Making Clothing Last: *A Design Approach for Reducing the Environmental Impacts*

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This article discusses the extent it is possible to delay clothing disposal through improved design, thus reducing negative environmental impacts. This has been done by including user centered design methods into more traditional quantitative consumer research to give new insights for design. Empirical data on reasons for disposal of 620 clothing items from 35 persons in 16 Norwegian households was collected. In total, 70 different disposal reasons were registered, which were combined into seven main categories. Changes in garments as well as size and fit issues dominated, while functional, situational, taste, and fashion related reasons were less common. The article concludes with design solutions on four levels related to the important disposal reasons including product design (material and shape), service design, and systems design, but also shows that consumer behaviour is crucial. In addition, the combination of results obtained with various qualitative and quantitative methods proved to be suitable for giving rich data that can be used to drive design research forward.

Keywords – Clothing Design, Consumer Behavior, Lifespan, Sustainable Design.

Relevance to Design Practice – The article has both practical and methodological relevance. It suggests several design strategies to prolong clothing lifecycles and reduce the environmental impact based on a new methodological combination of user research.

Introduction

Our modern Western society consumes large amounts of resources, and there is a seemingly endless stream of new products available. Textiles and clothing production is among the industries that contribute most negatively to environmental and social aspects of sustainability (Madsen, Hartlin, Perumalpillai, Selby, & Aumônier, 2007). Textiles production and consumption combined contributes to 3% of global CO2 equivalent emissions (Carbon Trust, 2011). This article addresses the potential of design to substantially reduce environmental impacts related to clothing consumption. The research employed a multidisciplinary approach which included design sciences, natural sciences, social sciences, and cultural studies. The results of this research show that this reduction may take place during any stage in the lifecycle of clothing, including at the systems design level (Fletcher, 2008). In the past couple of decades a considerable number of studies have addressed the potential for reducing the environmental impact in the phases before products reach the consumer, including the production and transportation phases, as well as the post-consumer phase through recycling and re-designing of the discarded textiles (Morley, Bartlett, & McGill, 2009; Morley, Slater, Russell, Tipper, & Ward, 2006). Recently there has been increased focus on the "use" stage. To reduce negative environmental impacts in the use stage, research largely goes in two directions: How to diminish the total amount of textiles in circulation through expanding the life of the existing textiles and re-using the products (Cooper et al., 2013; Fletcher, 2012; Jørgensen et al., 2006; Madsen, Hartlin, Perumalpillai, Selby, & Aumônier, 2007), and how to reduce the consumption of energy,

water, and chemicals during the use including laundering and drying of clothes within households (Bain et al., 2009; Laitala, Boks, & Klepp, 2011; Pakula & Stamminger, 2010).

This article discusses the possibility of delaying clothing disposal through improved design, consequently increasing the active use period. Most existing research on clothing disposal is measured either through quantitative surveys (Bianchi & Birtwistle, 2012; Domina & Koch, 2002; Hibbert, Horne, & Tagg, 2005; Joung & Park-Poaps, 2013; Lang, Armstrong, & Brannon, 2013; Shim, 1995) or qualitatively (Albinsson & Perera, 2009; Cluver, 2008; Ha-Brookshire & Hodges, 2009; Klepp, 2001). By triangulating user-centered design methods of data collection into more traditional ways of quantitative consumer research, the authors sought to achieve richer data that would bring new insights for design. In this article, we use the word design in its broad sense, not only the direct forming of clothing, but also the design of services or systems around clothing consumption.

Firstly, the article presents some background information on sustainable clothing consumption and design, secondly a section on methods used for collection of the empirical data. The analysis of the data then provides input to a discussion

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of potential design strategies. A summary, conclusions and recommendations for relevant stakeholders, as well as an outlook conclude this article.

Sustainable Clothing Consumption and Design

Pettersen (2013) argues that design can contribute to changing consumer behaviour in a more sustainable direction. In order to understand the dynamics of the activities and the potential for change she combined several theories, including practice theory and system innovation theory, with a multi-layered sociotechnical transformation perspective (Geels, 2004; Reckwitz, 2002; Rip & Kemp, 1998; Schatzki, 2001). Pettersen concludes that the social practices can be used as a measuring unit to quantify the dynamics of private consumption, and can be used as a starting point by those who wish to contribute to changes in practices through design. Correspondingly, in this article our starting point is the various consumer practices related to clothing consumption that are covered by the acquisition, use, and disposal phases. Most literature on clothing consumption concentrates on the acquisition phase, where consumers' selection of more sustainable products is discussed. This article uses the two latter stages as a starting point and connects sustainable design to clothing use and disposal practices. It is also important to note that each of the consumption stages influences the other stages. For example, the amount of clothing a person acquires influences how much each garment is used, and if garments are not properly taken care of, they can end up sooner in the disposal phase.

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There are numerous design strategies for making clothing consumption more sustainable. For example, the Textiles, Environment, Design (TED, n.d.) project proposes ten sustainable design strategies for textile and fashion designers:

1. Design to Minimise Waste
2. Design for Recycling / Upcycling
3. Design to Reduce Chemical Impacts
4. Design to Reduce Energy and Water Use
5. Design that Explores Clean / Better Technologies
6. Design that Looks at Models from Nature & History
7. Design for Ethical Production
8. Design to Replace the Need to Consume
9. Design to Dematerialise and Develop Systems & Services
10. Design Activism: leave behind the product and work creatively with the consumers and society at large.

Another example is a co-design toolkit for sustainable fashion design and consumption that facilitates positive behaviour (Hur, Beverley, & Cassidy, 2013). It includes six design and use patterns with several examples of each.

1. Choice: e.g., choice of use of resources in production and ways of use (wear, care, dispose).
2. Optimisation: e.g., cradle-to-cradle thinking, zero-waste and rethinking alternatives such as swap and share services.
3. Empowerment: propose solutions that satisfy psychological and social needs, such as personalisation.
4. Persuasion: ways to motivate people, e.g., providing information or rewards.
5. Interaction: patterns in user-product relationships, such as behaviour feedback and sensory effects.
6. Social conversation: enables changes through social learning, use of open-source, creative communities and ways of living.

