Exploring Smart Handbag Concepts through Co-Design

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ABSTRACT
In this paper, we explore design preferences and possibilities for smart handbags from the user perspective. We present designs and findings derived through a co-design process, which consisted of two studies; first with individual drawing based brainstorming (n=20), and second with two co-design workshops (n=10), where participants assessed different designs and features, and created low-fi prototypes of smart handbag concepts. Participants proposed large shape and style variations for smart handbags, according to the intended contexts, use cases, and lifestyle. In this respect the desire for modifiability, e.g. adapting in size and shape, was highlighted. The handbag's durability, weatherproofness and use of high quality materials were also raised.

Author Keywords
Handbags; wearable computing; aesthetics; co-design; user studies.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Mobile technology is getting more and more ubiquitous, being embedded to our everyday life objects which we carry with us wherever we go. Technology miniaturization allows its integration to ever smaller and less visible form factors, and wearable computing has begun to take steady steps on the consumer electronics markets. Smart watches, activity bracelets and wearable cameras (e.g. GoPro) are examples of mobile computing gadgets, which go beyond the shape of traditional mobile phones and tablets. Flexible electronics, e.g. bendable displays and fabric-woven conductive materials enable new types of wearable computing products to be developed, creating the demand also for new user interface (UI) and gadget types. Indeed, clothes-integrated sensor products and displays already exist (e.g. [20, 27]), and the trend of garment-integrated technology is expected to grow vastly in the future.

As technology matures and its possibilities get more and more varied, there is also more room for thinking the user experience (UX) design, industrial design, and aesthetics of the computing form factors. The holistic user experience consists of a utilitarian and hedonic side [13]. While technology can respond to the call for pragmatic solutions for fulfilling different utilitarian user needs, UX design needs to focus also on hedonic aspects such as visual appearance, comfort of materials, or social function and engagement with the product. According to the principles of user centric design (UCD), it is important to gather background knowledge from the users when designing new technologies or novel applications in order to create end-products, which as both usable, acceptable, and desirable.

In this paper, we report our work on a user centric approach on smart handbag design. We consider handbag as a potential novel form factor for mobile computing devices due its commonness in everyday life, its shape and size that allow easy technology integration, and its general wearability. Handbags are commonplace objects, which roughly half of the adult population, i.e. females, carry. Until now, handbags have been completely free from any interactive technology. In the following, we look at the possibilities for smart handbag design through a co-design approach. We introduce the findings of two studies, where feedback on the topic was gathered through different UCD and co-design methods, see Figure 1.

Figure 1. Work during a co-design session, and examples of smart handbag concept prototypes created during the workshops.

As contribution of our work, we report:

- to the best of our knowledge, the first co-design based HCI work on a smart handbag concept,
- design recommendations for future designers of smart handbags, derived from the studies.

Our findings offer insight to the topic of smart handbags, and help future designers and practitioners to focus on desired and acceptable functions and appearance when designing future research concepts and products in the area.

RELATED WORK

Locating Interaction Devices on Body and Accessories

According to the framework presented by Liu et al. [19], smart accessories, clothes and skin interfaces are all part of the emerging wearable computing landscape. Whereas skin interfaces are out of the scope for our research, an overview to the related work in the area of wearable output and input technologies is relevant.

Different wearable gadgets such as smart watches, bracelets and glasses type computers have quite defined locations in the interaction space defined around our body, and there is already quite extensive amount of interaction design research on them, e.g. [5, 15, 24]. In addition to the design cases on head and body worn devices, some more general studies on placing wearable input have been conducted. Holleis et al. [14] have compared wearable touch input on mobile phone bag, biking helmet, gloves and an apron, and collected general feedback on people's preferences on locating input areas. They conclude that it is important to locate and access wearable inputs quickly, and in standing posture, (front) thighs was the most commonly selected location for touch sensitive input [14]. Harrison et al. [11] have investigated reaction times on wearable visual stimuli, comparing seven different body locations. The findings point out that visual notifications on a wrist and arm were well noticed due the vicinity of the location, but occlusion by furniture and sitting posture have an effect on thigh, waist and shoe areas [11].

Due the form factor and design possibilities with handbags, prior art on wearable displays is especially interesting. Whereas the research in the area is still somewhat sparse, several different examples exist. Using wearable displays in a use context of sports is considered by Mauriello et al. [20] for placing information display on the running shirt. Jarusriboonchai et al. [16] have demonstrated a social use case, where a neck-worn information display is aimed to facilitate co-located social interaction. Von Zadow et al. [31] have demonstrated a sleeve with a display. Moreover, Schneegass et al. [27] have presented a design space for on-body displays, and also an ambient communication display on a bracelet has been suggested [29]. When smart accessories are considered, displays have been demonstrated e.g. on an umbrella [12], a backpack [1], and even in a handbag [7].

