Thinking like Apple's recycling robots: towards the activation of responsibility in a postenvironmentalist world

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Abstract

This article turns to valuation studies to enrich the critical capacities of postenvironmentalism with a more situated approach. Debates in postenvironmentalism suggest moving away from a romanticized notion of nature and instead shining the spotlight on the responsibility humans have towards the built environment, which includes technologies. We use Liam and Daisy, two recycling robots of Apple Inc., as intermediaries to discuss the multiplicities of value-production in the recycling economies of electronic waste. The company introduced these robots as innovations to revolutionize the recycling industries; yet, drawing on our ethnographic research in the UK, Germany, India and Ghana we emphasize that Apple's approach to research is a limited one. The notion of dis/assembling value enables us to activate the production of responsibility as a value in empirical contexts, with a focus on (1) decisions on material breakdown that are hidden in the black box of Apple's algorithms, (2) the vulnerability and fragility of electronic waste work, and (3) the rising impact of shredding technologies in the global recycling economies of e-waste.

Key words: Postenvironmentalism, valuation studies, Apple, e-waste, robots

1. Introduction

Postenvironmentalism is an emerging field that offers thought-provoking insights into considering the built environment as part of nature (Vogel, 2015; Certonma, 2016). Central to postenvironmentalist theories is the notion of responsibility towards nature, especially in light of the sociotechnical construction that is now ever present. However, to understand the role of the built environment in nature we must consider how social values are attached to and

coproducing nature. Whilst postenvironmentalism makes welcome advances in the areas of valuation analysis, with research into technologies as coproducers of nature (*ibid.*), the end of nature as an external biosphere to us (McKibben, 1989), and recognising built environments (Vogel, 2015), in the current writings, the valuation ideas are in an abstract form. Drawing upon valuation studies, we make use of the notion of dis/assembly as a means to connect the theoretical in an empirical context (Greeson et al., 2019). Through these connections we aim to *activate responsibility,* as outlined in postenvironmentalist debates. To do this, we explore some of Apple Inc.'s (henceforth, Apple) latest innovations – Liam and Daisy, two recycling robots introduced as part of Apple's 'Renew' and the 'Rethinking Materials' programmes, respectively, and the company's attempt to take responsibility for societal and environmental degradation. These programmes can also be seen as attempts to enact a circular economy[1] (Gregson et al., 2015) in a bid to address challenges associated with discarding electronic waste (or e-waste), which is a complex, fast growing global stream (Baldé et al., 2015).

In September 2016, Apple introduced Liam, and Daisy followed in 2018 (Apple 2016a, b; 2018). These robots specialize in breaking down, separating parts and recovering materials from iPhones. They present themselves as lovable robots that can take care of consumers' stuff, and get things done – Liam can disassemble 1.2 million iPhones a year and Daisy drives the numbers up to almost 2 million devices, Apple claims (Apple, 2016a; Apple, 2016b; Apple, 2019a; Moorhead, 2018). The company advocates that Liam and Daisy (as a line of robots) have the ability to reintroduce resources into their supply chain (and, more generally, into the global economy), thereby reducing the impact to the natural environment. The company thus promises to establish an environmentally and socially compatible way of processing electronic waste. Consumers only have to hand in their old device as if they were walking by, so that Apple can take care of it. Liam and Daisy are supposed to make things easier, and at the same

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[1] A circular economy is one that is premised on designing waste out, keeping products, materials and resources in use and regenerative, thereby minimising impact to the natural environment (European Commission 2015; EMF and McKinsey 2015)

time they are presented in a sympathetic fashion. These robots, however, take a particular perspective on mobile phones they are said to recycle automatically; they value the materials in a specific form. Part of this enactment of the value of responsibility is also a public discussion which adopts Liam and Daisy's perspective to a certain degree, thereby highlighting the importance of recognising the built environment.

In this article we address the following research questions: how does the focus on dis/assembling values contribute to postenvironmentalism?, and how do the robots Liam and Daisy enact the value of responsibility? We draw on concepts in postenvironmentalism (Vogel, 2015; Certoma, 2016) and suggest extending the discussions through the pragmatic perspective of valuation studies (Dewey 1939; Lamont 2012; Dussauge 2015; Greeson et al., 2019). We aim to show that there are competing value systems being enacted around the notion of responsible recycling. Liam and Daisy's thinking is good at hiding alternative forms of organizing. Apple's robots deactivate certain modes of responsibility; Liam and Daisy dis/assemble values by utilising high-tech recycling procedures that render alternative setups and actors redundant. Studying Liam and Daisy helps us understand how a particular form of responsibility is organized. Based on our research of the global recycling economy of electronic waste, in the UK, Germany, India and Ghana, we are also able to show how specific this valuation really is. Our article then, is a critical assessment of the way in which waste is being appreciated or prevented from being valued in a multitude of ways. We argue that reconceptualising postenvironmentalism enables us to activate the production of responsibility as a value in empirical contexts. We thus discuss limits to a technocratic approach to e-waste and aim to move beyond a demystification that is prominent in contemporary e-waste reflections. This helps us discuss the complexities and ambiguities of the recycling reality.

