PROJECT WEAREVER:

DEMONSTRATING THE FEASIBILITY OF USING DIGITAL TAGS TO MEASURE CLOTHING USE

FEBRUARY 2021

THE SUSTAINABILITY CONSORTIUM™

Acknowledgements

This research project emerged out of an innovation challenge created by John Atcheson, CEO of Stuffstr.com, which was presented during the Phoenix meeting of the Ellen MacArthur Foundation in 2018. The Sustainability Consortium (TSC) and Arizona State University's Walton Sustainability Solutions Initiatives engaged in a planning process with the Ellen MacArthur Foundation and other stakeholders and the group of stakeholders chose clothing as its focal area, with the idea that this approach could be replicated later in other types of products. With the help of an anonymous Foundation gift, TSC engaged in a project to demonstrate the feasibility of using digital tags to measure clothing use in 2019 and 2020.

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Research was carried out by The Sustainability Consortium (Kevin Dooley, Jessie Kosak), Arizona State University (Dan Mazzola, Olivia Chen, Aditi Nanda), North Carolina State University (Karen Leonas, Ali Clary), and University of Arkansas (Rogelio Garcia Contreras, Madison Paige Sutton).

Executive Summary

In 2019, global clothing sales were estimated to be $1.87 trillion. In addition to clothing's basic utility, a person's clothing can be closely tied to their identity and thus be a source of happiness, pride, and belonging. The clothing industry however has some of industry's most significant sustainability challenges. The production of clothing creates numerous environmental and social impacts. In order to reduce these negative production impacts, clothing needs to be made more circular -- made to last longer, be used more frequently by its owner, be re-used one or multiple times, or be recycled.

The vision of The Sustainability Consortium's Project WearEver is to help create a market-based system that will incentivize clothing manufacturers to make clothes that are used more frequently, used longer, and re-used, and incentivize retailers and consumers to show preference for clothes that have superior emotional and physical utility and durability. To this end, the goal of Project WearEver is to demonstrate the feasibility of using digital technology to track clothing use and laundering and identify appropriate metrics and measurement protocols to enable valid and trustworthy communication between stakeholders.

In this demonstration project conducted in 2019-20, we have successfully shown that:

1. Digital tags can measure the frequency and duration of clothing use with reasonable reliability.
2. Participant attitudes towards this idea were more positive after the trial than before it began.
3. There are still many practical constraints before this idea could be scaled more broadly.

The Sustainability Consortium will continue to work with stakeholders to test the concept with a larger pool of participants and explore performance differences between different technology solutions.

Opportunity

The average family in the U.S. spends $1700 per year on new clothes[1]. In 2019, global clothing sales were estimated to be $1.87 trillion[2]. In addition to clothing's basic utility, a person's clothing can be closely tied to their identity and thus be a source of happiness, pride, and belonging[3]. The clothing industry however has some of industry's most significant sustainability challenges. The production of clothing creates numerous environmental and social impacts, such as water and air pollution, unsafe working conditions, and child labor[4].

In order to reduce these production impacts, clothing needs to be made more circular -- made to last longer, be used more frequently by its owner, be re-used one or multiple times, or be recycled. Increasing clothing longevity is the strongest lever that the industry has to reduce its sustainability footprint[5]. Currently however, most clothing is part of the traditional make-use-dispose linear cycle, with the majority of clothing ending up in landfills. Additionally, clothing suffers from a dormancy phase, where it is no longer used by a customer but is still kept in a closet or drawer, providing no value to anyone. Consumers of fashion-related clothing are particularly vulnerable to pressures to only use their garments only for a short-amount of time, even though the garment itself is physically capable of being used much longer.

What is needed is a market-based system that will incentivize clothing manufacturers to make clothes that are used more frequently, used longer, and re-used, and incentivize retailers and consumers to show preference for clothes that have superior emotional and physical utility and durability.