Wearables Aesthetics and Smart Fashion

Integrating wearable computing to fashion products is a trend which is gaining an increasing amount of attention [17]. Examples of items where design and aesthetics plays a major role includes digital jewellery and smart watches, and e-textile consumer products with a strong brand image. Interactive technology has been demonstrated in fashion garments such as *Spider Dress*[1] and *Twitter Dress*[2]. Also shape-changing fashion has been in the interest of prior research. *Awakened Apparel* is a fully embedded pneumatically folding shape-changing fashion wearable [23], and *Scarfy* a scarf that can deliver information by shape-changing and vibration based on how it is tied by the user [25]. *SKORPIONS* is a set of kinetic electronic garments that move and change on the wearers body in slow, organic motions enabled by the shape-memory alloy Nitinol [3]. In addition to garments, e.g. painted fake fingernails integrating RFID tags have been introduced [28], and different design styles for glasses type wearable computing has been explored [10]. Fortmann et al. [9] have presented a design process, prototype and evaluation of an information bracelet, where the form factor and aesthetics have been taken into account in the form factor design. Juhlin et al. [18] have introduced a smartwatch that adapts to the color scheme of the user's clothes, and propose an outfit-centered design approach for fashionable wearables.

Handbags as Wearables

Altogether, research on digital fashion is still very sporadic. Especially related to our research, handbags are an underexplored area. They have been considered earlier from the sociological research point of view [4, 21], but even this approach has been scarce, as pointed out by Buse and Twigg [4]. The findings in this area report that for many of their users, handbags are intensely personal and private [21]. There is little HCI research related to handbags, however the first design handbags employing a public display are already available [8]. In [6], Gemini handbag concept design, consisting on mobile phone controlled LED matrix, is presented. Colley et al. [7] have evaluated different functionalities of a smart handbag integrating a pervasive display, e.g. displaying the bag contents and adapting the bag's appearance according to the user's outfit.

The novelty of our work lies 1) in the objectives on charting general design preferences related to smart handbags, and 2) in the methodological approach. Whereas Colley et al. [7] use a wizard-of-Oz method on selected design ideas, and Chen & Yan [6] evaluate a single concept with a low-fi

[1] Spider Dress. Retrieved July 1, 2016 from http://iq.intel.com/smart-spider-dress-by-dutch-designer-anouk-wipprecht/

[2] Twitter Dress. Retrieved July 1, 2016 from http://cutecircuit.com/the-twitter-dress/

prototype, in contrast, our work reports a wider, user centric concept creation through co-design approach.

CO-DESIGN AS A RESEARCH METHOD

Co-design is collective creativity applied across the whole span of a design process done by designers and people not trained in design together [26]. The role of the designer is becoming more and more important for the success of the co-design activities. As Sanders and Stappers [26] notify, with current and upcoming design problems of interaction design, professional designers need to be prepared for showing their expertise in co-design session as they professionally keep track of existing, new and emerging technologies, and have an overview of production processes and business contexts and thus are able to provide expert knowledge for the non-professional participants. In order to make sure that the non-designer participants are able to create something novel in co-design activity, co-design researchers and professional designers are typically acting as facilitators. As facilitators they are able to provide lead, guide, scaffolds and clean slates for enhancing people's creativity. In addition, they need to have social skills in order to be able to interview participants during the co-design activity to be able to understand what was created [26].

In co-design sessions it is common to have different kinds of materials to allow non-professional participants to construct their design ideas in understandable form for example if they are not comfortable or do not know how to draw their ideas on paper. This way of working is supported by the research through design approach, which emphasizes constructing artifacts which communicate and materialize the abstract research ideas and findings [32].

RESEARCH PROCESS

The user centric and co-design oriented research process conducted consisted of two parts, where different participants were involved. As the central method, the first study (Study I) utilized self-expression template designed for expressing the ideas by drawing and writing (Figure 2). The second study (Study II) focused largely on using different low-fi prototyping materials, such as cloth, office and sewing accessories, as tools for creating design concepts and prototypes. In addition, both studies included other tasks supporting the design exploration, as reported in more detail in further sections.

STUDY I

The first user study focused on understanding user needs for smart handbag design as well as its form factor and interactive content presented on the handbags surface. The study was conducted in laboratory like setting. At the beginning of the evaluation, participants completed a background questionnaire of demographic information and prior experience with handbags and wearable technology. After that, the purpose of the study was explained to the participants. The study consisted of two parts, where the first part included tasks focusing on interactions with design concept, results presented in more detail in [7]. The second part focused on charting users' specific needs for the form factor, materials, and aesthetic aspect of the smart handbag, and initial findings were shortly described in [22]. In this paper, we present deeper reflections for the data gathered in forms of user drawn ideas on a Self-Expression Template [2] (see Figure 2) as well as their explanations and textual descriptions on the end questionnaire.