We begin by engaging with a postenvironmentalist theoretical framework more thoroughly and sharpen its conceptual lenses with the help of valuation studies. Afterwards, we introduce our collaboration and methodologies to study Apple's robots and our empirical

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contexts. Moving forward, we map the introduction of Liam and Daisy as a means of organising the themes that emerged from our research, before concluding with a discussion on the activation of responsibility.

2. Approaching postenvironmentalism via valuation

Mainstream debates in environmentalism 'share […] sustainable development's interest in reconciling economic growth and environmental protection' (Dryzek 2003: 299). Theorists emphasize the need to transform institutions central to modernity – for example science and technology, production, consumption, politics, governance and the market. This should be done considering multiple scales (local, national and global levels) (see Mol, Sonnenfeld and Spaargaren, 2010; Schlosberg and Rinfret, 2008; Mol and Sonnenfeld, 2000; Beck, 1992).

Situated within environmentalist debates, ecological and reflexive modernists value the environment in specific ways. On the one hand, ecological modernists attempt to find ways to create a win-win between ecological reform and good economic performance (Mol et al., 2010). Underpinning these ideas is the assumption that the economy can be organized in a way that takes into account planetary and societal concerns, and thus produces responsibility as a particular value. Ecological modernization was a response to apocalyptic visions of societies running out of vital resources, as described in the report, *Limits to Growth* (Meadows et al., 1972), posed by more radical theorists (Mol et al., 2010; Warner 2007; Mol and Sonnenfeld, 2000). Reflexive modernists, on the other hand, are also concerned with the reform of modern institutions, but they take into account power relations and conflict dynamics (Certoma, 2016: 75). Scholars such as Beck (1999, 1992, 2010) emphasize uncertainties in transforming institutions that are central to modernity. He argues, '[r]isks are essentially man-made, incalculable, uninsurable threats and catastrophes which are anticipated but which often remain invisible and therefore depend on how they become defined and contested in "knowledge"' (Beck, 2010: 261). Both ecological and reflexive modernists open dialogues regarding nature,

society and our responsibility. Conversely, they have contributed to widening an ontological gap between nature and society, as argued by postenvironmentalists (Certoma, 2016: 73; Vogel 2015).

Postenvironmentalism is a relatively new term that builds upon the basic tenets of environmentalism but places the emphasis onto the complexity of sociotechnical entanglements (Certoma, 2016: 74; see also: Latour, 2005; Law, 2004). Authors here pay 'attention to technologies as coproducers of our world' (Certoma, 2016: 74) recognising nature as more than an 'external' biosphere. Here Certoma (2016) draws upon Latour (1993), who argues that modernist thinkers only refer to nature when they purify and thus mystify the actions we are involved in – excluding non-human actors and producing unintended consequences. In a similar vein, McKibben (1989: 7) argues there is no sense for environmentalism to focus on nature because, through industrialized human activity, the world is a different place. He announced the 'end of nature'; and this is in fact what the now prominent term 'Anthropocene' emphasizes: there is no nature anymore to connect with, no external body truly external to us (Steffen et al., 2011; 2015).

Taking inspiration from McKibben's critical claims, philosopher, Steven Vogel (2015: 12) takes postenvironmental ideas a stage further, by examining how environmentalists could value nature after the end of nature. In his book, *Thinking like a Mall: Environmental Philosophy after the End of Nature,* he recounts a personal story, linked to a renowned mall in his American hometown. Once welcomed, beloved and visited by many, it was soon considered obsolete and politicians campaigned for it to be demolished. It was, and a park was erected – hence a win for environmentalism and an appreciation of nature as such? Vogel is sceptical of this reading. He (2015: 137) asks 'why we find the loss of a wolf, or of a mountain, a matter for regret and yet feel nothing similar about the loss of a piece of the built environment'.

Inspired by environmentalist Aldo Leopold's 1949 seminal text, *Thinking Like a Mountain*, Vogel wants to examine 'what it might mean to think like a mall, or whether thinking like one might help us better understand our environment, at least as well as thinking like a mountain would' (2015: 137-138). For Leopold, it originally meant recognizing the complexity and self-regulating forces of natural ecosystems. In his famous text, Leopold recapitulated how he and his colleagues shot a wolf in the middle of the Grand Canyon, a wolf that seemed to be a danger for a neighbouring pod of deer. The more wolves, the more danger to the valuable deer – securing the latter was considered a 'win-win situation' for humans and nature alike. However, this shooting was a turning point in Leopold's life as he explained in this key passage: 'We reached the old wolf in time to watch the fierce green fire dying in her eyes. I realized then, and have known ever since, that there was something new to me in those eyes – something known to only her and to the mountain' (1949: 137).