Despite the ubiquity of clothing products, we collectively know little about how often clothes are used, how long they are used, and what happens to them after their first use. Manufacturers are challenged to design for durability when no one really knows what the industry average is for clothing longevity or utilization. Additionally, as more retailers move to business models involving renting of clothes, data about clothing utilization and longevity is essential for planning purposes.

Some positive progress has been made. The U.K.-based WRAP has done several market-based research studies to measure clothing usage and longevity. Their 2015 study with over 3000 participants showed that people tend to wear clothes for three to four years before discarding, although longevity differs across clothing categories[6]. The Longevity Protocol, developed by WRAP and Nottingham Trent University, has created a standard that enables specific testing data to be used to infer expected longevity[7]. They recommend "a longevity testing regime that uses a combination of extended wearer trials and repeated care label wash cycles to give an indication of garment lifetime"[8](ibid).

The EU commission has taken action to incentivize clothing durability. In 2016, a report from the Committee on the Internal Market and Consumer Protection made a series of recommendations for companies to change both product design and consumer communication to be more transparent about product longevity, repairability, and reuse[9]. An EU-commission report found that consumer product sales were 13.8% higher for products that had longer lifespan than comparable ones[10].

There are emerging examples of companies using modern IT technology such as RFID to track the position of an item of clothing[11]. These efforts have been primarily used to track clothing inventory across points within the supply chain. We believe this approach could also be used to track clothing use. There is little doubt that as tracking technology matures, more companies will desire to do this, as it will give them valuable insight into their products that they don't have today.

It is undesirable, however, to repeat what occurred with the use of tracking technology in consumer electronics, where consumers often lack privacy protection and measurement standards for product use are not widely adopted. If individual clothing manufacturers each go their own way with private efforts in this space, there will be no ability to create a baseline of performance, and little trust from retailers and consumers about manufacturer product claims that are based on proprietary methods. The time is right to get ahead of the adoption curve and use a multi-stakeholder approach to develop industry-wide buy-in for measurement standards and protections for consumers and brands that lead to a transparent and efficient system for clothing manufacturers to benchmark their performance against.

Thus, the goal of Project WearEver is to:

Demonstrate the feasibility of using digital technology to track clothing use and laundering and identify appropriate metrics and measurement protocols to enable valid and trustworthy communication between stakeholders.

Objectives

1. Prove that digital technology can be used to track when an item of clothing is being used (worn), being laundered, or being stored (not used).
2. Using a multi-stakeholder approach, develop measurement standards and protocol that can be used to create standard utilization and longevity metrics that are reliable and comparable across companies.
3. Develop or ensure the consumer privacy protections, brand anonymity protections, and data governance policies that make consumers, brand manufacturers, and retailers feel safe.
4. Develop a plan for scaling to industry-wide adoption during the next phase of implementation.

In this first phase of Project WearEver, the objectives are to:

1. Engage participants in using digital tags to measure clothing use
2. Measure participant attitudes towards this idea before and after the trial tracking
3. Observe some of the practical constraints towards doing this more broadly

Longer-term vision

We envision one of the possible outcomes of this work would be a benchmarking IT platform(s) that clothing brands can voluntarily report product use and longevity data into and compare performance to others in the clothing category. Similar to how CDP or Sedex enabled benchmarking of GHG emissions and ethical supply chains across industry, a Product Circularity Platform could have similar transformational potential.

It's unlikely that a single platform would satisfy all needs, so instead we advocate for interoperability between platforms and data by having widely agreed upon measurement and data standards, as depicted in Figure 1.