Study Setting

The Self-Expression Template (Figure 2, on the left) was designed with a human figure on the right lower corner, and a handbag illustrated in opposite corner. Participant were asked to draw on the human figure: *how they would like to wear the hand bag* and *preferable size of the smart handbag.* On the illustration of handbag, they were asked to draw *the content they would like to show on the surface of the smart handbag*. In the blank area in the middle, participants were asked to draw their smart handbag design. After finishing their drawings, participants were asked to explain them. The task duration varied between 18 and 5 minutes, mean duration being 11,5 minutes. To triangulate, participants were asked to write in the end questionnaire the *preferable content to be shown on a smart handbag* and *description of their dream smart handbag*. Participants' drawings were stored and their comments were video recorded and transcribed.

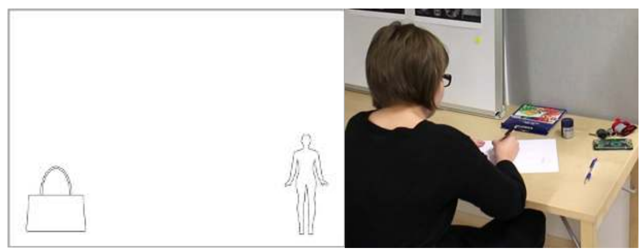

Figure 2. Self-Expression Template used in the user study and example participant drawing on it.

Participants

Twenty (20) female participants with ages between 22 and 63 years (M = 33 years) took part in our concept evaluation. All of them owned handbag/s: 50% of the participants owned one to five, and the rest from six to ten or even more handbags.

Data Analysis

The analysis addressed the transcribed participant comments and end questionnaire answers. Two researchers went through the material, and marked the emerging themes. After this, the data was categorized under the themes. Drawings were used for understanding participants' comments in more detail. Analysis followed general qualitative coding principles. In addition, the form factors and wearability of the bag was analyzed by visually combining each picture with the others (Figure 3).

Results

Form Factor of the Smart Handbag

Most of the participants (14/20) preferred a shoulder bag type of form, because of its most multipurpose form factor allowing carrying the bag in different ways. Six out of 20 preferred a satchel type bag where the strap went diagonally across the body, because of its practicality e.g. when cycling. Altogether 5/20 participants drew a bag which was held in a hand of which one was evening pouch. Figure 3 summarizes the participants' sketches, visualizing the variation of sizes and the way of carrying the handbag in different colors: shoulder bags in pink, satchel type of bags in blue, and hand held bags in green.

The most important feature mentioned by 13 out of 20 participants was the possibility to change the shape and size of the handbag to fit it for different purposes. Even though it was recognized that shape changing bag is difficult to design, participants offered solutions for enabling transformation. For example, there could be a zipper in the bottom of the bag to allow expanding the volume (participant ID #1) or some part of the bag could be separated to make it smaller (#16). For many participants (6/20) it was important that the handbag should be small and lightweight. The preferred handbag design was described as classic, timeless, simple, and neutral, in order it to fit with different kinds of outfits and use cases and not to become outdated too soon.

Figure 3. Participants' drawings on the handbags combined.

Material of the Smart Handbag

Texture and materials were considered as important features of the appealing smart handbag design by many participants (7/20). Participants in general thought that smart handbag would be made from plastic kind of material which could not mimic authentic materials. As one participant explained: *"… associating the texture on the surface to a smart material is difficult… you can't imitate the feeling with a plastic type surface… [the feeling of] leather, fur"* (#4). One participant defined attributes for preferable smart material: "*Silky like material, softly settling smart fabric*" (#4). Another described it as soft, bendable, gleaming, and reflective when on the go (#3). For many participants, leather was the preferable choice for material because of its durability, perception of quality, and the pleasant (haptic) feeling it gives when handled.

Other possibilities for texturing the handbag was suggested as well. Different personal favorite (#8) or self-made textures (#6) were mentioned. Two participants (#4, #6) also mentioned the brand and its logo as a design factor creating luxury and authentic handbag kind of feeling (#4) for them. It was suggested that owner of the smart handbag could get designer/ luxury brand pattern textures on the bag by buying some monthly vouchers to do that or either agree to show some advertisements on the bag to get them for a discount price (#3).

Interactive Areas of the Smart Handbag

Participants had various ideas on how large area of the handbag surface would be interactive. Most of the participants (7/20) draw and explained that the whole surface could be interactive. They wanted to change the color and surface pattern as well as even texture of the handbag's material. A few participants were not satisfied with a static color change, but wished for dynamic outlook:*"It could be a chameleon type of bag with video"* (#13), or *"in night club you could have it with animated stripes"* (#9). Other participants wished the interactive part to be only on one side of the bag (4/20) or on both sides (3/20) where the surface facing the carrier would be displaying personal things and outer side would be dedicated for self-expression. Some participants preferred to hide interactive area either in the bottom of the bag (#18) or inside of the bag, such as on inside the folding flap of the handbag (3/20) or in the pocket (#20).