The natural equilibrium was disturbed because of the missing wolf. The shooting did not stop the deer eating the grass at the heel of the mountain, and this grass would never grow again, because of some environmental management schemes. However, Vogel, contends that,

> [… e]nvironmental theory will remain stuck – on the one hand in a series of antinomies stemming from the conceptual ambiguities about what nature is, and on the other in the impotence of a romantic nostalgia for a lost and possibly imaginary world beyond the world of human action in which we actually live. (2015: 30)

For Vogel, what we need to do instead is answer the following questions:

> What sort of environment ought we to live in? What kind of world would be the best for us – and not just us, but also the many creatures, animate and not, with whom we share it […]? And what practices ought we to engage in, as a community, to help bring that sort of world into being? (*ibid*.: 237).

Vogel moves us into a closer engagement with environmental thinking that exposes us to new ways of making responsibility. There is no easy way to engage with environmental matters; new knowledge and new forms of organizing are required (Lousley, 2014: 160). Postenvironmentalism, however, can benefit from a more practical assessment of what responsibility actually implies – and could be transformed into.

We turn to valuation studies to enrich the critical capacities of postenvironmentalism with a more situated approach. Based on seminal contributions of this interdisciplinary field of studies (Dussauge, 2015; Lamont, 2012; Dewey, 1939), we understand responsibility as a quality that has to be brought forward – as a value that has to be given. Whilst it is important to recognize different values, it is equally important to understand the process by which they are produced. We suggest analysing this production by drawing on the notion of dis/assembling value, an approach developed to attract attention to the 'centre' as well as the 'peripheries' of the action of valuation (Greeson et al., 2019: 2). It is a very pragmatic approach that is keen on emphasising the particular materialities of certain valuation processes. Thinking in terms of assemblages (DeLanda, 2006) helps us attune the different pieces of the built environment (Vogel, 2015), and how to take the messy arrangements and the constantly changing dynamics seriously. Attuning to the dis/assembly shapes our perspectives on the study of value-production in the following ways: 'Creating value is a process of joining together: classifying, grouping, combining, making, re-forming. Yet it is also a process where persons, things, parts of bodies, or landscapes are disentangled, abandoned, dismissed, or corrupted' (Greeson et al., 2019: 5). Crucial to this approach is also to recognize the multiplicity of values being produced, with value orders perhaps competing against each other (or co-existing).

Below, we draw on the notion of dis/assembling value to understand the consequences of Apple and their introduction of the recycling robots, especially with regard to competing ways of recycling and enacting responsibility. However, before doing that we will briefly introduce our methodology and the way in which we bring our joint ethnographic research on the global e-waste economy together with the discussion of the robots and their consequences.

3. Methodology

The paper presented here is the result of a two-year long collaboration of our shared interests in e-waste recycling industries. In this section we clarify our methodologies to study Apple's

robots and their consequences, and these methodologies are closely linked to the history of our collaboration and reflections. It is important to appreciate this history and make our reflections transparent, because they directly influenced our procedure and are also key to the development of our theoretical argument on postenvironmentalism (see below for details on our phased approach). Having both undertaken ethnographic research, at multiple sites, we were able to bring our insights together. The robots, Liam and Daisy, function as intermediators – they enabled our cooperation and helped us explore new arguments and syntheses. On a more general note, we are thus drawing on, learning from and pushing what appears to be the core idea of the transdisciplinary field of waste or discard studies (see e.g. Moore, 2012; Alexander and Reno, 2012; Reno, 2015; Liboiron, 2018) that waste is understood as the result of wasting practices that have a certain history and that are driven by systematic or infrastructural dynamics. Therefore, to attune to and make wasting practices transparent requires a continuous critical exploration of field sites as well as the consequences of different kinds of approaches. Waste is in constant change, and scientific investigations have to account for that.

As we have argued in the previous section, adopting a valuation perspective provides the means to study values in the making. Following actors involved in recycling procedures and thus taking part in the valuation practices, as we will describe below, enable us to focus on 'the numerous and multifaceted frictions that come into view due to simultaneous efforts to enact different values' (Dussage et al., 2015: 271). Various scholars are sceptical of current recycling schemes and their approach of responsibility (e.g., MacBride, 2011; Gregson et al., 2015; Hird et al., 2014; Lepawsky, 2018). Valenzuela and Böhm (2017), who share these concerns, see Apple's recycling schemes as a prime example of an 'a-political fantasy of the manageable-waste-commodity fetish' (*ibid*.: 41). The company, in other words, wants to free consumers from any guilt, inviting them to keep on buying and discarding. This is a powerful critique. However, we want to slow things down, to explore how concrete sociotechnical issues surrounding e-waste may be re-evaluated so that responsibility can be shouldered collectively.

What follows is our exploration into the insecurities of value that can produce certain ways of organizing environmental thinking (which reinforces postenvironmentalism). For this we designed a strategy, to bring our different insights and sites together.

We call our collaborative approach multi-perspective ethnography. This is different from what is known as 'multi-sited research' (Marcus, 1995) – even though part of our individual research may be described by this notion. The data for this paper was taken from the authors' previous research projects and reanalysed. However, we are also keen on emphasising that our research is not just put next to each other. Our article, to rephrase anthropologist Strathern (1991), is about more than one but less than many perspectives. Liam and Daisy at times insinuate that e-waste is unaccounted for. Yet, as Gabrys reminds us in her research on digital rubbish. 'We not only need places of demattering; we already have them. They just tend not to register as places of regard' (2011: 98). Apple's robots are thus used as links; below we show how and why certain places are highlighted or forgotten when Daisy and Liam are put centre stage. Before, however, we briefly introduce our research sites.

