Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)
© 2017. Delft University of Technology and IOS Press. All rights reserved. This article is published online with Open Access by IOS Press and distributed under the terms of the Creative Commons Attribution Non-Commercial License.
DOI: 10.3233/978-1-61499-820-4-473

Electronic textiles and product lifetimes: exploring design strategies for product longevity

McLaren A., Hardy D.A. and Hughes-Riley T.

Nottingham Trent University, Nottingham, United Kingdom

Keywords
Wearables
Electronic-textiles
Clothing longevity
Product design
Sustainability

Abstract
Electronic textiles typically refer to textiles with integrated electronics (e-textiles) that can add additional functionality to a fabric or garment. Rapid growth in this area is on-going, with substantial benefits seen in sport, medicine and healthcare. Unfortunately, e-textiles can create environmental problems at the end of the product lifetimes due to the difficulties in separating electronics from textiles. The rapidly growing market for electronic textiles makes it increasingly important to find ways in which environmental impact can be minimized. Cross-disciplinary knowledge and understanding are essential to ensure environmental considerations are taken into account during the continuing development of e-textiles. This paper introduces the context of a workshop to prompt discussion on product lifetimes of electronic textiles, and strategies for improving the sustainability of this market. The workshop will include insights from a teardown of a piece of clothing with electronic functionality, giving the opportunity to find out what is inside an electronic textile and to discuss products that are being developed. The discrepancies in lifetimes of textiles, electronics and other components will be explored, along with discussion of methods of extending product lifetimes, reuse, recycling and disposing of products.

Introduction

This paper provides a context on sustainability of electronic textiles (e-textiles) in preparation for a workshop at the 2017 PLATE conference. The workshop brings together experts from electronics, product design and textiles to discuss lifetimes of an emerging product area that has yet to be explored fully. The workshop is organised by members of three research groups at Nottingham Trent University (NTU): the Advanced Textiles (ATRG), Clothing Sustainability (CSRG) and Sustainable Consumption Research Groups (SCRG). The aim is to bring together key expertise to explore discrepancies in the lifetimes of textiles, electronics and other components. Existing guidelines and further sustainability strategies will also be discussed. The priority of the workshop will be to set forth international collaboration on future research to bridge the gap in knowledge in this emerging field and to help develop new strategies for incorporating electronics into textiles in a sustainable way, specifically in relation to product lifetimes.

Context

The market for smart electronic textiles (e-textiles) and garments is growing rapidly, predicted to exceed 4.7 Billion US dollars by 2020 (Smart Textiles Market, 2017) with global technology and clothing heavyweights including, Google, Levi's, Nike, and Apple investing significantly (Balmat, 2017; The emerging e-textiles industry, 2016). E-textiles contain embedded electronics that provide enhanced 'smart' capabilities, whereby materials can sense, react to and/ or adapt themselves in response to external stimuli (Kettley, 2016; Black, 2007). These are used in the application of 'wearable technology' which exploit e-textiles as a soft surface within which connected systems can be incorporated into garments, giving potential to communicate with external devices such as smart phones or accessories (Kettley, 2016; Black, 2007; Braddock, Clarke & O'Mahony, 2005).

There are many health and wellbeing benefits of e-textiles in medical, healthcare, sports, and wellbeing contexts, where they can, for example, facilitate health monitoring (Lugoda, et al., 2015) or manage stress and anxiety (Tillotson et al, 2013). Commercial developments are often grounded in specific social contexts, such as interactive, networked 'hug shirts' that enable haptic communication between long distance partners (Cute Circuit, 2017); digital gloves that translate sign language into speech, for better communication and understanding between Deaf people and their hearing peers (Enable Talk, 2012); and temperature sensing socks that can warn of ulcer formation (Lugoda, et al., 2015).

