Vulnerability Tests

Matters of "Care for Matter" in E-waste Practices

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Abstract: In this paper we will think ethnographically about how material vulnerability is dealt with and conceived of in the practice of informal menders. We explore different practices to "care for matter", mobilized in dealing with obsolete computers, categorized as electronic waste, and will analyse the epistemic repertoires to acknowledge and intervene in such computers vulnerabilities. In dialogue with STS and Repair and Maintenance Studies literature, we will move from vulnerability as an ontological quality of the world to the enacted properties and epistemic repertoires emerging from concrete "tests", through which we might learn how vulnerability matters. In particular, we pay attention to three specific vulnerability tests performed by these informal menders, underpinning particular distributions of labour as well as concrete enactments of vulnerability, and how to make it matter. Namely, *sensing matter*: manipulative practices of electronic waste whereby vulnerability is enacted as a property of materials; *setting up informal experiments:* informal practices of trial and error whereby vulnerability appears as a result of dis/functioning technical systems; and *intervening in obsolescence:* whereby sociomaterial orders regulate how material vulnerabilities are redistributed and put to the test.

Keywords: maintenance & repair; matters of care; vulnerability; test; electronic waste.

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1. Introduction: Dealing with E-waste

Observing the world around us, we might realise that material vulnerability is probably inevitable, a kind of ontological condition affecting all matter and bodies. Something we might take for granted, be it because of the passage of time or because of the wear and misuse of our everyday

things. However, in this paper we would like to reflect on how such vulnerability is dealt with and conceived of, or as we will say 'enacted' or made to matter, in maintenance and repair practices. Through different empirical vignettes drawn from ethnographic fieldwork on informal practices of mending, reusing, repairing and hacking of electronic waste in Spain, we will try to explore how such material care – or "care for matter" – practices mobilized to deal with obsolete computers could also be thought of as powerful epistemic repertoires to acknowledge, make perceptible and intervene in particular vulnerable matters. More specifically, we would like to consider these practices as working experimental trials or vulnerability "tests", similar to the ones occurring in the implementation, repair and maintenance of other diverse matters, objects and infrastructures. We would like to put forward that these vulnerability tests also underpin the ethical and political orders and ecologies that are being sustained, maintained and produced alongside.

Hence, this paper seeks to develop a twofold argument: On the one hand, we seek to foreground the importance of material care or "care for matter," and the recognition of vulnerability occurring there, paying attention to the situated knowledge methods mobilized to tackle it, to understand it and, eventually, to intervene in it. On the other hand, and as an effect of the previous point, we would like to suggest "mending" as a particular form of maintenance and repair practice, whereby conservation is exerted in a more interventional and politically nuanced register.

The ethnographic material we would like to think about stems from a research project[1] on informal but innovative responses to e-waste problems carried out in Spain between 2012 and 2014 by Blanca. Considering the limited results of public policies on e-waste and the relative novelty of this emerging ecological problem, the aim was to explore the material and epistemic informal practices arising at the margins of institutionalized managerial circuits, in the space that seems to appear between a mainstream consumerist conception of electronics and the e-waste treatment solutions, focused on recycling. The idea was to understand how these informal experiences might be practically altering (be it resisting, avoiding, slowing, hacking or transforming) the managerial processing sequence that goes from "computers" to "e-waste", but also offering alternative models on how to make electronic waste matter. Hence, Blanca observed three different experiences.

The first one was a group of informal migrant waste pickers who look for metal pieces and components in the streets of Barcelona[2]. Living and

[1] To know more about the "Politics of scrapping" research project, see http://politicadechatarra.wordpress.com/.

[2] From November to December 2012, Blanca visited their warehouse three or four times a week and used to accompany one of them in his daily activities. Besides fieldwork direct observation and informal interviewing, several individual

trading, at that time, in an impoverished neighbourhood's huge squatted warehouse, they wandered around the city every day picking up scrap metal and precious objects to sell them to bigger scrap-traders. In the case of still "useful" computers and electronic devices, they were sent – either directly or through middlemen traders – to second-hand markets in Africa through informal but trustworthy networks of contacts in order to have them repaired and sold again.

The second and third were located in Madrid[3]: Obsoletos, a small hacker research project in Madrid, composed of four friends trained in different scientific and technical disciplines. Thanks to a grant from the Spanish Ministry of Culture they organized several workshops and meetings to teach how to rebuild obsolete computers and to create other "hacks" from discarded components and devices. They also published a blog[4] dedicated to the analysis of different aspects of technological obsolescence and to document their creations, such as a soap bubble-maker, a hard drive speaker or a laser oscilloscope. Despite the fact that their educational project finished a few years ago, they still blog, collaborate with other groups and develop some hacks and creations just for fun or the pleasure of learning.

And *Cyclicka*, a self-managed computer repair collective workshop[5] that operated, at that time, as an informal learning hub inside a huge social centre in Madrid. They were hosted there and, as an exchange, they offered help with maintenance and repair services. Old computers were donated (mostly by neighbours) and volunteers gave lessons on computer refurbishment. There was also a weekly repair workshop open to the public. The repaired and refurbished computers could either be sold by repairers – who then earned two thirds of the money – or given for free to social and activist local projects. They could also be given to schools and educational projects all over the world, thanks to a self-managed social network called Labdoo[6], which puts laptop' donors, repairers, carriers, petitioners and receivers in touch.

