5: Excerpt 6, C simulating the collar with hands

When Cs bodily movement is studied in more detail, it becomes clear she does *not* point at the collar of the prototype, which she could have done, since it is in front of her. In stead she mimics with her hand how the collar would be placed at her neck if she had it on. Thereby C accomplishes the gestalt of the positive feature of a collar when wearing the cardigan, thus underlining her positive assessment being made from the perspective of the user wearing the cardigan, rather than it being positive for technical-design reasons. Note in contrast how B, the designer may be moving to demonstrating this technical-design reason by validating it by use of the prototype itself which he reaches for in line 4.

BY MEANS OF AN IMAGINED FUTURE OBJECT
Furthermore, design sessions sometimes evolve around aspects of a product that neither is present nor has been - for example when discussing ideas for functions that have not (yet) been incorporated in a prototype. In these cases participants rely on their experience with tangible objects that have not played a role in the design process yet, for example by gestural handling of imagined objects which they have experiences with from their daily lives. In Excerpt 7 the manager of the eldercare organization (C) is demonstration a function with her body (1.4), this is a function that refers to the Vigour prototype on the table (2.1), however the function is not yet implemented, but for future use (3.2). An assessment (easier) is made about a referent (belt). C gestures the placement of a belt, much in the same fashion as she gestured the collar in the previously shown example.

1C	Maar ik denk ook dat een riem makkelijker is want anders heb je het nog niet (0.4) passend *But I also think a belt is easier since otherwise you will not have it (0.4) fitting*

Excerpt 7: YT1: 1:45

Only in this case, the belt is not a feature of the prototype and is only being talked about as a possible, future aspect of the design. In these cases thus, participants use their bodily knowledge of objects that have not (yet) played a role in the design sessions in order to make their points about the design.

Figure 6: Excerpt 7, C gesturing a belt using her own body as a canvas

BY MEANS OF AN IMAGINED INTANGIBLE OBJECT
Finally, some functions of designs may be hard to make tangible, for example service plans, software, or the interaction between a tangible part and software. Also in these cases, the participants use their bodily knowledge of tangibility either with existing parts of the design, and gesture accordingly in order to explicate their assessments of those design functions. In Excerpt 8 one of the physiotherapists (F) is using her body to demonstrate (1.4) an aspect part of the service of Vigour (2.4), which is not yet implemented in the current prototype but could be implemented in the future (3.2).

1F	En dan kan je [bijvoorbeeld met de] ene hand [z::ang doen?] *And then one could for example with one hand do singing*
Flefthand	[lifts up in the air]
2E	[ja:: (met de twee) huh] *yes with those two huh*
3	[En de andere] [dat- ie dus][dat mensen gaan zingen. *And the other that it thus that people will sing*
Flefthand	[--rest on table] [rise up stroke, back in front of body]
Frighthand	[rise up in midair. stroke] [rest on table]
4E	[precies]
5F	Ah das grappig *Ah that is funny*
6E	ha(h)a
7C	m(h)m(h)m

Excerpt 8

Figure 7: Excerpt 8, F line 1: 'zang doen'

The validation of the assessment, consisting of a demonstration of the referent which the assessment is about, is presented before the assessment itself. F is talking about a possible function of the PSS, the possibility of incorporating singing in line 1-3, initially moving towards making a contrast (sing with left and right hand) but abandoning it and ending up only referring to doing singing with the one hand. After this, she provides an assessment of this function in line l. x ('that is funny'). Several observation can be made of her bodily movements: First, her movement with her left hand in line l. 1 is understandable as a mimicking a movement a user of the prototype would make when using the system. Second, this movement is done at the exact moment where F describes the function (singing) that this movement would accomplish in the system. Thus, by producing talk and movement simultaneously, F creates a gestalt that is understandable as the function singing combined with the users' movement while wearing the cardigan. In line 3, F starts to describe a function moving the other hand may do, but abandons this and repeats the earlier gestalt of singing combined with movement of the left hand - both in her talk and her movement. It is now this combination of a movement imagined to be worn by F in combination with her talk of a function (doing singing) that as a gestalt is being assessed by her in line 4.

The bodily knowledge of tangibility thus becomes a vehicle through which the participants work towards agreement on design decisions. The tangible objects do not have to be present in order for tangibility being a central tool in design processes - they may work as vehicles to make the referents of assessments understandable for others by participants exploiting their bodily knowledge of the objects' tangibility. Moreover, functions that are hard to represent in a tangible object may be communicated by a similar exploitation of bodily knowledge of objects related to that function: The bodily movement becomes a description of such functions.

CONCLUSIONS

The goal of this analysis was to investigate whether the prototypes would enable the participants asses the tangible (from the textile), embodied (healthcare) and intangible (of the service) components of the “Vigour” Smart Textile Service. In the previous section we described four observations of how the body was used in relation to the prototype, and in relation to the specific design feature that was being discussed and assessed.

1) The body and the tangible object. Using body to tap and touch the tangible object while gazing (in Excerpt 5 the designer is talking about existing use of the Vigour prototype on the table and is indicating that certain parts in the prototype are too hard by gazing and tapping on the prototype).

2) The body and the imagined tangible object. Using the body to demonstrate certain aspects by “imagining” the object is on the body, instead of using the tangible object itself. We call this the *bodily knowledge of tangibility* of the object (in Excerpt 6 the manager makes a movement with her hands around the neck to indicate the collar is comfortably located for senior people).

3) The body and the imagined future object. Using the body to make gestures of handling an imagined object that is not implemented in the prototype, relying on bodily knowledge from other experiences (in Excerpt 7 the manager makes the movement of adjusting a belt, which is immediately understood by the other participants).

4) The body and the imagined intangible object. Using the body to refer to design features that cannot be physically represented in the prototype. The participants use bodily knowledge about comparable situations to explicate their assessment (in Excerpt 8 the physiotherapist uses her hand to indicate that the volume of the singer would increase when making a movement).

From this overview a spectrum is emerging that shows the different assessments that are being made by means of interaction with the body. From using the body to discuss properties of the prototype as they are presented in the tangible object (1) on one side of the spectrum, to using the body to represent imagined and future parts of the service which are not present in the current prototype yet (4) on the other side of the spectrum. The tangibility of the design objects (such as the protype of “Vigour”) can be seen as central in the design process since this can be used as a trigger for bodily interaction. The tangible features of objects can be exploited to assess aspects of the design, even when an object is intangible or not at hand.

In the middle of this spectrum there are interesting instances where the participants could choose to use the tangible object, but instead used their body to demonstrate these imagined tangible objects (2) (such as demonstrating the imagined collar in Excerpt 6). And similarly, bodily demonstrations of future objects are used to assess future features of the design (such as the demonstration of the belt on the body in Excerpt 7), instead of relating them to current implementations on the tangible object itself (3). The expression through bodily gestures enables the participants to demonstrate subtleties in the assessment, which cannot be easily expressed by talking or pointing to existing elements.

As addition to methods in service design where hand gestures, role-play and acting-out are used as main methods to develop future tangible and intangible service interfaces. We propose thus, that tangible objects such as prototypes in relation to participants' bodily behavior provides the basis for participants to assess both tangible and intangible aspects of a design.

ACKNOWLEDGEMENTS

This work is part of the project “Smart Textile Services” sponsored by the Dutch Ministry of Economic Affairs under the CRISP program.

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