Also Niinimäki and Hassi (2011) present design strategies that can be used in promoting sustainable consumption of textiles. Strategies related to extending the life span of clothing include increasing product durability through higher quality and informing the consumers about the expected lifetime, using emotional attachment to increase product satisfaction, customization, as well as co-creation. Some of these strategies were presented to consumers to evaluate their opinion on the possibilities. Niinimäki and Hassi conclude that consumers were most positive to the solutions that they are most familiar with and that already exist to some degree, but that a combination of design strategies might improve efficiency.

Design for durability consists of improving the physical and technical robustness of garments as well as addressing the emotional and expressive qualities they can provide for consumers. This may lead to extended use and a longer functioning cycle (Fletcher, 2008; Hethorn & Ulasewicz, 2008). Fletcher (2012) points out, in her study of garment use practices in the *Local Wisdom* project, the garments that were used for a long time were not really intended to be special during the design phase, but became so in unintentional ways and often because the user took better care of them. This indicates the importance of both sides

of durability, the material side is needed as a starting point, but product attachment is needed for the user to keep on using and taking care of the garment.

Physical durability is often connected to clothing quality, but consumers perceive clothing quality to include also other features that can be either concrete, objectively measurable facts, or abstract, subjective features. They evaluate these qualities based on extrinsic, intrinsic, aesthetic and performance cues such as price, brand, fibre content, and how fabric feels (Hines & Swinker, 2001). The definition of quality in ISO 9000 (2005) is the "degree to which a set of inherent characteristics fulfils requirements." Consequently, quality is a question of degree. High quality can be achieved if all inherent characteristics meet the requirements, while the opposite is true for low quality. However, for clothing there are not that many official requirements. Legislation can be found for labelling of fibre content and care labelling, as well as requirements for chemical content and production conditions, and some safety features especially on children's clothing, but these requirements vary greatly between countries. Since almost no clothing includes information about expected lifespan, consumers' evaluation of durability is mainly based on cues that do not directly reflect it, such as price or brand (Laitala & Klepp, 2013). Rahman (2012) has tested how young female consumers evaluate quality and price level of jeans when no brand or price information is given. These consumers developed expectations of product durability based on visual evaluations of the fabric and stitches, as well as tactile evaluations of hand feel and the stretchiness of the material. In many cases they managed to guess the price level of jeans, and assumed the high price jeans to be of better quality. However, no quality tests of the jeans were performed and, therefore, it is not known how correct their evaluations were.

A consumer survey in five European countries showed that consumers assume high quality to be an important environmental measure, as they perceived buying fewer clothes and extending the length of use by repairing clothing to be environmentally preferable measures compared to buying eco-labelled clothing or reducing laundering (Austgulen, 2013). At the same time, research on fast fashion clothing lifespans showed that most of the informants thought that low price justifies lower clothing quality and shorter lifespans (Collett, Cluver, & Chen, 2013).

This short review suggests that several sustainable clothing design strategies exist. However, there is limited research on their connection to clothing lifespans and consumers' clothing use and disposal practices, and no empirical data connecting all these aspects were found. Therefore, this article seeks to find empirical data on clothing disposal reasons that affect lifespans, and identify design strategies that could increase the active use period of clothing and postpone the disposal phase. In the following section, the empirical data collection method is presented.

Research Methods

The research presented in this article has been part of a nationally funded project on clothing research. Within this project information was collected about consumers' experiences, opinions, and practices concerning clothing use, maintenance routines (washing, drying, and ironing) and disposal practices. In this article we aim to connect the results from clothing lifespans and disposal reasons to potential design solutions.

Wardrobe Studies

Wardrobe study is a methodological approach that combines methods such as qualitative research interviews, field work, inventories, and laboratory testing. It often includes an inventory of wardrobe contents, either complete or partial, and enables us to analyse the material and symbolic properties of clothing, as well as the relationship between the clothes and their users (Klepp & Bjerck, 2014). Our study included 35 persons from 16 Norwegian households who stored all clothes that were to be taken out of use during a period of six months. A total of 620 clothing items were collected and registered for the study. One or two representatives of the households were interviewed about the use and disposal reasons of each item, including how long and how much they have used the items, and why they stopped using or, in some cases, never started using the garments. On average, each participant stopped using 18 garments, but the figure varied from 0 to 71 items per person. Together with the garments, this interview material is used as the empirical starting point of the analysis. Lockton, Harrison, Cain, Stanton, and Jennings (2013) suggest that behavioural heuristics involving problem-solution pairs can be used to link the insight from user research to possible design strategies. In their methodology, if using interviews the designer approaches the relevant question by asking the informants a series of "why" questions to get their behavioural reasons, and then suggested design solutions for each reason. Our approach was similar, but we have usually asked "why" question only once or twice for each garment to keep the interview length limited to few minutes per garment.

Informants were selected from respondents that had answered to an earlier quantitative survey within the same project, and agreed to be contacted for further interviews. The aim was to select informants in different life situations and of different age, gender, civil status, family size, and so on. Three main groups of households were chosen:

1. Young adults age between 18 and 35 that are either single or couples, but not living with parents anymore and do not have own children.
2. Families with children below the age of 16.
3. Adults above the age of 55, who are either retired or approaching retirement, and have no small children living at home.

Based on the earlier survey answers, it was also known that these informants had different economic situations and varying levels of interest in clothes, fashion, and environmental issues. The 16 households included 8 children, 2 teenagers, 16 women, and 9 men. In addition to the main informants in each household, three of the cohabitants/spouses were interviewed, two female and one male, resulting in 19 interviews. The background information of the main informant of each household is given in Table 1. The interviews were recorded, transcribed, coded in Excel and finally analysed with SPSS software. Quotations from the interviews are given with age and a fictional name assigned to the respondent.

Table 1. Main informants' background information.

Property	Variables	Main informants
Sex	Women	13
	Men	3
Age	20-34	8
	35-49	6
	50+	2
Family	No children	7
	Parents to small children	7
	Parents (adult children)	2
Relationship status	Single/living alone	6
	Living with partner	10
Area of living	Oslo	8
	Neighbour counties to Oslo	5
	Trondheim area	3
Education	Vocational	1
	Bachelor level	6
	Graduate level	9
Employment situation	Working [a]	12
	Student [b]	3
	Retired	1

Note: [a] Three of them only work part time; [b] All three students had also part time jobs.