Figure 4. Participant #2 wished for an interactive display that would remind her of upcoming events, and #12 drew a cartoon character to inform of reminders and arriving text messages.

The area for interactive content should be possible to be reshaped and sized based on the content shown. For example, one participants suggested: *"Arriving message or call could be displayed as a small element on the bag"* (#6). Another wished more creative solutions for showing text messages on the bag (see Figure 4, on the right): *"The message could be shown on a speech bubble of* [an interactive and animated] *cartoon character"* (#12).

Suggested Interactive Content

Participants suggested many applications and tools that would be practical in everyday use situations. The first category included suggestions for improving the usability of the handbag such as *an interior light* (#3), *menu* (#5), *item reminder* (#2, #10), and *navigator* (#2) or *voice commanded intelligent personal assistant* (#5) to help searching the bag's content or showing it contents to the user. Second category consisted of other important items that could be handy in various everyday situations when it is not possible to take the item in hand. These were *calendar with reminder* (#2, #12) (see Figure 4, on the left), *notes* and *checklists* (#1, #6, #7, #10), *map with a navigator* (#2), *clock* (#10), *thermometer* (#10), *weather application* (#18), and *photos* (#1, #10) or *videos* (#1, #9, #13). Also more creative needs for interactive content was suggested, allows user to be more creative by making the bag more chameleon like with live feeds of images (#13) or any kind media (#9).

For some, the safety and security monitoring were important smart features of the bag. For instance, the handbag could *warn about approaching cars* (#11). If robbed, the bag could alarm the user and people nearby by "*turning to red and starting to scream*" (#15), or it required "*a pin code to be opened*" (#15).

STUDY II – HANDS-ON CO-DESIGN SESSION

Study Setting

In order to plan and conduct co-design workshop, we used two professional interaction/industrial designers as facilitators in the co-design workshops. Designers were in responsibility of introducing an overview of state of the art in fashion wearables, as well as instructing and guiding workshop participants in their design activities. The procedure of the co-design workshops was the following:

- Signing a consent form and written survey with background questions
- Task 1: Assessing pros and cons of existing fashion wearables and smart bag concepts (pictures)
- Task 2: Assessing preferred features for a smart handbag (text)
- Task 3: Introduction and discussion on materials (physical probes)
- Task 4: Co-design and creation of physical concept prototypes (physical probes, low-fi prototyping, and sewing materials)

The task flow was constructed to roughly follow a common design process from benchmarking existing designs to creating a prototype. The tasks started with assessing existing designs, prioritizing features, and familiarizing with materials, and progressed to creating a concept design and prototype. Each session lasted approximately two hours, and was video recorded. The tasks are explained in detail in the following paragraphs.

Task 1 functioned as an introduction to interactive handbag topic, and led participants to assess different existing designs. Eight pictures of selected existing or concept designs of smart bags were attached to wall (Figure 9). Two piles post-it notes, red and blue, were given to each participant, and they were asked to come up with pros (red notes) and cons (blue notes) for each concept (Figure 5). After this, the workshop facilitators led the discussion of perceived pros and cons of each concept.

Task 2 was an individual task, where the participants assessed different features and design qualities for a smart handbag extracted from findings of the study 1, and selected their preferences. This was done by providing shared A3 sized paper sheets with 26 different terms (four statements/ paper in a table) on the table, and 12 notes (2 x 5's and 10 x1's = worth of 20 units in total) of (game) money. The participants were asked to place the money, one note or more at a time, on the terms according to their preferred features (figure 6). After completing the task, participants were asked to describe and justify their selections. The list of terms are introduced in the Results section, in Figure 10. The terms were selected based on comments gained in Study I, complemented with a few additional aspects in order to gain a comprehensive set of available features.

Figure 5. Assessing pros and cons of existing designs in Task 1.

Figure 6. Valuing preferred features for a smart handbag in Task 2.

Task 3 was a combination of collaborative and individual exercise. Facilitators gave participants different kinds of textiles, natural materials, for example leather, and smart materials, such as printed solar panels and electro luminance wires, see Figure 7, and provided explanations on them. Participants were asked to look and feel the materials while thinking aloud. After tinkering the materials, participants were asked to design their smart handbag on the paper and encouraged to utilize these materials in their designs. After sketching, participants were asked to explain their design ideas to all and give comments to each other.