Stefan, first of all, did ethnographic research on e-waste in India and Germany. He analysed an Indian law that tries to reorganize e-waste value chains. Interviews were conducted, and the classification system surrounding waste (with its documents and regulations) was analysed and brought together with the experiences and skills of the so-called informal sector. Formalization efforts were highlighted, while the new high-tech recycling actors turned out to be the new essential actors. In Germany, he then worked at a global market leader of recycling, where the preparation (the shredding, sorting, evaluating; in short: the accounting) as well as refining and smelting of e-waste is conducted. Stefan went to this facility to understand what kinds of daily boundaries and edges (Lepawsky and Mather, 2011) high-tech recycling is really facing. This helped in understanding the complex global values chains, and the accounting procedures a self-proclaimed efficient recycler needs to invest in – as a means to attune to the dynamics of the financial (metal) markets.

Alison in turn explored how UK e-waste management legislation was enacted into working practices at an asset recovery organisation whose core business was mobile telephones. During May 2012 to June 2013 she, and a fellow researcher, followed the trajectory of a mobile telephone through one of the largest asset recovery companies in the UK (inspired by Czarniawska, 2004). Research included interviews, participant observation, photographs, access to documentation, archival materials relating to the company's operations and work practices, and publicly available texts (for instance promotional material and their websites). In particular they went to this site to explore how waste and value were extracted, assembled and circulated in everyday practices (Stowell and Brigham, 2018). More recently, since February 2018, she has begun to engage with the informal e-waste and waste sector in Accra, Ghana (among it the infamous Agbogbloshie e-waste site) – building contacts with the waste organizers, sites and fellow researchers. This research is in the early stages of development and the data is from personal visits to two waste sites and informal conversations and observations.

There were two stages to our analysis. The first focused on the emergence of the robots and the second on a re-interrogation of our empirical research data. It should be noted, and in keeping with the epistemological, experimentalist positioning of this paper, these stages did not happen in a linear fashion; they were emergent, entangled and messy (Law, 2004). Stage one began with a review of different data sources from Apple's official websites in the UK, Germany and India (in line with the key empirical sites), to extract the inscribed values produced. This was followed by a review and the consequences of the responses given by journalists and the online technical community. The data gathered from Apple and its respondents included company reports, a white paper, videos, newspapers, blogs and press releases. A comparison was undertaken in regard to the different countries and inscribed values to identify key themes. In stage two we explored how the enactment of these robots connects to and/or challenges the understandings of responsibility in our field sites. Against this backdrop, we can now move to the introduction of the recycling robots.

4. Thinking like Liam and Daisy. Or, how are the robots enacting the value of responsibility?

When you select the environment menu on Apple's website you are invited to 'GiveBack' your old phone (this indicates a specific take-back mechanism that is slightly different country-wise, as a new term Apple also uses 'Trade In'). The website suggests 'have it recycled responsibly for free', and if you follow the 'see how it works' link provided, they emphasize that your phone 'will be recycled in an environmentally responsible way' (Apple 2019a; Apple 2019b).

Apple can make these statements because of the introduction of their recycling robots – Liam and Daisy – that are presented online. So, what does this mean for the enactment of the value of responsibility? How are they dis/assembling this value? To address these research questions we chronologically map the introduction of Liam and Daisy as a means of organising three key themes that emerged from our research – algorithming of knowledge, vulnerability and fragility of e-waste work, hegemony of shredding.

Algorithming of knowledge

Liam featured prominently in Apple's keynote event in March, 2016. This event was by invite only to their USA Headquarters and livestreamed through their website for the rest of the world to view. Although, we should be mindful that the world is not built on equal terms and there were substantial disparities in how this message was communicated and picked up in different regions – in India for instance, Liam's presence was ignored as Apple does not offer a convenient 'GiveBack' scheme in most countries from the Global south (Apple, 2019b).

A video clip (Apple, 2016a) introduces Liam as follows: 'True innovation means considering what happens to a product, at every stage of its life-cycle', then suddenly a fancy robot arm ascends, holding an iPhone; there is a motivational and rather hip soundtrack in the background, and a voice announces: 'Meet Liam' (fig. 1; at 00.05-00.10 mins). One then witnesses this robot deconstructing the iPhone. Have a look at how this robot presents himself:

Figure 1: 'Liam – an Innovation Story' (with subtitles). Source YouTube (www.youtube.com)

The male video narrator, in between jazz musical interludes (indicated below by '[…]'),

further advises:

> […] when it is time, Liam deconstructs your iPhone […], parts are detected and removed, and separated. So the materials inside those parts […], can be repurposed […], to rescue cobalt and lithium from the battery […], separate the gold and copper in the camera […], extract silver and platinum from the main logic board […], so that the materials in your iPhone […] can live on […], because of a world with limited resources […], some things can't be replaced (Apple 2016a: 00.10 – 1.03 mins).