The collected clothing items were studied further in a textile laboratory. All garments that were given to the study were registered with the following information:

- Type of garment
- Fabric structure (woven or knitted)
- Fibre content (if no label, a qualified guess was made in easy cases)
- Colour
- Care label content
- Country of origin (when given)
- Changes (e.g., pilling, stains, holes, broken seams, dimension, or colour changes)
- Repairs or other adjustments
- Home/handmade or not

In addition, some technical laboratory tests were performed. Garments that were disposed of due to properties that were suitable for technical testing such as amount of pilling and degree of colour change were evaluated in order to quantify the technical quality. The pilling grade was evaluated based on grading given in standard EN ISO 12945-2 (2000), and colour change was evaluated according to ISO 105-A02 (1993). Both of the standards use a scale form of one to five, where five is best (no pilling or colour change).

Limitations

The sample was strategically selected, also called judgement or purposeful sampling, meaning that the informants were actively hand-picked in such a way that it maximizes the chance that many different and even conflicting sides of the phenomenon in question are encountered (Eneroth, 1984; Marshall, 1996). The distribution of respondents is by no means representative of the population, but the wide selection criteria provide examples of different consumers who are suited to discuss the project's research questions. Furthermore, the over representation of women may accurately reflect that clothing-related practices such as purchase, maintenance and making final decisions on discarding may be unevenly distributed between males and females in most households.

Although informants were questioned about each of the disposed garments, some information is still missing, as not all informants remembered how old some garments were, and in some cases when a large number of garments were to be disposed of and the interview extended over several hours, there was not time to register all aspects as detailed as planned. This was especially the case with children's clothing, when there were heaps of clothing and they were all to be disposed of mainly because the child had outgrown them. In these cases, the informants did not necessarily also say that the garments had other deficiencies such as holes or stains, or specify the use period of each item. Often they said at least once during the interview that the child usually used clothing for one season.

The Involvement of Design Schools

The research project involved three design schools from different countries as partners; Chelsea School of Art & Design, Oslo National Academy of the Arts, and The Swedish School of Textiles. Students were given a task to design solutions to some of the sustainability challenges based on the first initial project's research results on disposal reasons, as well as general education on how the different phases in the life-cycle of clothing effects the overall environmental footprint. Students got too choose their topics freely. Many of them chose to include the environmental aspect to their graduation projects, and some of these designs are presented here as an example of how designers worked with these issues.

Overview of Clothing Disposal Reasons

Informants talked freely about their use of garments that were to be disposed of, and no disposal reason categories were given beforehand. In total, 70 different reasons were registered. On average, each garment was given 1.7 different disposal reasons, and at maximum, five different reasons. Research on product disposal practices in general differentiates between absolute and relative obsolescence (Cooper, 2004). Absolute obsolescence means that the product has failed and is no longer usable. Relative obsolescence applies to products that are still functional, but discarded for some other reasons. In the literature, the main categories generally used for distinguishing between reasons for disposal are 1) functional: replaced by products with improved

utility or expression, 2) quality: product failure, or wear and tear, 3) psychological: also called symbolic obsolescence, and 4) new consumer needs or desires (Heiskanen, 1996; Kostecki, 1998; Packard, 1960; Strandbakken, 1997; van Nes & Cramer, 2006). We decided to use a large number of descriptions to classify the different disposal reasons that apply to clothing, before grouping

them into seven main categories. The distribution and grouping of disposal reasons is given in Table 2. In this article, the disposal reasons are given mainly as weighted results. That means that if the owner gave four different reasons for disposing a garment, each of the reasons is given 0.25 points, instead of each receiving one point (i.e., each garment gets a total of one point).

Table 2. Grouping and division of clothing disposal reasons.

Disposal reasons in each group	Unweighted reasons		Weighted reasons	
	Points	%	Points	%
Changes in garments		41		40
Hole or tear	112	18	77.5	13
Looks very used or worn	42	7	20.7	3
Stains (not sweat)	35	6	22.5	4
Worn out	34	5	18.4	3
Colour change or fading	29	5	12.8	2
Lost elasticity	24	4	10.3	2
Shape changed (dimensional change)	21	3	13.3	2
Pilling	17	3	7.4	1
Discoloration - bleeding from other garments	15	2	7.3	1
Broken seam or sewing failure	15	2	7.3	1
Shrinkage (dimensional change)	12	2	7.2	1
Broken zipper	11	2	6.3	1
Material has become thin	10	2	4.2	1
Washed out	10	2	3.7	1
Sweat smell	9	1	5.6	1
Failed mending or repair	8	1	3.0	0
Stains of sweat	7	1	4.2	1
Print faded	7	1	4.0	1
Yellowing	7	1	3.3	1
Threads drawn out	6	1	3.1	0
Broken decorations	3	0	2.5	0
Felting	3	0	1.3	0
Bra underwire broken or bent	2	0	1.3	0
Fuzzing	2	0	1.0	0
Fabric became harder	2	0	0.8	0
Buttons missing	1	0	0.3	0
Spirality	1	0	0.3	0
Size and fit issues		26		30
Too small – grown out of it	143	23	111.4	18
Fit – length	31	5	15.1	2
Too big – always been	27	4	16.5	3
Too small – always been	24	4	16.2	3
Fit – general or not specified	22	4	10.0	2
Fit – waist	11	2	4.2	1

Disposal reasons in each group	Unweighted reasons		Weighted reasons	
	Points	%	Points	%
Fit – hips	6	1	3.1	0
Will outgrow soon or before next season	4	1	1.8	0
Fit – shoulders	4	1	1.7	0
Fit – bust	3	0	2.0	0
Fit – collar	3	0	1.0	0
Too big – lost weight	2	0	0.6	0
Taste related unsuitability		12		11
Dislike of design or shape	44	7	23.5	4
Not own style	26	4	13.7	2
Dislike of colour	22	4	11.4	2
Does not use that type of garments	20	3	7.2	1
Dislike of pattern or print	15	2	8.8	1
Does not like – unspecified	4	1	2.3	0
Situational reasons		8		7
Have several similar or better garments	71	11	35.7	6
No occasions to use it	6	1	2.7	0
Does not fit with other clothes	5	1	2.3	0
Change in life situation	4	1	1.4	0
Someone else needed it	1	0	0.5	0
Functional shortcomings		6		5
Material not good	15	2	7.0	1
Uncomfortable (physical)	14	2	4.2	1
Unpractical	10	2	4.2	1
Too wrinkled, has fold marks or would need ironing	7	1	3.4	1
Too warm	6	1	1.8	0
Rolls up	4	1	2.5	0
Static electricity	2	0	2.0	0
Itches	2	0	1.3	0
Not water resistant	2	0	0.8	0
Does not fall nicely	2	0	0.6	0
Buttons or zipper do not stay closed	1	0	1.0	0
Functional failure	1	0	0.5	0
Too cold	1	0	0.2	0

Table 2. Grouping and division of clothing disposal reasons (continued).