Task 4 was a group or individual task, based on the willingness of participants to work in groups. Participants were asked to construct their smart handbag in 3D form by utilizing the given materials introduced in Task 3, and optionally an additional 3D template of the bag (white bag base made of waffle cloth), see Figure 8. In addition, other hand craft and sewing materials as well as office tools, such as scissors, staplers, glue, and tape were provided. People were encouraged to take their initial design/s to further and when working in groups, try to combine best ideas from all the sketches. After 15 minutes of working, they were asked to present their designs to each other and discuss their perceptions of them.

Figure 7. Task 3 in action.

Figure 8. Example of a participant utilizing a handbag template and modifying to her own design during prototyping session (Task 4).

Participants
Altogether ten (10) female participants took part in the two workshops in Study II, six participants in Workshop 1 and four participants in Workshop 2. The age of the participants varied between 27 and 50 years old (median of 35 years). All participants owned at least two handbags and 50% of them owned more than ten handbags. None of the workshop participants had prior knowledge of nor had participated in Study I.

Data Analysis
The analysis was started from participants' individual drawings and transcribed explanations as well as 3D mockups of the created smart handbag designs. When reading them, emerging themes were marked within the data and data was categorized under these themes. Drawings and 3D designs were used for understanding participants' comments in more detail. Analysis followed the general principles of qualitative coding and was done by two researchers.

Results

Evaluating Existing Handbag Designs
In the first task, participants gave positive and negative comments on post-it notes for the eight bag concepts presented (Figure 9). Results are presented in table 1. The 'triangle bag' (Figure 9, H), where the structure consisted of small triangle shapes, was given most of the positive notes (12 positive/ 2 negative/ sum 10). People liked its visual aesthetics and its was mentioned to look ”*stylish”* (7/10) and ”*neat*” (5/10). The form and material of the bag was perceived to be interesting: ”*It looks expensive, even though it does not have any technology inside, only the material* (which makes the form to change)” (#10).

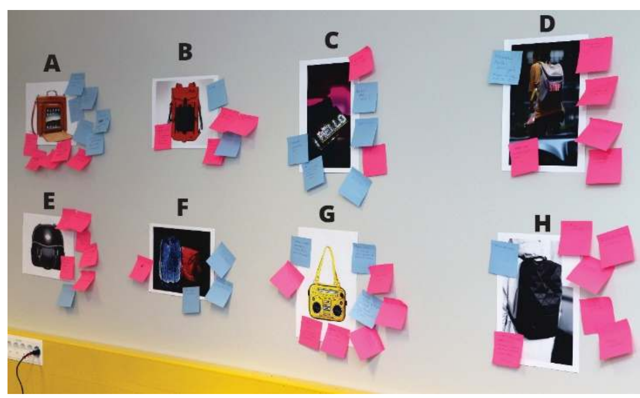

Figure 9. Comments on post-it notes related to the pictures of smart bag concepts presented in Task 1. Photo from the Workshop 1.

	A	B	C	D	E	F	G	H
(+)	7	7	10	10	11	5	9	12
(-)	12	6	7	2	3	6	6	2
Sum	-5	1	3	8	8	-1	3	10

Table 1. Amount of positive and negative notes and their sum when commenting the existing bag designs in task 1.

Also one participant appreciated its "*non-smart looking*" outfit (#2). However, the most appreciated feature of the bag was its perceived possibility to adjust the volume of the bag based on the content inside. For example one participant explained her note: "*Does it understand to change the form based on the things I have inside?.. I was looking that kind of smartness in it*" (#1). Another participant wrote: "*Could it contract and open individually based on the amount of belongings inside?"* (#7).

The second highest amount of positive notes was received by the bag with a light inside, Figure 9, E (11 positive/ 2 negative/ sum 8). Even though the light itself was not perceived as smart nor interactive feature, participants thought that it was practical and "*brilliantly good idea*" (7/10), and should be included in every bag they owned. It was perceived to help searching items from the bag, e.g. "*Sometimes you have to turn over your bag to find what you are looking for… that is needed*" (#2). However, participants raised their concerns of the durability, weight, and the maintenance of the light, e.g. changing its batteries. One participant wondered: "*If it could have some small solar panel for producing power to the light*" (#3). Another suggested kinetic energy as combination with the solar energy (#5). It was also wished that the light could be removed or extended to be able to use it as a torch when for example, trying to open front door in the dark (#7) or when some large item is blocking the fixed light (#4).

Third highest amount of positive notes (positive 10/ negative 2/ sum 8) got the STOP-backpack designed for bicyclists, Figure 9, D. It was perceived to fit be its use purpose and offer safety for people in traffic (6/10). It was seen to help car drivers to notice bicycle drivers' intentions better. However, as one participant commented, it could also cause problems in the traffic. She stated: "*when you are driving a car… there are already different kinds of traffic lights, for example for* [cars]*, trams, and bicycles…it is information flood you know, you need to think that which ones* [traffic lights] *are for me"* (#7).