These official PR announcements are supplemented by research published in a white paper

(Rujanavech et al., 2016), and insights from the British/American digital media website

Mashable, who Apple gave insider knowledge in advance of Liam's launch. Below are

examples of how these sources emphasize the proclaimed importance of the work that Liam

and his brothers are doing:

> There are currently two Liam systems – one in the United States (California) and another in the Netherlands. The Liam lines operate at an 11 second take time – every 11 seconds an iPhone is disassembled into 8 discrete components, with each line capable of disassembling 1.2 million iPhone 6 units per year. To meet this capacity, the Liam system is comprised of 29 robots in 21 cells with dual robots used in certain cells with particularly high cycle times (*ibid*., 2016: 4).

According to Murphy (2016), 'Liam is programmed to carefully disassemble the many pieces

of returned iPhones, such as SIM card trays, screws, batteries and cameras, by removing

components bit by bit so they'll all be easier to recycle' (para. 9). Liam results in deskilling

handicraft workers by transferring their knowledge into automated scripts: discreet and clearly defined steps – something we refer to as the algorithming of knowledge. This can be seen from a look at our extensive empirical studies. Our on-site research revealed workers developing clever strategies to work with obsolete devices such as mobile phones. Empirically, three approaches may be differentiated, while their notion of breaking down things (and putting them back together) differs substantially, also indicating how the value of responsibility is dis/assembled.

The first approach (a) is reusing or repairing one's phone, whether with the help of an expert, by checking on or offline manuals or by experimenting with abandoned gadgets. It is also critical to note that people became used to well established workarounds to prevent obsolescence. Below is a field note (in its original form) by Alison that gives an insight into the tools, skills, and experience of this art (while presenting the story of two male repairers), in the UK:

> The workbenches were scattered with an array of miniature tools, electronic testing devices, laptops with phone manuals open, anti-static mats, storage containers with draws comprising of screws, screens, keyboards, casings and memory chips… John eagerly remarked that '98% of the stuff is reused' … Depending on the fixer's skill level and depending on the time spent on the repair – 'the worker makes a judgement call.' But the official rule of thumb was the value of the phone dictated the time spent and whether it was beyond economic repair. … Greg enthusiastically started explaining the repair process – the phone is switched on to see if it is operating before the factory settings are restored, all traces of the previous owners were removed. Replacing screens, keyboards or upgrade software were the next steps before the phones looked as good as new with the final step being electrical safety checks… entering back into the warehouse John proudly told us his phone was 'actually reconditioned from their stocks, with the screen replaced, upgraded with reused stuff'

In this quote we begin to see a second approach (b), the breakdown and selling or reusing of mobile phone parts. Components are rearranged in the marketplace; the particular marketplace one is involved in really makes a difference – the material entanglements differ in different places. Bricolage techniques help make technologies. In northern India, for example, urban city dwellers are accustomed to *jugaad*[2], indicating a playful and open perspective on technologies that takes the need for workarounds for granted (Sundaram, 2009; Rai 2018). There are plenty

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[2] The hindi term *jugāṛ* is translated by the Oxford English Dictionary (OED) as a 'flexible approach to problem-solving that uses limited resources in an innovative way' (OED 2019).

of repair shops that are similar to the UK company cited above but they are attuned to the needs of citizens of megacities. The image below (fig. 2), taken by Stefan, gives a sense of the dynamics and possibilities of Dehli's infamous Nehru Place. If you roam around this place, sellers on the street tempt consumers by selling future imaginaries for your phone – tweaking, repairing, disassembling or replacing one's device (Laser, 2016). Despite being a place for marketing pitches, however, here you also meet plenty of people that can simply help with various issues.

Figure 2: Nehru Place, Delhi – copyright Stefan Laser

A third way (c) is known to be, as introduced above, the recycling of the materials included in a device. Waste plays an integral role in the global economy and is a permanent feature as demand for critical raw materials grows and concerns are raised regarding finite resources (European Commission, 2015). Engineers have trained themselves to know which materials they are confronted with and which ones may be captured in a safe manner (Minter, 2013). During the visit to the German recycling and smelting facilities Stefan, for example, learned

about the complex arrangements that make a sound assessment of materials delivered possible in the first place. Imagine a seller were to drop 40 tonnes of e-waste materials at your premises – a truck loaded with a complicated selection of printers, toasters, personal computers, servers, etc. And you have to pay this seller the appropriate amount of money, manoeuvring the slippery slope of gains and losses. Workers at the recycling site need to react to the changing material compositions of the deliveries, adjusting machines, looking for crucial objects, and sensing changes. Not every delivery can be checked separately, because different contracts emphasize different assessments, which makes this endeavour so interesting and in need of trained personnel. The accounting becomes closely linked to the experience of particular workers (Laser, 2019).

Unlike Liam, the e-waste workers are not following a simplified algorithm, as they can view e-waste not for what it is but for what it can become (Gregson et al., 2010). Liam hides the decision on material breakdown in the black box of Apple's algorithms – which is why we refer to this practice as the algorithming of knowledge.