Disposal reasons in each group	Unweighted reasons		Weighted reasons	
	Points	*%*	*Points*	*%*
Fashion or style changes		4		4
Fashion change or outdated	25	4	16.2	3
Own style changed	19	3	7.7	1
Bored with the garment	1	0	1.0	0
Other or unknown		2		4
Unknown	15	2	14.5	2
Other	4	1	3.3	1
Missing pair	4	1	3.0	0
Lacks sentimental value	2	0	1.0	0

The most common disposal reason was that the user had grown out of the garment (18%). This was followed by holes and tears (13%), and having similar or better garments (6%). Then dislike of design or shape (4%), stains (4%), and worn out look (3%).

In some cases, the grouping of disposal reasons into the main categories was not straightforward. For example, "Own style has changed" was categorised as "Fashion or style changes", but it could also have been categorised as "Taste related unsuitability." In the separation between these two main groups the meaning of *change* was emphasised. In the taste related main category, the owner never liked the product, whereas in "fashion and style changes", the product has been used and liked before, but goes out of use because there has been a change. This change is often related to cultural aspects such as fashion, even though the owner might not be that aware of it. For example, one informant explained that it was no longer her style to use a short skirt made of old jeans. These types of garments were fashionable in the time period she used it.

In Figure 1 the main groups of disposal reasons are separated between children and teens, and adult men and women. The results show that material properties of the clothes dominate when the informants describe their reasons to stop using clothing. Nearly half of the clothing for adults had changed appearance. The most common change was that the garment had a hole or was torn (22%), followed by generally worn appearance (15%). The next largest main group was related to problems with size and fit, either that the owners had grown out of their clothing, or that the clothing never fitted well to start with. This group does not include cases where clothing has changed dimensions, as these belong to the group of changes in garments. The third biggest group comprised different taste related preferences, e.g., that clothing has a style or colour that the user does not like, or a print that the user does not want to promote, such as commercial t-shirts received from different businesses. The fourth group includes different situational reasons, e.g., the owner having several similar or better garments, or that the life situation has changed. Typical changes in life situation were changing jobs, becoming retired or not being pregnant anymore, thus having a change in needs for clothing. The fifth group is called functional shortcomings. This group includes garments that are described as unpractical, uncomfortable (physically), itching or not warm or waterproof enough for the intended use. Fashion does not come up until the sixth and second to last group, which shows that 4% of garments are disposed of because they are out of fashion or otherwise outdated. The same main group includes changes in own style (3%), as it can be connected to changes in fashion, even though the respondents may not be aware of it. These results partly confirm those of three other studies on clothing disposal reasons, as they also had wear and tear as the most important category (Collett et al., 2013; Klepp, 2001; Ungerth & Carlsson, 2011). However, the order of importance of the other categories varies, and another study on young female students' clothing disposal reasons indicates that fashion was a more important reason for them (Chun, 1987).

Clothing disposal reasons grouped between adult men and women, and children and teenagers (percentage, weighted)
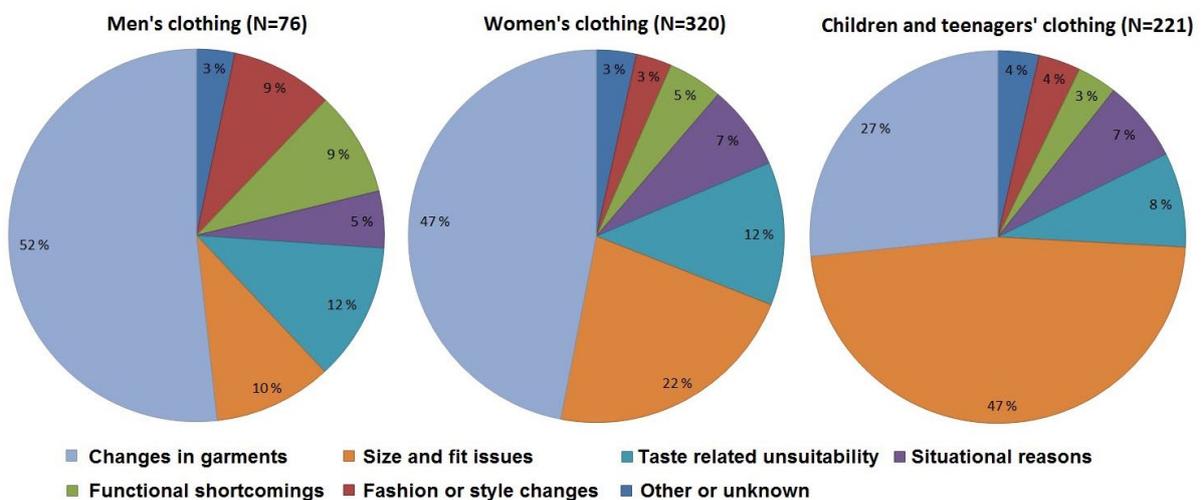

Figure 1. Clothing disposal reasons for adult men and women, and children and teenagers (*N* = number of clothing items).

When examining the clothing that went out of use because of fashion, the type of garments plays a role. No underwear, socks, stockings or nightwear were disposed of because of fashion. Fashion was a more important reason for trousers and jeans, where it was mentioned in 11% of the cases, and for jackets and other outerwear (10%), than other types of garments. Four out of five socks and stockings were disposed of due to physical changes, the next biggest reason being size and fit (mainly children's clothing). Size and fit issues were dominant for trousers, skirts, dresses and jackets.

The material from 16 households is relatively limited. It is not possible to generalise which demographic variables determine the different disposal habits. The results of this study suggest that teenagers may more often dispose of clothing based on fashion than the other age groups: this is consistent with other studies (Storm-Mathisen & Klepp, 2006). It should be noted, though, that the teenagers did not give their own disposal reasons, instead they were given by their parents. Our results also indicate that families with higher income mention fashion more often than families with average income, and families with low income mentioned it least.