Other presented concepts were perceived as follows. The 'Hello LED' bag with changing Twitter feed shown on the bag with LEDs (Figure 9, C) was seen to be a party bag for people who want to express themselves and it was perceived to be visually interesting, e.g. lights, yet quite bulky looking. The backpack with integrated solar panels (Figure 9, B), was seen to be meant for outdoor activities, however the functionality of solar panels in dark was questioned. Also, the bag was not considered as visually pleasing. The leather briefcase with tablet case integrated on it (Figure 8, A) was commented to be a neat and classic looking bag, however the perceived usability was not rated good. Also the bag was perceived to be lasting longer time than the tablet, and the participants suspected that the pocket would thus not be useful anymore. With the 'LED pouch' which had fabric with LED strings in it (Figure 9, F), the light was perceived to be interesting, but the shape of the bag did not please. The 'retro radio' looking bag with MP3 player and speakers integrated in it (Figure 9, G) was seen as good for special occasions, such as picnic, but the design was targeted more for teens and was not considered visually pleasing among workshops participants.

Valued Qualities and Features in Smart Handbag

In the second task, participants gave 200 units (20 units /participant) worth of (game) 'money' for the qualities and features that they value in bags. Results are presented in Figure 10. The most valued quality was *aesthetical*, gaining a total of 34/200 'money' units. Second highest amount of 'money' was given to the term *practical* (27/200). Interestingly, some participants' valued aesthetics over practicality and vice versa. One participant explained: "*It does not necessary have to be so practical, as long as it looks really good*" (#10). Another participant who valued practicality more than aesthetics, commented: " *I will not use it, if it is not practical*" (#8). Participants explained what practicality of the bag means to them: "[The bag is] *good looking, made of good materials, voluminous, suitable for different events, outfits, and places*." (#10), "*easy to open, [has] a lot of small pockets*" (#8), no one could open it without the owner noticing it (#9), and items were protected when raining (#10).

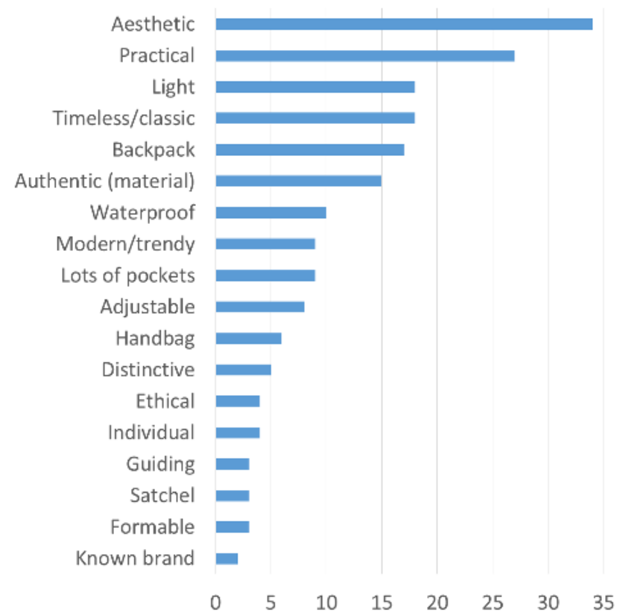

Figure 10. Preferred features and qualities (amount of money given) for a smart handbag in Task 2. The chart excludes the terms with one or zero 'money' units: reminding, clutch, simple, safe, decorative (one unit), and pocketless, unbranded and heavy (zero units).

Also *light weight* (18/200) and *classical style* (18/200) of the bag was valued. Participants did not want their handbags to be heavy, and technology should be fitted in without adding the weight of the bag. Selecting *classic* as one of the key terms was interesting, as on the other hand people wanted to have trendy handbags, but also classical looking ones which do not get out dated too fast. Also it was stated that handbags, especially luxury brand ones, are quite expensive, contributing to the wish to buy more classical looking bags. This discussion led to smart handbags: "*Why couldn't the interactive handbag be transformed to be trendy, classical or timeless whenever we want that*" (#1).

Co-designing Smart Handbags

In tasks 3 and 4, participants created their visions of interactive handbag, two resulting examples presented in Figure 1. Participants in Workshop 1 were discussing and ideating aloud while browsing the given materials in Task 3, and probably hence this, many of the collective ideas were incorporated in their individual drawings. Therefore, in Workshop 1, the final outcomes in concepting and prototyping tasks presented quite similar functions and smart features. In Workshop 2, the situation was quite opposite, as participants did not discuss that much together when experimenting the given materials. Here, their individual designs had different features presented. Either did not want to work in groups in Task 4, but favored creating their own designs. The shape of the bags concepted in Task 3 varied as follows: 5/10 designed a handbag, 3/10 draw a back bag, one drew a messenger bag, and one an evening pouch. There were 6 mockups of a smart bags created in total in task 4, of which four utilized the given handbag template (Figure 11).