Postenvironmentalism recognizes that our world consists of many creatures (inanimate and animate) (Vogel, 2015). Using Liam as an intermediary, we have dis/assembled values to activate the multiplicity of competing notions of responsibility (Greeson et al., 2019). For instance, glossing over the future visions e-waste workers have for what the discarded technologies could become (Gregson et al., 2010), or the potential of Liam to close the loop of Apple's supply chain cutting off supplies for other workers.

Vulnerability and fragility of e-waste work

Daisy made her debut ahead of the 2018 Earth Day, at Apple Park in Cupertino, California (Apple, 2018; Tibken, 2018). Apple proclaimed this robot as 'the most efficient way to reclaim more of the valuable materials stored in iPhone' (2018: para. 5). Her introduction was a more subdued affair (see fig 3); it was announced as one of many Apple initiatives, supporting their

'GiveBack' programme. Her broadcast informed the audience that she 'can take apart up to 200 iPhone devices per hour, removing and sorting components, so that Apple can recover materials that traditional recyclers can't – and at a higher quality' (*ibid*.).

Figure 3: 'Apple introduces Daisy, a new robot that disassembles iPhone to recover valuable materials'. Source Apple (2018)

Protected by glass, she operates alongside her co-workers (humans among them indeed!) engaged with the dismantling and the 'GiveBack' process. In contrast to Liam's presentation there is no narration; the music is softer, and subtitles inform how she enables

> […] customers [to] return their devices to Apple[…] Apple will donate to Conservation International through April 30[…] These efforts lead to positive change, detailed in Apple's Environment Report for 2018[…] Showing ways Apple is reducing its impact on climate change conserving precious resources and driving energy efficiency (Apple 2018, 00.15 – 00.45).

Daisy is now on the stage superseding Liam. Not only can Daisy handle nine different iPhone models (Liam only managed to deal with the iPhone 6 model). She is also 'made from some of Liam's parts' (Apple, 2018), with the plan for her sisters to appear in Europe soon (Tibken, 2018). Like Liam, we are reminded that Daisy is there to protect as she dismantles/recycles iPhones in a 'safe' and 'clean' way (Rujanavech et al., 2016: 3), but at the same time she and her sisters are set to displace and abandon Liam and his brothers, who are deemed to be inefficient and awaiting *deactivation*. Apple also appear to reflect on this shift by way of subtle

hints – that may have been identified by informed fans and presumed early adopters. The introduction of the robots has been intensively discussed in digital media. Regarding Daisy, YouTube commentators makes the association with the film '2001: A Space Odyssey', since Daisy is the song sung by HAL, the computer, as he is being scrapped (JBey4you, 2018). There is some irony to be had here. Other commenter mention how they are puzzled seeing phones being discarded that are newer than theirs. Consumers show their critical capacities.

Daisy is skilled, dexterous and protects us from harm, it seems. In the video, the robot is gleaming white, a bit of silver, contains a few black spots yet shines like a star. Apple's robots, we would like to argue, offer the polemic picture of those working in e-waste, disentangling themselves from global e-waste value chains. The absent other of this situation is the so-called informal sector.[3] Here, one needs to look at the iconic pictures, popularised for example by the Basel Action Network and Silicon Valley Toxic Coalition (Puckett et al. 2002), of workers in Agbogbloshie, Accra, in Ghana (Fernandez-Font Perez, 2013) or Delhi, India, where men, women and children are toiling away in insalubrious environments (Laser, 2016). Such images depict grimy, dirty, open air toxic conditions that show primitive separation practices used to extract (economic) value. This is a one-sided framing, characterized by a specific American-European view and partly mediated by racist stereotypes, thus shaping the discussion in a particular way (Osibanjo and Nnorom, 2008; Sahpores et al., 2009). Indeed, and in contrast to that, in the so-called formal sectors, the images typically represent an assembly line of men, wearing health and safety clothing separating and preparing devices ready for feeding large recycling machines. Apple appears to pay homage to the high-tech recycling machines that these formal industries celebrate.

Both images, our research emphasizes, are not doing justice to the complex recycling realities and their limits (see also Schulz, 2015; Fernandez-Font Perez, 2013; Lepawsky, 2018).

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[3] We write of 'so-called' because the in/formal categorization is disputed and partly rejected by various authors; we preserve the notion to reflect the performativity of the terms (see also Laser/Schlitz, 2019; for alternative conceptual inputs such as 'reclaimers', 'irregulars' or 'in_formal' e.g. see Samson, 2015; Schulz, 2019; Hafner and Zirkl, 2019).

In the pictures shown below (fig. 4 and 5) we have confronted the two worlds with a rather different set of pictures. The informal sector (f. 4) is not as unorganised as it seems, one needs to appreciate the complex ordering of the scrap yard not always visible at first glance; it is indeed similar to the formal operations, which simply use more and (crucially) more expensive tools to do the job of sorting (fig. 5). Most importantly, only a small fraction of informal labour surrounding e-waste is dangerous. Daisy tries to enforce Rujanavech et al.'s 'safe' and 'clean' practices that culminate in making the e-waste sector invisible from the landscape (Apple, 2019a).