The largest differences between women's and men's disposal reasons are found in the group size and fit, which was mentioned in 22% of cases by women, as opposed to 10% by the men interviewed. Otherwise the distribution between gender and the other disposal reason groups is very similar.

As expected, children's clothing was most often given away because children had outgrown the clothing. Otherwise the distribution of disposal reasons was similar to that of adults' clothing. Changes in garments were the second most frequent reason, whereas each of the other groups made up less than 10% of cases.

Examples of interaction between the different categories were observed. For example, garments could be disposed of due to situational reasons, e.g., that the user has too many similar products. At the same time, there needs to be some intrinsic product related properties that prompt the disposal of a particular product that makes it less desirable to keep than other similar products, e.g., that it starts to look worn. In addition, the personality of the user is important; a hoarder could for example decide to keep the garment despite lack of storage space, while a person who is interested in environmental matters would be more likely to give it to someone else for reuse.

In the following section we will first give two examples of clothing registrations that show the type of rich data that can be acquired through use of wardrobe methods, and how different aspects have affected clothing lifespans and the amount of clothing that is used. Examples include a picture of the garment, excerpts from the interview transcripts, information on how the garment is registered, a diagram of the lifespan, and a brief analysis of improvement potential and design implications. Based on these examples, design recommendations are given.

Example 1: *Emma's Bathrobe with Long Life-cycle Despite of Many Shortcomings*

Here 30-years old Emma explains how she has used her bathrobe (Figure 2), and why she now wants to dispose of it:

This is my old bathrobe. I have had it since I was maybe 14 or something like that. And I've never been very satisfied with it, because it is not very comfortable. It's a bit stiff and like that.... And it's a little too short on the sleeves. And it's not particularly warm (*laughs*). So the only thing it does is cover up. But that's not the type of garment you want to use for wandering around the apartment. So therefore I wanted a new bathrobe for Christmas. Things take their time. I've used it a lot but..., Then I had to wear long johns under it if I was going to wear it, so.... And before I got the new one I used to use Erik's when I was alone. (*Comes with the new bathrobe*.) I wouldn't have chosen this colour myself. So my mom has chosen this colour for me. But it is very lovely and warm. I had probably given the old one to charity. It is clean and does not have any holes or tears or anything like that. It is not exactly something I think they would earn much money on, and it might not be what they need most either, but I... I do not give damaged clothing to charity, but they can make the decision themselves whether they need it or not. I used it until last Christmas.

Figure 2. Emma's bathrobe.

The garment was registered as a white medium-sized bathrobe of 100% cotton. According to care instructions, it can be washed with similar colours at 60°C. The analysis of the condition of the garment showed that the material looked rather worn and had some discolorations. Colour change was evaluated to grade 4 on a scale from 1 to 5, where grade 5 is best (no changes) according to ISO standard 105-A02 (1993). The changes may be caused by washing with non-white clothing. The bathrobe has also quite visible yellow stains, especially around the neck area. It had some loose threads and in some areas the terry loop threads had disappeared. The hanging loop had unravelled. The garment had no noticeable shrinking, pilling, or repairs. Overall changes and wear were evaluated to grade 3, which means noticeable changes but still usable. However, it is uncertain whether the charity organisation would have accepted it for reuse, as it did have staining and showed clear signs of wear. The garment lifespan given in Figure 3 indicates the major stages of use of the garment. During this time, the bathrobe had not been used as much as it could have, as it was not warm enough on its own, and Emma sometimes preferred to use her boyfriend's bathrobe instead.
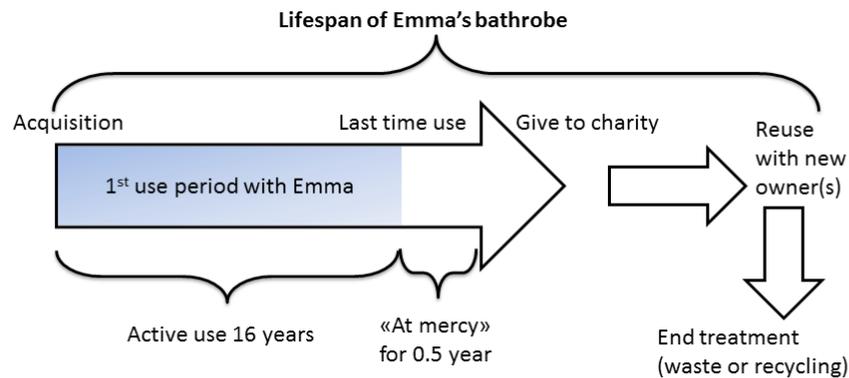
Figure 3. Lifespan and intended future use for Emma's bathrobe.

Sixteen years use period is over ten years longer than the average lifespan of garments in this study. It is not known whether Emma had bought the garment herself, or if she received it as a present. It is more common to give this kind of garments such as nightwear as a present than many other types of garments that have more specific fit requirements. It might be that she would have chosen a different bathrobe herself, with longer sleeves and softer material, or that she had not noticed these shortcomings during the clothing acquisition if she bought it herself. It is uncertain if these properties could have been improved during production, as they are related to the individual user's preferences. Properties related to increasing the durability could have been improved at the production stage, but Emma did not consider them as reasons for disposal, although the stiffness may be related to material wear. This example shows the importance that the contents of wardrobe have for clothing use and disposal. Emma kept on using the bathrobe in spite of its deficiencies, as she had no good alternative garment in her own wardrobe.

Example 2: *Lena's T-shirt: Low Quality and Bought on Sale*

Thirty-nine years old Lena explains how she acquired her t-shirt (Figure 4), and why it never got to be used:

> OK, this one I have not used at all, this t-shirt. I bought it on sale at H&M, but this is like loose, so it does not look good on me. And even though I haven't used it, maybe once at home, it has some

pills on it. So they have appeared when it has been stored in the wardrobe, in a drawer. So it got all these…. Because it hasn't been used. And even though it's loose, the material sucks into you, it's so thin, so it doesn't look nice when it shows all the stomach "rolls". This is the same age as the previous ones, two years.