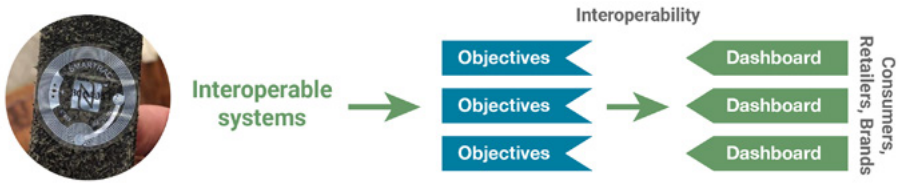

Figure 1 Interoperability enables data sharing and commonly define metrics

Expected benefits

- Consumers and retailers get valid information that helps them choose clothing brands that are more durable. Some customers will find data about their own usage patterns valuable.
- Retailers and brands get information on how their clothing products are being used, allowing them to understand the elements that drive clothes to be used more often, used longer, and re-used.
- Brands get a reliable, trustworthy, and efficient way to benchmark their product use quality against others and make public claims. They also get empirical data on longevity that helps them validate and create better clothing design criteria and accelerated testing methods.
- Deeper, on-going engagement between brands, retailers, and consumers.

Business and sustainability value to measure longevity and use

- Understand impacts of garment design, production, and use attributes
- Support benchmarking and product claims
- Learn from garment, wardrobe use patterns
- Customize communication with consumer
- Improve demand forecasting

Demonstration Project

Conceptual Model

Figure 2 shows the conceptual models that underlies this research. At any given moment of a clothing choice, a consumer considers the usage context for the garment, how they feel about the garment, and how the garment fits the usage context.

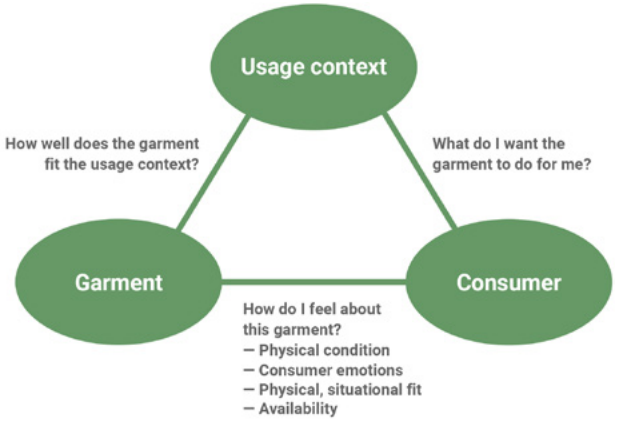

Figure 2 Conceptual model of clothing choice

We can also view the system from an inventory flow perspective (see Figure 3). On the bottom, utilization of the clothing is driven by two factors: Is the garment available to use, and is it preferable to use over other alternatives? Availability depends on the physical location of the item. An item is available when it is not currently being in use, being laundered, in storage, in repair, or removed from inventory. Particularly insightful from this is that the more clothing that is queued up or in process for laundering (washing, drying, sorting, putting away), the more overall clothing inventory is needed in order to the number of options to remain the same.

Preferability depends on both emotions of the user and the physical state of the garment, and how they interact. As user will ask: How does this garment fit the current need? What are my experiences with the garment? What social influences might cause me to wear, or not wear? The physical state can be defined by various design attributes (e.g., is the cotton organic?), the physical integrity of the garment, it's aesthetic integrity, and physical fit, which can be dynamic. These three elements – physical location, physical state, and emotional state – form the basis of the data and theoretical model needed to fully represent the phenomena. The focus of this initial study is only on the physical location.

Measuring Clothing Use

There are several ways in which clothing use can be measured, as shown in Table 1. Near Field Communication (NFC) tags can be read only from a short distance (a few millimeters); they are often used for access applications . QR tags are similar, but instead of using radio waves for communication, they are optically read by a scanner. Both NFC and QR tags require the user to engage the system in order to record a usage event. The benefits of these tags are that they are already used in garments (to track in-store movement), they are inexpensive, and can be read by a smart phone. There may be limitations however to how many washings a tag can endure.