These demonstrate that wearable e-textile garments and accessories can enhance quality of life, where the focus is on gaining societal – as well as economic – value out of technological innovation. However, literature shows that there are significant environmental issues surrounding

both clothing (WRAP, 2012) and e-textile waste (Velden, et al., 2015; Kohler, 2013; Kohler, et al., 2014; Ossevoort, 2013; Wilson and Teverovsky, 2012). There is a significant risk that combining these two product areas, especially as they both represent short-life mass consumer goods, may lead to increased toxic waste (Kohler, et al., 2014). To be sustainable, technological developments must address social and economic concerns in harmony with nature, as agreed in the United Nations 2030 Agenda for Sustainable Development (United Nations, 2015). It is therefore important that design strategies to minimise the environmental impact of e-textiles products are developed, taking into consideration all stages of the product's lifecycle (Köhler, 2013). Challenges for the eco-design of emerging e-textiles have been discussed in relation to design for recycling, disassembly, and disposal (ibid.), but product lifetimes remains an underexplored area of investigation.

Product and material longevity is a key sustainability strategy: longer usable lives and circular material cycles can reduce the amount of raw materials required and reduce waste (Earley & Goldsworthy, 2015; Cooper, 2010). There are discrepancies between the lifetimes of textiles, electronics and other components in e-textiles, and complex challenges in making appropriate design choices for different garment lifetimes (Earley & Goldsworthy, 2015) that must be considered in designing for these converging technologies.

Clothing Lifetimes

It is estimated that 350,000 tonnes of clothing waste ends up in landfill in the UK every year (WRAP, 2012), and while the production, distribution and disposal phases all create environmental impacts, life cycle assessment (LCA) has found that the most effective intervention to reduce the environmental impact of the clothing industry is to extend the usable lifetime of garments through design, maintenance and re-use (WRAP, 2012). NTU research has extensively explored how to improve design and testing for clothing longevity (Cooper et al, 2016, 2014, 2013 & 2012).

A toolkit of industry-led strategies has been developed from the findings to support multi-disciplinary systems thinking across design, merchandising, business, production, marketing, and sustainability managers (Cooper et al, 2016). This included holistically promoting the importance of physical durability and testing, ensuring transparency and communication in complex global supply chains, supporting consumers through product labelling and communications, provision of lifetime guarantees, laundry, care and maintenance guidance, and enabling repair and adaptability through design. Adding emotional value to enhance user-product attachment and alternative business models to encourage greater active use of garments through leasing are also encouraged (ibid.).

Elsewhere, extending material lifetimes by keeping products in perpetual use through circular economy systems is also being explored (Earley & Goldsworthy, 2015). This explores the interplay between fast and slow fashion, recognising that different 'speeds' of products require different design approaches. As such, fashion and textile designers operate within complex problem spaces when developing and/ or selecting materials and approaches that have the most positive sustainability implications in relation to intended product use, lifetime and commercial restraints (Kane and Philpott, 2013). These considerations are particularly pertinent when aiming for enhanced 'positive' functionality offered by e-textiles and must be weighed up in relation to the social implications (ibid.). Knowledge and understanding of the whole lifecycle of materials from both a scientific, design and user perspective is essential.

E-Textile Lifetimes

In the development of sustainable garments that utilise e-textiles, the considerations mentioned above must also be considered, with added complexity of embedded electronic components. Increasingly sophisticated methods are being developed to add electronics into textiles, from early attachment to clothing surfaces or pockets (Cork 2013) to incorporating electronic functionality into the textile structure, such as incorporating electrically conductive yarns. More recent developments have seen electronic components integrated at a yarn-level (Dias, 2016) with the possibility of integrating a range of sensors (such as thermistors) or output devices (such as light-emitting diodes). Conductive inks, fibres, and power sources, may also feature.

This variety of electronic components contains non-renewable materials and minerals: plastics, metals, silicon, and 'critical' or 'conflict' minerals subject to high supply insecurity (scarcity) or geopolitical conflict (Köhler et al, 2013). Understanding of the issues surrounding these, ensuring supply chain transparency, design to enable recycling at end-of-life, use of alternative materials and promotion of sustainable products are therefore essential. Issues of physical durability specific to e-textiles include washability, durability of interconnects and inks, and lifetimes of components. Depending on the nature of a device the fibres may wear-out well before the electronics. Conversely, the rapid development of microelectronics might mean electronics may become out-dated before the material aspect of a garment. The lifetime of an e-textile is dictated by the shortest lifetime of any individual component, unless repair or replacement is possible.