The garment was registered as a knitted, 100% viscose, navy blue t-shirt that is size medium and made in India. According to the care label, it can be washed at 40°C. The condition was evaluated to be almost like new, with the largest noticeable change being some pilling. The area with the most pilling was evaluated according to EN ISO standard 12945-2 (2000). The result was grade 3-4 on a scale from 1 to 5, where grade 5 is best (no pilling, Figure 5). The t-shirt had no visible holes, broken seams, colour changes, shrinkage or repairs, which means that there is a good chance that it could go to reuse.

Lena had either never worn the t-shirt, or at most, once at home. Still, it waited for two years in the drawer before she decided to give it to charity (Figure 6). In this case, improvements in production and acquisition could have enabled and prolonged the use period of this garment. In production, the pilling properties should have been tested, as products that receive grade 3-4 after only one use are really poor quality and should not have been produced. Producer's quality management should have spotted this problem. During acquisition, Lena should have noticed already in the purchase situation that the combination of shape and thin material is not something she prefers to use, and refrained from buying the garment even if it was cheap. It is uncertain

Figure 4. Lena's t-shirt.
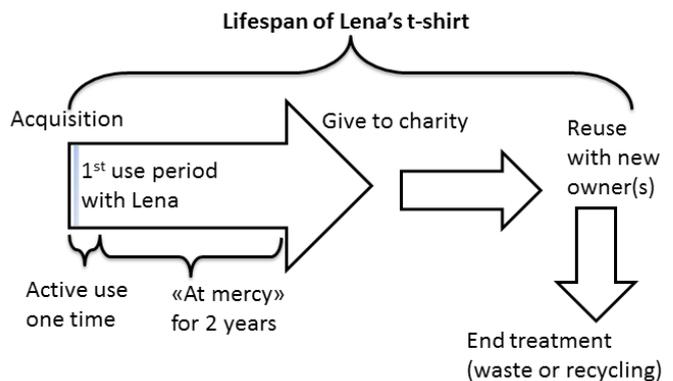

Figure 5. Pilling on Lena's t-shirt.

Figure 6. Lifespan and intended future use for Lena's t-shirt.

whether she tried it on before buying it. This was one of several examples of garments in this study that were purchased because of low price, and then did not get used. Low pricing drives unnecessary overconsumption of clothing.

Design Strategies

The overview of disposal reasons and the two examples of clothing have shown the benefits of the wardrobe method for acquiring rich, detailed data. However, they also demonstrate that the effect of design is limited. Even poorly suited products can be used for a long time, such as Emma's bathrobe, but that is not an excuse for producing poor quality clothing, such as Lena's t-shirt with pilling. In the following sections design solutions to specific disposal reasons and other problem areas within use are discussed.

Size and Fit Issues

One very important disposal reason was size and fit issues (30%). These were the dominant reasons for disposal of children's clothing and the second most important reason for women's clothing. The data suggest that children often wear clothing for only one season before they outgrow it. Petersen (2010) has proposed design solutions for adjustable clothing for growing children. She discovered that the garment length is more often the problem than the garment width, and she therefore suggested solutions for having adjustable sleeves and trousers through adjustable pleats, zipper openings, and extendable cuffs. However, we also saw that it was very common to give away children's clothing to reuse within circles of acquaintances. This requires that the condition of the clothing is suitable for reuse, and often garments with visible stains or some other changes were discarded instead of delivered to reuse or recycling.

Despite previous studies that acknowledge clothing fit as a reason for the early discarding of clothing, the magnitude of the problem has neither been acknowledged nor have any solutions been tried in large-scale clothing production. Sizes and fit are more significant problems with women's clothing than with men's clothing. The great design challenge of women's clothing is the adaptation to the body. Few ready-to-wear items fit well and close to the body while also being flexible enough for changes in user's weight and body shape. Designers and pattern makers could address this issue in greater detail in order to increase the use period and lifespan of clothing, and to avoid the unnecessary production of clothing that does not get sold due to size and fit problems. One strategy to overcome this problem is to increase the user involvement in design by trying sample patterns on differently sized and shaped bodies, instead of basing the grading on small model sizes, which is the current practice. This could not only contribute to better-fitting clothing for users of different sizes and non-standard figure types, but it could also lead to general improvement in comfort and flexibility for all consumers. For example, only 47% of the American women fit the medium hip category, which is defined as hips being two inches greater than the bust (Cooklin, 1990).

For the users to recognise clothing that will fit their bodies, the size labelling should be improved so that the code could be trusted. Today great variations exist both within the same coding systems, and even more so between the different systems (Chun-Yoon & Jasper, 1996; Faust, Carrier, & Baptist, 2006; Ujevic, Szirovicza, & Karabegovic, 2005). In addition, the label could be expanded to include more information, such as length measurements and suitable body figure type. This has been suggested in European standardisation work, but has so far not been implemented (SaiGlobal, 2015). It has been shown that women using larger sizes found it more difficult to find a size standard they could adhere to (Laitala, Klepp, & Hauge, 2011; Otieno, Harrow, & Lea-Greenwood, 2005). But more importantly, most ready-to-wear clothing cannot be individually fitted, except maybe in leg lengths. This is, however, changing as designers are finding ways to custom-fit even what is in fact ready-to-wear.

One of the student's designs in this project called "Make a change" presented the classic black dress, which was made using details learned from traditional folk costumes, such as the *bunad* in Norway, which includes sufficient seam allowance and could therefore be amended as the figure of the user changes, or the garment is inherited by new users, Figure 7 (Nordberg, Mattsson, Nowak, & Erdes, 2012). Additional ways of improving the fit could be to use elastic materials, but the combination of different fibre types such as cotton and elastane makes the recycling process more complicated. Fit can also be improved by using specific tailoring methods when making the patterns, such as diagonal cutting in woven fabrics to increase the flexibility, or through the use of flexible solutions that fit to several body sizes, such as wrap dresses.

Figure 7. Classic black dress that can be amended (Nordberg et al., 2012). Photo: Jan Berg, The Swedish School of Textiles.

Another way of thinking about clothing is not to have it ready sewn to specific garments, but to use pieces of fabrics that can be worn differently. This is also a traditional way of using clothes in some parts of the world, for example the sari in India, but was also an inspiration in one of the students' designs called "Square" (Figure 8). These design students used old bed sheets from hotels with added luxury finish to create one-size clothing that can be worn in various ways (Larsson, Nilsson, Furderer, & Lange, 2012).