Figure 4 (top): Complex scrap yard order at an informal site - copyright Alison Stowell

Figure 5 (bottom): Ordering practices and tools at a formal recycler's site - copyright Stefan Laser

While the informal sector is often misrepresented, the limits of formal recycling operations are not well accessed either. It takes a lot of organisational and financial power to successfully recycle e-waste, while success is narrowly defined. During Stefan's ethnographic study of a German recycling company, he observed a peculiar differentiation of labour that provides an interesting perspective. Inside one of the facilities there was a department where the workforce were almost exclusively elderly men or handicapped people (this term is deliberately used as quite often their hands had been damaged in some way). At this particular department, they were doing rather easy and lightweight jobs (classification and documentation of testing samples – bureaucracy, if you will). As Stefan learned, most of them used to work in different facilities/departments of this company. They had been transferred because they could not withstand the physically demanding repetitive work. The required skill and stamina to be deemed efficient, it could be argued, is being replaced by technology. Daisy is relocating and reconfiguring workers too, even other robots like Liam.

What all the e-waste workers (including the robots) and these competing recycling operations have in common is that they require physical stamina, strength, dexterity and skills in order to identify value (Stowell and Warren, 2018). Reconsidering public discourses around recycling and their effects on recycling programmes, Pickren (2014: 33) argues that 'given the complexity of global commodity networks like those used for electronics, these governing narratives rely on abstractions that oversimplify and rework the fetish of what e-waste is, where it goes, and how it should be managed'. For us, Daisy shines a spotlight on the vulnerabilities, fragility and inequalities of waste work. All in all, it is important to acknowledge that multiple actors claim to do a good job while handling the e-waste, both in the Global North and South, and not just in Cupertino.

Hegemony of shredding

In this last sub-section, we aim to discuss Liam and Daisy by focusing on one essential element they both share. The robots highlight a hegemony of shredding, the rising impact of shredding technologies in the global recycling economies of e-waste, which helps us revisit our research sites once again. Below are two quotes from the introduction of Liam and Daisy respectively, stressing what is at stake.

> Traditional e-waste recycling can only recover a handful of the materials actually used in today's electronics. This is due to the challenges faced in pre-processing where highly complex electronics have to be shredded and are separated into only a few different material streams that aggregate many individual materials. Liam lets Apple address this problem by producing eight different material streams that can be sent for targeted material recovery. As a result, end-processors can recover a more diverse set of materials at higher yields than ever possible before (Rujanavech et al., 2016: 6–7).

> Our newest disassembly robot, Daisy, is the most innovative and efficient way to reclaim more of the valuable materials stored in iPhone… For example, Daisy makes it possible to recover rare earths, tungsten and Apple-specific aluminium alloys. Then we can use these materials to make new products or return them to the market, reducing the need to mine more resources from the earth[…] Daisy not only yields more, but also teaches us more about what's possible (Apple, 2018: para 3–4).

Apple is connecting with the recycling industries, aiming to advance the options already used, taking them one step further towards more efficiency. For the establishment of efficiency, as Stefan learned during his studies at the German recycler, the precision of shredding machines is important (Laser, 2019) in order to differentiate between different streams of valuable scrap that can be sold off or processed with a clear destination. The mixture of materials delivered at the recyclers' site is a challenge, yet this is where the robots are said to help out to capture key metals (aluminium, gold, silver, rare earths, tungsten, copper, palladium, tin, cobalt, tantalum) and plastics (Rujanavech et al., 2016: 7).

Liam and Daisy are said to receive the iPhones when options of repair are believed impractical (*ibid*., 2016). Yet, there are critical voices that question this claim. Recycling industry exports highlight that consumers should be wary of giving Apple their old telephones, for they would hinder alternative, more sustainable uses of the devices. 'Don't give it to him [the recycling robot]', they suggest (Urry, 2016). More research is required on this topic, because we lack data on what kind of recycling value chain Apple is in fact establishing. The

company, for example, has also been under considerable pressure from the Right to Repair movement that urges Apple to make their devices more accessible to professional and layperson repair – and recent news reports suggest they indeed appear to have succeeded in making their demands heard (Koebler, 2019).

Our research suggests that Apple's technocratic scheme to deal with broken/used phones is just one of the many strategies at present to deal with waste, pushing repair and refurbishment actors out and thus stabilizing a hegemony of shredding. As indicated, this is not only this particular company's endeavour. The recycling robots rather help illuminate a global trend. Electronic waste has been hitting the news as a major global issue since the early 2000s, coming into prominence also by way of dramatic NGO storylines on illegal global exports of waste (Puckett et al., 2002). Since then (and in fact beginning with the negotiation of the original Basel convention from 1989) we can see a political shift towards the establishment of an infrastructure of high-tech recycling. Technocratic means of grappling with the e-waste issue have become an end on their own, while reappearing news reports on the dramatic scenes of so-called amateurish recycling practices in the Global South emphasize the need to stick to high-tech means-ends.