RFID tags have broad, existing use in supply chains, and the tags can be read at a distance of a few meters or more. The tags are inexpensive and can even be made into a thread that can be woven into the garment and washed. RFID cannot generally be read by a smart phone, and RFID readers are expensive, so application to consumer/home settings is impractical. RFID though has the advantage that it requires no actions by the user to engage a usage reading. Bluetooth sensors could also be used and would have the benefit of reading at a distance, high precision location information, and they ability to embed other sensors, like temperature or movement. The battery though is not amenable to washing and there may be signal strength limitations. Finally, people can track clothing usage manually, using other IT tools like a digital diary to collect data. For example, an individual has recently publicly shared their experiences and data from tracking every garment he used for three years[13].

In this project, we focused on testing NFC tags. These tags could be sewn into a garment in various ways, but instead we used credit-card sized tags.

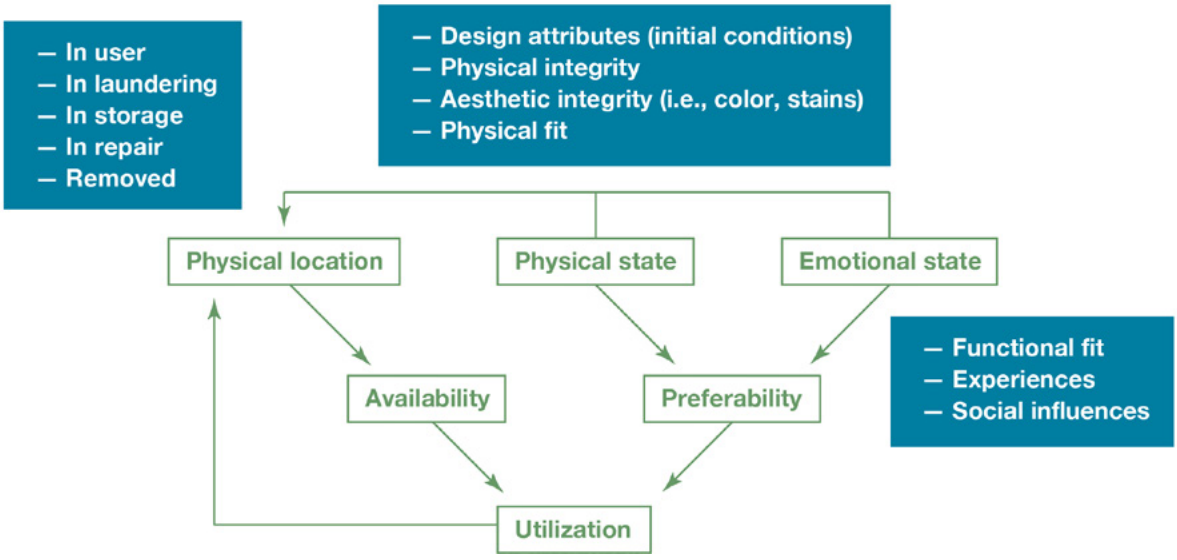

Figure 3 Clothing as Inventory

Technology	Consumer role	Technology	Technology
NFC, QR tag	Active	Used in garment tags Inexpensive tags Reader on smart phone	Washing Reliability depends on consumer
RFID tag	Passive	Used in suppy chain Inexpensive tags Make into washable thread	Readers expensive Signal strength through water
Bluetooth sensor	Active or passive	Variety of sensors Precision & distance	Battery Washing Background noise
Phone app	Active	No need to affix tag	Search for garment in list Reliability depends on consumer

Table 1 Clothing tracking technologies

Pilot Demonstration Protocol

Figure 4 depicts the protocol for participants in the feasibility demo pilot. Sixty-two (62) Participants were recruited from The Sustainability Consortium, North Carolina State University, and University of Arkansas. They filled out a pre-trial survey and chose a garment to test. They were provided a credit-card sized NFC tag and instructed on how to read it with their smart phone. Half of the participants were told to read their tag when they started wearing the garment, while half were told to read the tag at the beginning and end of wearing the garment. They conducted the trial for 4-8 weeks, and usage data was collected on the Blue Bite platform and downloaded for analysis. At the end of the trial, participants filled out a post-trial survey.