Currently, most of these solutions are only tried out in smaller niche markets, but many do have potential to be used in mass production within the current economic paradigm. They mainly demand additional work in the design phase, as well as a minor increase in material consumption and possibly also time consumption in the sewing stage, for example if seam allowance is increased and sewn in several stages instead of only using one overlock stitch, or if patterns are cut diagonally.

Figure 8. Square (Larsson et al., 2012). Photo: Daniel Larsson, The Swedish School of Textiles.

In addition to improving the fit of clothing, design at the service and systems level could be used; especially the acquisition situation. This should be improved so that customers can easily know whether clothing will fit, either through improved labelling, good access to fitting rooms (even for customers with physical disabilities), and by using new solutions such as body scanning and computer aided design. Some studies indicate that clothing fit can be improved through the use of these new technologies (Ashdown & Dunne, 2006; Istook, 2002; Meunier, 2000). Price is of course an important property, as consumers will consider it easier to buy cheap clothing even if it would not fit perfectly. Buying clothing online has increased in the past years. This means that a larger selection of sizes and fits is available, but it also presents the challenge of not being able to try on before purchase,

although most of these stores have good return policies. However, in order to see the effect of the changes on the service and systems level, more research on the topic is needed.

Clothing Care

Many of the changes in garments were related to laundry related problems such as stains, odour, shrinkage, and colour changes. This shows that the care phase is important for continued use of the garments. As the care phase also has environmental impacts due to energy and water consumption (Bain et al., 2009), design strategies that aim at reducing the need of extensive care are preferable. It is possible to use clothing as well as systems design to reduce the environmental impact related to the use period. In her PhD project, Rigby (2011) has researched which types of clothing items are seldom washed, and designed a clothing line based on that information. She identified different themes that affect the washing behaviour, including material choice, use area and fit. For example woollen materials, home wear and loose- fitting clothing were washed more seldom than other types of garments. As odour is one of the important reasons for laundering, material selection is an important way to reduce this need, for example wool can be aired to remove odours and to freshen it up. Also the design of loose fit and airier arm-pits that reduce sweat stains, or the use of inlays that could be removed and washed would reduce the need for laundering.

Stains on clothing were one of the most important disposal reasons, especially for children's clothing. Butler (2011) used this as a starting point in one of the design tasks, where she developed different methods of embroidering around stains, as well as using natural dyestuffs to create figures that were inspired by weeds. Another way of thinking about this is to design clothing so that stains could be hidden within the patterns, or to use surface treatments that prevent soil from sticking, although in this case the safety of such products would need to be assessed to evaluate the complete environmental impacts.

Clothing care is also connected to lifespan of clothing. For example, some garments in the study did not get used because they would have required ironing before use, and that was considered to be too demanding for some of the owners that chose to give away the clothing instead. Non-iron labelled shirts can be found in many stores, but the products that require ironing are not labelled, and in some cases it is difficult to predict how they will turn out in use.

Technical Quality, Durability and Function

The largest disposal reason category was changes in garments (40%). It is possible to reduce these changes through several measures in production and design, such as selection of suitable materials for the intended use and stricter quality control. Most of these properties can be easily tested in a textile laboratory, and large textile companies do have their own quality manuals. However, examples such as Lena's t-shirt show that either the requirements are too low, or that they are not tested and followed up.

Based on the examination of clothing, it is also possible to suggest strengthening areas that are more prone to stress, and show signs of wear and holes. On trousers this will typically be at lower legs (if too long), between the thighs, and around pockets and knees, but these abrasion points varied some based on the body types of the user, as well as the use situations (for example if pockets were used a lot or not). On clothing with lining the lining often showed more signs of wear than the main material, and especially the seams were often broken. On shirts most signs could be seen in collar, cuffs and elbows, while in socks the most common place for holes was the heels, but also sometimes the toe area.

The investigation of clothes showed that approximately 40% had pilling or fuzzing to some degree. Only a small proportion of these were mentioned by the owners as disposal reasons. When pilling or fuzzing was given as disposal reason, the level was evaluated to be on average grade 2 on a scale from 1 to 5, which is very noticeable pilling (ISO, 2015).

The analysis also shows how closely the social and material reasons for disposal are connected. When something is worn out is not only an objective matter of degrees that can be measured in a laboratory, but also a socially dependent matter. Some users accept a more worn look than others, and accepted it easier on some materials and garment types than others, such as jeans compared to suit trousers. Similarly, stains, pilling and other changes are evaluated differently by different informants and are based on the style of clothing and the location on the clothing. Such assessments of the material change vary over time and are thus bound to the social and cultural evaluation of clothing, including current fashion.

Functional shortcomings (5%) are often directly related to production and quality control, as well as acquisition situation. If rainwear fails to be waterproof, it is difficult to know for the user beforehand, as these properties are usually not given in the garments (apart from in some items of sports clothing). Some functional shortcomings can be recognised if the garment is tried on before purchase, while others may require longer use to be noticed (for example too cold garments, such as Emma's bathrobe).

Emotional Value and Acquisition

The third largest disposal category was taste related unsuitability (11%). The acquisition method was crucial here; items that were inherited or received as gifts were more often discarded because of this, as the user did not have that much control of what was given to him/her. In general, it could be recommended to avoid giving clothing as presents, unless the giver is sure to know the taste, size, and needs of the receiver. Otherwise these products do not provide enjoyment in use.

Increasing the consumer product attachment is one potential way to prolong the clothing lifespans. The degree of attachment is connected to memories and use enjoyment (Schifferstein & Zwartkruis-Pelgrim, 2008). Favourite items go through several stages of attachment during their lifecycle, where the items owned for short time are connected to satisfaction in use,

but as they are owned for longer period, the level of attachment increases, while the use frequency often decreases. If a product is used longer, it increases the possibility for it being connected to memories of persons, places and events. Favourite clothing items that are owned for more than 22 years are mainly stored as mementos (Niinimäki & Armstrong, 2013). Therefore, in order to increase the sustainability of consumption patterns, designers should try to evoke the enjoyment through creating products that are both useful and enjoyable. Niinimäki and Koskinen (2011) studied consumers' long-term product attachments to garments and showed that these attachments are created at multiple levels, including personal and emotional values, but also memories and associations, as well as construction of self. Even though many of these aspects are outside the power of designer, designers can enable these attachments to emerge through using specific design styles, aesthetic and quality related attributes, as well as improved functionality.