Figure 11. Six mockups of a smart handbags were created by the participants in the Study II workshops.

The most favorite and commonly adopted idea was a pocket inside of the bag for charging mobile phone (8/10) either with printed solar energy panels integrated on the body of the bag or its shoulder strap (6/10), hanging from the bag (#9), or kinetically with separate add-on decorative element hanging from the bag (3/10). One participant explained that if possible, the excess energy of the backpack could even be used for heating the cooker on hiking trips (#7).

Applications for the bag were also incorporated in the designs (5/10). Mainly the apps were visioned for changing the texture and color (3/10) of the bag, but also more elaborate ideas were presented. Group 1 in workshop 1 (#1-3) explained that the app could contain, for example a ticket to rock concert, and a concert related color or print pattern would appear on the bag. One participant wanted her bag to react to the environment lighting (#9).

Transformability of the bags shape was favored (4/10) because, it would 'make the bag to last forever', as phrased by two participants: "*everlasting bag*" (#2 & #3). One participant went to extreme with transformability of her bag design. She wanted her bag to be dynamically shaping its volume and form based on the content inside. In addition, she wanted the backpack to adjust autonomously the length of the shoulder straps and adjust the back panel of the bag to fit ergonomically to her back. In addition, she wanted her backpack to balance the weight of the content optimally. When not wearing the backpack, she wanted it to shrink it to small cube which could be put away from sight (#5).

People did not want their bag to look smart and interactive from outside. Nevertheless, they wanted to have smart features hidden inside, as one participant explained: "*I want it to be leather and that it does not look like smart bag, it has to be classical looking bag with all the functions hidden inside… as all these smart features might attract thieves*" (#6). In general, participants wanted the bag to look aesthetically good (group 1/ Workshop 1) and stylish (#8). The bag itself should be made of authentic materials, such as leather (6/10) or felt (#7).

Also interior light was favored (6/10). Participants extended the idea of basic inside the bag light shown in Task 1, and placed it in the inner seams of the bag with electro luminance wire, to let the light disperse better into most difficult corners of the bag (6/10).

Also participants brought up ideas increasing the security of the wearer. For example, the bag would not open to anybody else than the owner of the bag (3/10), or it could not be carried by anyone else. Suggested solutions were finger print scanner (#1, #4) or autonomous shape changing to a difficult to carry one, e.g. "*bag could wriggle when some wrong person tries to carry it*" (#5). Also a panic button was suggested for situations. When someone tries to steal the bag or the user is threatened, a push on the panic button would initiate automatic call to police with GPS coordinates (#6). This raised a lot of discussion, and it was suggested that the bag could also start an alarming noise (5/10).

Other desired functionalities included small screen on inside the folding flap of the handbag (7/10), speed and kilometer counter (#2), navigator with speech assistance (#6), and an item reminder function (#4 & #9). One participant even incorporated in her design a possibility to use her party pouch as a communication device and replacement for the bank card (#1). Even though people wished a lot of technology to be adopted within the bag, it was seen essential that it was still light to carry.

Issues Impacting on the Selection of the Bag

In the discussions throughout the workshops, people were commenting about the aspects that impact why a certain bag is chosen to be used in certain situations. The decision is not limited only to the clothes worn, but also season, weather, use context, and use case. Participants noted that some materials and colors were not the best choice for certain seasons and weather, for example: "*Black leather bag in* *summer does not feel good, and when it is raining, I do not want to take a bag made of really sensitive materials*” (#1), or “*Felt would feel too warm in the summer*” (#4).

Considering Implications to Business Models

During Workshop 1, participants were discussing what would happen if smart handbags with adapting shape, materials and textures were on the market. Participants agreed that it would make their life easier as well as help in obtaining a more eco-friendly and ethical lifestyle. However, they were also concerned of bag manufacturers’ loss of markets, as less bags would be purchased if one product was a solution for every use case. They offered accessories and applications as a solution for this problem: *“[people] would buy accessories, such as tassels*” (#5) and “*or apps…for changing the color and pattern of the bag, but I would not spend a lot of money to those*” (#3). The facilitator asked participants opinions on purchasing luxury brand and design patterns and textures for their bags. Participants were not interested of this option for themselves, but stated that for some more brand oriented people it might be more important.

DISCUSSION

General Findings

Handbags are utilitarian items for their functions, but aesthetics play a key factor in their design and desirability. The ideas generated by 30 study participants around a smart handbag demonstrated both utilitarian and aesthetic factors, and some features, such as light weight, combined them both as a design driver.