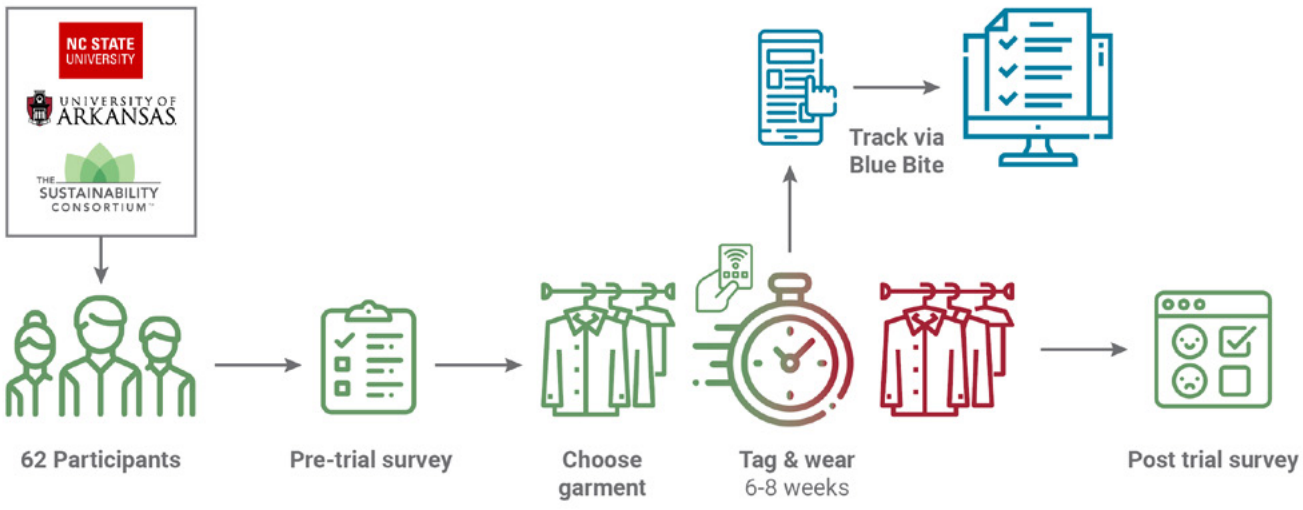

Figure 4 Experimental protocol

Question	Agree?
Tracking clothes use provided benefits to environmental sustainability	Strongly Agree
Tracking clothing use provided benefits to consumers	Agree
I would be interested in shopping information customized to my clothing use patterns	Agree
I would be interested in knowing when I last wore a specific garment	Neutral/Agree
Tracking clothing use provides puts my privacy at risk	Neutral

Table 2 Participant pre-trial perceptions

Results from Pre-Trial Survey

As Table 2 shows, participants generally believed in the value of tracking clothing use. TSC participants, who are sustainability professionals, believe most strongly in environmental benefits. Arkansas participants, who were generally younger, were least concerned about privacy. NCSU students, who were mostly engineers, were most interested in garment usage data.

Participant responses indicated they distinguished benefits to self, versus benefits to consumers (in general) and the environment.

Usage Patterns

At the time of this report, we are still doing detailed statistical analyses on the usage data itself. We have initially found:

- About half of participants never missed a reading, and half missed a few readings
- Participants were more likely to miss a reading at the end of trial period
- Participants perceived that the experiment did not make them wear garment more
- Usage rate
  - 40% less than once per week
  - 30% once per week
  - 30% more than once per week
- People who used garment more often had:
  - Higher belief in tracking use's benefit to consumer
  - More interest in durability, donation/resale information

Results from Post-Trial Survey

Table 3 indicates that participants found the tagging task easy to do, and 65% of participants had used their mobile phone before to read a digital tag.