While waste prevention as well as repair mechanisms are declared laudable goals in the important policy frameworks we came across during our studies (WEEE in Europe, the e-waste Rules in India), however, the most important financial support mechanisms drawing on these schemes share a focus on supporting new shredder technologies rather than, say, repair strategies and initiatives (this is partly the reason why Lepawsky (2018) suggests that we need to rethink the e-waste issue). We need to be careful with our critique here though, for the new infrastructure of high-tech-recycling is complex and anything but unidirectional in its influence. In practice we see contradictions and the coexistence of infrastructures. Actors are able to creatively link with different parts of diverging sociotechnical arrangements. At the UK asset recovery site, Alison, for example, found that the organisation oscillated across different

systems to extract value and thereby produced different understandings of responsibility – placing the impetus on data security and eradication services refurbishment, and component sales, before shredding and smelting (Stowell and Brigham, 2018). In India, Stefan found that the new e-waste law wants to reorganize by way of devaluing practices like repair, while the new high-tech infrastructure in fact does not simply replace the previous recycling and repair efforts (but it might make their work more difficult and expensive). Despite such complexities, however, Liam and Daisy help us see that particular high-tech approaches towards e-waste are becoming more dominant when it comes to the handling of discarded materials – something we refer to as the hegemony of shredding.

5. Reactivating responsibility

So, how does dis/assembly contribute to the understanding of postenvironmentalism? Returning to the postenvironmentalist, Vogel, we remind ourselves of the importance of exploring the concrete sociotechnical issues surrounding the production of responsibility and how this can be activated. He points out vividly that focusing on individual human beings and what they should do with regard to certain ecological issues could even be harmful. For Vogel (2015: 208), the infamous tragedy of the commons (Hardin, 1968; Ostrom, 1999) results from the inability to coordinate one's action with others (consequences then appear in the form of stiff natural facts). The moral obligation of each individual, in turn, is to make responsible decisions. In doing so, he does not focus on individual consumer decisions, as has become so common today, but explores political collectives and their ability to mobilize, in order to generate knowledge that can help organize society in different ways. In addition, we need a pragmatic approach that enables us to be attentive to the valuation processes at hand and their materialities. We argue that dis/assembling value helps to put a spotlight onto the action of valuation. Using Liam and Daisy as intermediaries, by focusing on how they enact the value of responsibility, we have shown the multiplicities of value-production, and how value orders compete against each other.

We thus highlight the limits of adopting a technocratic approach to e-waste and how this contributes to a reassessment of politicisations.

Limits to a technocratic approach to e-waste

How do the robots, Liam and Daisy, enact the value of responsibility? They gloss over the future visions the e-waste workers have for what the discarded technologies could become (Gregson et al., 2010). Whilst automated disassembly might be advantageous, since the take apart process provides homogenous component streams (Rujanavech et al., 2016), one could argue that the robots are representative of the power and control by Apple creating algorithms that 'black box' certain recycling practices. Thus, we argue, attention should be paid to what decisions are behind these material breakdown process. From the point of view of our research, Liam and Daisy close the loop of Apple's supply chain and contribute to the decision as to who then can own an iPhone.

In addition, it is indicative to look at which actors and locations are absent in newly introduced (and cherished) technologies. In this case, Liam and Daisy emerged as particularly white and powerful robots, and the absent other that got silenced was the informal sector and its actors in the Global South as well as the Global North.

Moving beyond demystification

Finally, however, it may also be helpful to slow down one's criticism when being confronted with such inequalities. Exploring the production of responsibility through dis/assembly shows a particular way of developing critical arguments. Environmentalism traditionally suggests the protection of something, but the something usually embraced (called nature) does not exist anymore (or has never existed in the first place) (Latour, 2005). Drawing upon Vogel's (2015) postenvironmentalism, we are reminded of the importance of taking Apple's robots seriously and to move beyond demystification in order to deepen our understanding of the responsibility of waste. What we investigate here is the protection of the

built environment, which includes electronic devices and the infrastructure surrounding these. As Apple documented, the Liams were also a recycling experiment so their existence is just as insecure, precarious and unstable. How long will it be before Daisy is disassembled to create the new army of robots? Like Liam, Daisy becomes the absent other, silenced, and her creativity and innovation lost. Reinforcing the importance of protecting the built environment carefully to ensure inclusivity remains, and those less visible are not forgotten. However, it is an ongoing challenge that is faced when attempting to create a circular economy solution.

To summarize, we argue that through the introduction of Apple's recycling robots the company is claiming to be responsible, but what they in fact do is to remove important parts of the recycling realities from our sight. What is required is an exploration of multiple responsible ways of dealing with electronic gadgets and their waste. We argue that reconceptualising postenvironmentalism, through the lens of dis/assembling values, enables us to activate the production of responsibility as a value in empirical contexts. Through adopting this conceptual framework, we can engage with the built environment in a more democratic way. There was not enough space in this article to discuss the plethora of actors and skills to be found at our research sites; but there was sufficient space to hint at a selection of key themes to think of, which can also nudge future research.

Acknowledgements

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