The participant input also highlighted that the technology should be embedded to the design in a way that it aligns with the material design, which was considered as an important part of the aesthetics. The technology should not break the desired feeling of softness, the use of luxury of materials, or the haptic feel of the fabric or leather. On the other hand, the comments on timelessness and modularity indicate that, when carefully designed, technology can help in adapting the handbag to different outfits or matching the design to different type occasions.

Technology Related Notes

Whereas our research focused on smart handbag design on concept level, without being limited by the available technology, some technology related themes emerged from the findings. These represent both challenges as well as opportunities for technical implementation.

Suggested context sensitive adaptivity of the smart bags, including its shape, size and color, can already be visioned with the emerging technological development of, e.g., 3D printed fabrics and shape changing technologies, such as presented in Yao et al. [30], Perovich [23], and Radziewsky [25]. One problem, however, with current technology concepts is the physical weight of the solutions. Our findings indicated that people are cautious if integrating technology to a handbag will make it heavier, and emphasize that lightweight components should be used. In addition, participants did want that the electronic components themselves to look aesthetic. Thus lighter and more aesthetical technology is needed to be able to please the needs of the users of fashionable wearables. Also the supply of electrical power, preferably a self-reliant energy, to enable the smart features needs to be considered.

As handbags are not as tightly body-attached wearable gadgets as for example watches and bracelets, the designers need to take into consideration also security issues. Handbags are in risk to be stolen, women physically threatened, or when in the traffic, not be seen by other people. Integrating security technology to a handbag could offer solutions to prevent such occurrences from happening.

Recommendations for Smart Handbag Design

For our both studies participants, the smart handbag needs different kinds of features to be smart. In addition, also some less interactive features were listed as important. To create a synthesis of our findings of the both studies, we created a set of ten design recommendations to be considered when designing a smart handbag:

1. Classic, aesthetic, and practical base design: To be an everlasting bag, the smart handbag’s basic form itself needs to look classical, yet easy to transform to trendy or different shape.
2. Transformable: The form and size of the bag should be possible to change and vary when needed to make the bag more usable in different situations. Here, smart shape-changing materials can allow shapes that are not possible with zippers and removable parts, and enable autonomous volume change depending on the carried content.
3. Materials: The bag should be made of smart materials that imitate the look and feel of the authentic materials, and e.g. feel soft to skin. The material should be as durable and long lasting as authentic leather, however allow adjusting its color, texture, and pattern to make the bag fit to different use cases, events, seasons, and clothing.
4. Hidden technology: Smart handback should not look interactive or smart outside all the time to protect its user’s safety, however the material of the bag should allow to show digital media within the user defined area/s.
5. Applications and add-ons: Provide a possibility to rent or buy virtual and physical props to modify the bag’s visual appearance.
6. Provide simple things that make user’s life easier. Examples of these are an interior light, reminders and notes, as well as time, temperature and weather, or even speed and activity monitoring applications.
7. Sustainable energy sources: The handbag should preferably be energy autonomous, harvest the needed energy by itself and be able to charge also other interactive devices carried in it. Energy harvesting technology should also look aesthetically pleasing.

8. Light and maintenance free technology: Technology should not increase the weight of the bag nor need to be maintained every now and then.
9. Weather proof: Smart handbag should be usable in any kind of weather and not get broken too easily.
10. Security to the user: The bag should have integrated safety features, such as lock, alarm, and location tracking in case of robberies.

Methodological Notes and Limitation

As a methodological note, in Study I, using the self-expression template after the participants had conducted a user study with a smart handbag prototype including a display, as described in [7], may have created a bias towards display-integrated handbags. On the other hand, we believe that it also opened people's eyes and imagination for all kinds of other possibilities related to technology enhanced handbags. Our follow-up co-design study confirmed our findings. Even as the participants of Study II workshops did not see the porotype described in [7], concept ideas, or the results of the Study I, they came up with quite similar needs for the smart handbag design and its functionalities. Thus the procedure in the first study did not cause much bias after all, and in our experience, we can recommend it to other researchers as well. The procedure and tasks in our workshops worked as we planned, and we are planning to research it more in the future.

CONCLUSION

In this paper, we have presented findings from two user studies conducted in total with 30 participants to explore the design preferences and possibilities for smart handbags. The studies followed a co-design process, where the first was conducted as an individual drawing based brainstorming on a self-expression template (n=20), and second with two co-design workshops (n=10), where participants assessed different designs and features, sketched, and created low-fi concept prototypes of their smart handbag concepts. Our salient findings indicate strong shape and style variations for a smart handbag according to the intended contexts and use cases, as well as the lifestyle. Here, the suggested modifiability, e.g. adapting the size and shape as well as texture and color, was relatively large. Durability for weather and age, and perception of high quality materials were also highlighted. Derived from our findings, we have presented ten design recommendations, which aim to provide assistance for future designers of smart handbags.

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