Stakeholders in smart textile development, use and disposal cover a wide range including consumers, legislators, designers, engineers, garment producers, and consumers. Each group has differing priorities including functionality, cost, appearance, fashion, recyclability, and disposal. Ensuring knowledge and understanding of sustainability across design and production will be imperative, alongside supporting sustainable consumer behaviour during use, care and end of life. Lifecycle

and systems thinking approaches are therefore required alongside technological research and development to enable design for sustainability of these converging technologies (Köhler, 2013), in order to consider their design, manufacture, use and end-of-life for extended product lifetime or maximised circular material lifetimes.

There are a variety of questions that need to be asked regarding this topic. Key to the focus of this workshop is what is the expected lifetime for an e-textile? Consumer perspectives on smart wearables in relation to clothing lifetimes, care, use and disposal also need to be explored. It is also important to deliberate the ethics of materials used and how they affect the waste stream, particularly identifying components that should never be integrated into textiles from either a safety or sustainability viewpoint. Currently it is unclear whether e-textiles are covered by textile legislation, or electronics legislation, and current recycling schemes for e-waste (Waste Electrical and Electronic Equipment Directive, 2005 [WEEE]) are not technically suited to deal with them (Köhler et al, 2014) so clarification and action is required. Reviewing these aspects together this will help to inform industry-led design strategies that ensure sustainable development within this emerging industry.

The Workshop

The aim of this workshop is to explore aspects of sustainability and product lifetimes relating to e-textile garments.

The introduction will include insights from the teardown of a smart garment, giving the opportunity to find out what is inside an e-textile and discuss products being developed in this fast growing market. The discrepancies in lifetimes of textiles, electronics and other components will be explored with an expert panel representing different perspectives relating to the research, development, manufacturing, and use of wearable e-textiles products. This will be followed by group discussions to explore each perspective further and discuss sustainable strategies.

Objectives include:

- To identify the current provision of sustainable strategies / toolkits for the development of smart wearable e-textiles;
- Discuss and explore a wide range of perspectives on the sustainability and lifetimes of wearable e-textile products;
- Extract data to identify challenges and opportunities to developing and implementing sustainable smart e-textiles design strategies;
- Identify research interests and map out future research proposals for potential cross-institutional international collaborative research proposals.

Proposed outcomes of the workshop will include:

- A new set of directions for the field, available open access to all participants after the event;
- Identification of collaborators for making funding applications at national, European and international scales to further the research agenda and/ or collaborate in an international research network.

References

Balmat, N. (ed.) (2017, 8 February). Fashiontech, future scene or utopia? A conference within the Wearable Lab at Première Vision, Paris, 8 February 2017.

Black, Sandy. 2007. Trends in Smart Medical Textiles. In L. van Langenhove (ed.) Smart Textiles for Medicine and Healthcare, pp. 1–20. Cambridge: Woodhead Publishers.

Cooper, T. (ed.), 2010, Longer Lasting Products: Alternatives to the Throwaway Society. Farnham: Gower.

Cooper, T., Oxborrow, L., Claxton, S., Goworek, H., Hill, H., McLaren, A. (2016), Strategies to improve design and testing for clothing longevity, Defra: London.

Cooper, T., Claxton, S., Hill, H., Holbrook, K., Hughes, M., Knox, A., & Oxborrow, L. (2014). Clothing Longevity Protocol. A report for WRAP: London. Retrieved from http://www.wrap.org.uk/content/clothing-longevity- protocol-1

Cooper, T., Hill, H., Kininmonth, J., Townsend, K. and Hughes, M. (2013). Design for Longevity: guidance on increasing the active life of clothing. Prepared for WRAP: Banbury. Retrieved from http://www.wrap.org.uk/sites/files/wrap/Design for Longevity Report_0.pdf

Cork, C. et al. (2013). The next generation of electronic textiles. In Proceedings of the 1st International Conference on Digital Technologies for the Textile Industries. Manchester. Available at: http://www.texeng.net/conferences/first-international-conference-on-digital-technologies-for-the-textile-industries.html.

Dias, T., 2015. Electronic textiles: smart fabrics and wearable technology, T. K. Dias, ed., Cambridge, UK: Woodhead Publishing.