Several of the design students' works aimed at increasing the emotional value and connection of clothing to the user through different techniques. For example, Juin (2012) aimed at linking the designer, producer and customer through a label "made in and by, worn by..." (webpage). Næstby (2012) researched the clothing consumption of eccentric people and used the alternative thinking and different views on society as an inspiration in her work to create clothes in a life perspective where there are relations between the textiles and the user.

Fashion

Fashion or style changes were not given as a major disposal reason and constituted only about 4% of the total. In general, fashion changes are often strongly connected to clothing, but the fashion life cycles change faster and in more visible ways in some other product areas, such as currently the case of mobile phones, although in combination with technological developments. Within clothing research fashion is usually given a much higher importance for clothing discard than our research indicates (Bianchi & Birtwistle, 2012; Chun, 1987; Collett et al., 2013). However, fashion did affect specific garment types such as trousers and jackets more than others, but was never mentioned as the disposal reason for consumable items such as socks or stockings. Disposal due to fashion was quite user specific and depended on how interested the user is in fashion and what kind of requirements there are for clothing at work and for other social occasions. Clothing disposed of due to fashion was often given to charity, thus enabling a longer lifespan through reuse. In the interviews, a wish for something new was given as a reason to acquire new clothing, but seldom mentioned as a disposal reason.

In design the logic of fashion vs. durability, sometimes referred to as fast vs. slow fashion, could be challenged more (Niinimäki, 2009). It is often assumed that these two concepts are in opposition, but maybe they can co-exist if some measures are taken. For example, fashion clothing with short lifespans could possibly be designed to be potential "good" waste that is easy to recycle or compost, and not even necessarily made of textile

fibres. On the other hand, classic and quality clothing could be designed in such a way that it could be updated either by those who created it or by the users to enable long lifespans. One of the design school's tasks aimed at producing clothing of high quality and durability of leftover pieces, where focus was on style rather than fashion (Steen, 2012), thus aiming to prolong physical durability and postpone fashion-related disposal (Figure 9).

Figure 9. Textile leftovers (Steen, 2012).

Situational Reasons and Storage

Situational disposal reasons (7%) were often not related directly to the garment, but more to the other factors surrounding it or the use situations. These garments were disposed of because the owners had too many similar garments or had changed their user needs, for example because of retirement. These aspects are difficult to relate directly to design, besides ensuring that the garments are suitable for versatile use situations. Owning too many garments decreases the amount each item gets used, and contributes to overcrowded wardrobes and lack of storage space. This is also related to the number of occasions one clothing item can be worn, and it may be possible to use to use design and styling to make few items go a long way. Then a few basic items could become the basis for numerous combinations.

In addition, sometimes the storage of clothing affects their life-time, how often we launder them and how much we use them. Interviews of the 16 households showed that much of the clothing that was only used for a short time and not considered to be soiled enough to need laundering yet were laundered anyway when the families wanted to clear up the pile of half used items on the chair, floor or some other temporary storage location. This led to unnecessary washing, as most of the informants did not want to put worn but not yet dirty clothing back into the wardrobe together with clean clothes. This suggests that storage solutions for these items could help in reducing the unnecessary laundering, for example if these items could be stored in well ventilated wardrobes where they were hanged neatly to avoid creases.

Some informants stated they had so many items of clothing that they were not always sure what they owned. Only a small portion of the wardrobe was in actual use. In these cases storage solutions that could make it easier to find the clothing that is placed at the back or bottom of the wardrobe would help. Circulation of these items could make users more aware of what they own.

In the Case delux design task the students suggested that if each item got an individual case, it would make each item seem precious (Bendzovski, Brorsson, Ringström, & Andersson, 2012; see Figure 10). Regardless of whether this idea is good or not from an environmental point of view, it still points to an important area of disposal that could be explored further. A situation with clothes that nobody cares about and that owners hardly realise they own and why, is not optimal, and focusing on attaching value to things that are already owned could help.

Figure 10. Case delux, because each item is precious (Bendzovski et al., 2012). Photo: Jan Berg, The Swedish School of Textiles.

Conclusion

The lifespan of garments is affected by many different aspects. It is possible to counteract and delay clothing disposal through improved design to some degree, but understanding user behaviour that stems from norms, values, habits and contexts is crucial. Four essential design aspects emerge for expanding clothing lifespans. The first two are related to product design, the third to service design and the fourth to systems design:

1. The technical quality including material choice and seams that promote durability. Examination of used clothing showed areas that need special attention. Even the potential for reuse could often be improved through increased quality of clothing.

2. The design of clothing form and shape, which is crucial for the use satisfaction including the fit to the body, versatility of use and appearance.

3. Services such as altering the fit, mending, styling, stain decorations, body scanning, as well as education in sewing and altering.

4. Design of communication systems between the users and the clothing designers and producers, including labelling of size, fit, social and environmental aspects, durability and feedback from users.

At the moment, a lot work remains to be done on all these areas and for different stakeholders within the textile value chain. Changing focus of fashion design from the aesthetic side of fashion shown in photos and on catwalk models to the practical side of consumers' use of clothing, where quality, fit and lifespan are important, could encourage the development to move in a more sustainable direction. By utilising the information received from users and their disposed clothing, we have obtained new, detailed knowledge from clothing use and lifespans, as well as the design aspects that affect them. The data has shown that especially clothing fit and durability are more significant disposal reasons than previously thought, as fashion has traditionally been emphasised more. Designing clothing to meet these challenges is more tangible than trying to counteract fashion change. These insights are acquired by combining two types of data, and in that way this article has added to our knowledge on how to study these issues, in addition to the topic of how to improve the sustainability of clothing. This research method could be transferred to other areas where information of users and their interaction with products could aid in improving the design.

When it comes to consumer behaviour, we see that addressing clothing acquisition is important, and therefore this phase should be studied further. With this we do not solely mean research on whether consumers buy clothing that is produced in a sustainable manner, but more importantly on what could be done to reduce the total number of acquired items of clothing, especially the ones that do not get used at all. This article has pointed out some possible improvement areas within service and systems design, but for a more detailed analysis, different research methods including all the involved stakeholders may be more appropriate.

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