Question	Very easy	Easy	Mod. hard	Hard
How mentally challenging was it?	65%	33%	2%	----
How physically challenging was it?	78%	22%	----	----
How challenging was taking the time to do the task?	58%	28%	14%	----
How bothered or annoyed were you doing the task?	55%	20%	23%	2%

Table 3 Participant post-trial: Ease of task

Participants found different value in different value propositions for such a system, as seen in Table 4.

Highest value
— Recommend when i might want to sell or donate a garment because I have not used it in a long time
— Compare clothing brands on clothing durability and longevity
— Purchase clothing products that fit my style and use pattern
Moderate value
— Select which garments(s) to wear today
Lower value
— Communicate with my peers about my clothing use through social media

Table 4 Participant post-trial: Value propositions

Variation in Duration of Use May Differentiate General from Single Purpose Items

Concurrent with this broader pilot, one researcher tracked their usage of two clothing accessories, sandals and a pant belt, over a nine-month period. Figure 5 shows distribution of durations – the difference between the beginning and end of a single usage. Sandals were used on average for about an hour, and only in rare cases did it go over a longer time. The belt duration data however has a flat distribution, ranging from an hour to ten hours. While this is just a single experiment, it may indicate that when the variance of duration is low, the item has a single purpose. In this case, the participant only wore the sandals outside of work when going on short trips outside. On the other hand, the belt was used to "hold up" any pants (work, leisure) and so were might be considered more general purpose. This is an example where clothing use data can provide novel insight into how consumers actually use their clothing.

Conclusion

The goal of Project WearEver is to demonstrate the feasibility of using digital technology to track clothing use and laundering and identify appropriate metrics and measurement protocols to enable valid and trustworthy communication between stakeholders. In this demonstration project conducted in 2019-20, we have successfully shown that:

1. Digital tags can measure the frequency and duration of clothing use with reasonable reliability. About half of participants reported not missing any readings, and about half said they missed some. A more detailed sub-study indicated reliability was around 90% at beginning of trial and lower as time went on.
2. Participant attitudes towards this idea were more positive after the trial than before it began. Most participants saw value in a system that could compare the durability of one brand's clothing versus another, and one that informed them about clothing that had not been used in a long time.
3. There are still many practical constraints before this idea could be scaled more broadly. Until a passive system is technology and economically feasible, incentives will need to be developed to have people reliability engage over a period of time.

TSC will continue to work with stakeholders to test the concept with a larger pool of participants and explore performance differences between different technology solutions.

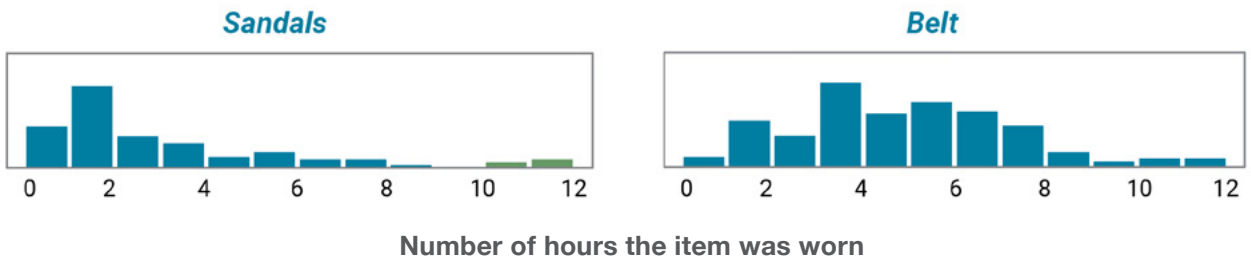

Figure 5 Distribution of duration of use: Sandals v. belt

End notes

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The Sustainability Consortium (TSC) is a global non-profit organization working to transform the consumer goods industry by partnering with leading companies to define, develop, and deliver sustainable products. The Sustainability Insight System, or THESIS, is the independent, science-based, holistic sustainability performance solution created by TSC that allows brands and manufacturers to understand the sustainability story of their products. In 2019, THESIS was used by over 1500 companies covering products representing over a trillion (U.S.) dollars in annual sales.

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