Dias, T.K. (2016). ELECTRONICALLY FUNCTIONAL YARNS. WO2016/038342 A1. Available at: https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2016038342.

Earley, R. and Goldsworthy, K. (2015). Designing for fast and slow circular fashion systems: exploring strategies for multiple and extended product cycles. In Product Lifetimes And The Environment (PLATE) Conference Proceedings, 17-19 June - Nottingham, UK. Edited by T. Cooper, N. Braithwaite, M. Moreno, G. Salvia. Published by Nottingham Trent University: CADBE. Pp. 113-118. ISBN 978-0-9576009-9-7.

Fisher, T, Cooper, T, Woodward, S, Hiller A and Goworek H, (2008) Public Understanding of Sustainable Clothing: A report to the Department for Environment, Food and Rural Affairs. Defra, London.

Kane, F. and Philpott, R. (2013). Textile Thinking for Sustainable Materials. Making Futures Journal Vol 3 ISSN 2042-1664

Kettley, S. 2016. Designing with Smart Textiles. London: Fairchild Books

Köhler, A. R. (2013). Challenges for eco-design of emerging technologies: The case of electronic textiles. Materials and Design 51 (2013) 51–60. DOI: http://dx.doi.org/10.1016/j.matdes.2013.04.012

Köhler, A., Bakker, C. & Peck, D. (2013) Critical materials: a reason for sustainable education of industrial designers and engineers, European Journal of Engineering Education, 38:4, 441- 451, DOI: 10.1080/03043797.2013.796341

Köhler, A. Hilty, L. and Bakker, C. (2014). Prospective Impacts of Electronic Textiles on Recycling and Disposal. Journal of Industrial Ecology. Volume 15, Number 4. DOI: 10.1111/j.1530-9290.2011.00358.x

Lugoda, P., T. Dias, & R. Morris. (2015) Electronic temperature sensing yarn, Journal of Multidisciplinary Engineering Science Studies 1, no. 1.

McLaren, A., Goworek, H., Cooper, T., Oxborrow, L., and Hill, H., (2016). The effect of consumer attitudes on design for product longevity: The case of the fashion industry. In: P. Lloyd & E. Bohemia, eds., Proceedings of DRS2016: Design + Research + Society - Future-Focused Thinking, Volume 10, pp 3831-3846, DOI 10.21606/drs.2016.XXX

Ossevoort, S. H. W. (2013). Improving the sustainability of smart textiles. In: Kirstein, T.

(Ed)(2013) Multidisciplinary Know-How for Smart-Textiles Developers. Woodhead Publishing.

Textiles Magazine (2016). The emerging e-textiles industry. Textiles 1 (2016).

Smart Textiles Market worth 4.72 Billion USD by 2020. (2017). Marketsandmarkets.com. Retrieved 8 June 2017, from http://www.marketsandmarkets.com/PressReleases/smart-textiles.asp

The emerging e-textiles industry (2016). Textiles: Magazine of the Textile Institute. 1 (2016)

Tillotson, J., Rolland, M., Lahiri, K. (2013), The Oneiric Dimension of Electronic Scents, FutureScan2: Collective Voices 2, pub Association of Degree Courses in Fashion & Textiles, ISBN 978 1 907382 64 2

United Nations (2015). Transforming Our World: The 2030 Agenda for Sustainable Development. Retrieved from: https://sustainabledevelopment.un.org/post2015/transformingourworld

Velden, N. M., Kuusk, K. and Köhler, A. (2015). Life cycle assessment and eco-design of smart textiles: The importance of material selection demonstrated through e-textile product redesign. Materials and Design 84 (2015) 313–324. DOI: http://dx.doi.org/10.1016/j.matdes.2015.06.129

WILSON, P. and TEVEROVSKY, J. (2012). New product development for e-textiles: experiences from the forefront of a new industry. In: Horne, L. (2012) New Product Development in Textiles. Woodhead Publishing. ISBN: 978-1-84569-538-5.

WRAP (2012). Valuing Our Clothes: The true cost of how we design, use and dispose of our clothing in the UK. A report for WRAP: London. Retrieved from: http://www.wrap.org.uk/sites/files/wrap/VoC%20FINAL%20online%202012%2007%2011.pdf