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interviews were also made with different waste-pickers, a "middle-man" trader and a local seller who used to make deals with scrap-traders in the warehouse.

[3] From October to November 2012, Blanca hired a place in the co-working space of the Obsoletos' warehouse. However, considering the decrease in their activities as a group, what was to be observational fieldwork turned into an ethnographic research carried out through individual and collective interviews and a documentary analysis of their blog, which operated as an archive of their past activities and publications about e-waste, hacking and repair of electronic products. In the case of Cyclicka, Blanca made a participatory observation of their activities and interviewed different participants of Cyclicka and Labdoo. Also, a public presentation of the research project operated as a debate and collective interview with Cyclicka's crew.

[4] See http://obsoletos.org/

[5] See http://blogs.latabacalera.net/cyclicka/

[6] See http://www.labdoo.org/es

2. Re-enlivening Mending, Tackling Vulnerable Matter

These practices indeed bear witness to how, since the 1970s, in different countries of both the so-called developed North and the Global South, different collectives have begun to explore other models of design and production, different habits and everyday routine practices (be it in communes or in self-organized groups and institutions; see Turner 2006), building different narratives and manifestos on what it would be like to inhabit a finite world, thinking of alternative distributions of goods and community economies (Roelvink, St. Martin and Gibson-Graham, 2015), talking about other kinds of relationships with the immediate environment, personal and collective resources and the things around us.

We use the word "menders" to describe those diverse collectives engaged in different sorts of mending and repair practices, be it through professional practice or through the revival of traditional crafts and the articulation of new technological hopes via open-access technologies – such as "do it yourself" (DIY) and "do it with others" (DIWO) philosophies and other sorts of participatory design projects (e.g. hacker or maker cultures studied by Kelty 2008). Indeed, many of these collectives have articulated a critique of innovation (Suchman and Bishop 2000) – reanalysing Schumpeter's works on capitalistic "destructive creation" – by focusing not only on the sheer ingenuity of designers and engineers in materializing their ideas but also, and more fundamentally, on the practical issues related to the user adoption together with the work of technical implementation and the practicalities of maintenance and material wear affecting the objects and technical systems conceived of by them (Akrich et al. 2002; de Laet and Mol 2000). To use Ingold's (2013) vocabulary these collectives warn us against focusing exclusively on practices of "form-giving" and direct our attention towards the crucial practicalities of "form-keeping" in our life with materials.

Following this interest in maintenance and repair, some research and social projects, such as the ones observed by Blanca, have already started to explore the reach and effects, as well as the limits and scope of what could be called, in line with the recent re-enlivening of craftsmanship and workshop cultures, "mending cultures" – see also Dant (2010), Oroza (2009) and Sennett (2008). Many activist projects and experiences that critique design's logic of conception and its grandeur are also claiming mending and repair practices as vibrant social and innovative acts, far removed from the tedious, and domestic attributes usually ascribed to them (being considered by some as "chores"). From this perspective, mending means establishing direct, caring and lasting relationships with our surrounding material world. For some, these new "craft consumers" (Campbell 2005), "lead users" (von Hippel 2005) or "creative communities" (Meroni 2007) are defining a sort of open-source "new DIY age" (Hoftijzer 2009) or "Post-Professional Era" (Atkinson 2010) where

mending and repair result in opportunities for social, economic and technological innovation. Without any doubt, the everyday practices of such menders constitute particular cultures that could maybe challenge and redefine, in more creative and sustainable terms, our economies and environments as well as our role as active citizens or the way we approach our daily infrastructure and socio-technical systems, or more generally how we approach design (Papanek 1971).

These movements signal, indeed, the emergence of more conscious and sustainable growth ideals in which the meanings attributed to values, the definition of matter and design, as well as the concepts of time and the economy are affected. For instance, Graham and Thrift (2007) note that perhaps the main imperative in more responsible forms of object design should be to address "repairability," hence stressing their potential for a renewal of economic and industrial practices. Such potential is also put forward by Gregson et al. (2009) who analyse different practices of object maintenance at home, thus showing their importance, in terms of competence, purchasing power or parenthood, for the social lives of consumers. Recent research has also put under a critical lens key aspects of unsustainable practices of consumption, such as the "planned obsolescence" of technological devices (Huisman et al. 2008; Maycroft 2009).

What remains clear for many of these projects is that, sooner or later, more or less intensively, everybody experiences material vulnerability at some point, revealing the neglected, denied, bracketed or forgotten counterparts of common modern assumptions regarding subjects and objects (Jackson 2014). Or, "thinking big": the risks to economic, social and environmental well-being posed by, amongst other issues, environmental damage and climate change, the shortage of natural resources, the global financial crisis, or the increase in impoverished, vulnerable and marginalized populations both in the North and in the Global South, are just some of the current problematic expressions of widespread social obliviousness to the conditions of finitude and fragility affecting not only our organic and social bodies but also the "bodies" of those objects we live by.

Many of these themes have also been present in recent STS literature, such as Bijker's (2006) reflections on how our contemporary technological cultures are underwritten by variegated and polysemic forms of vulnerability having both positive and negative aspects: ranging from the negative vulnerability appearing in the presence of increasing technoscientific risks requiring us to develop precautionary principles to the positive discovery of many forms of grassroots resilience and coping practices in relation to such risks (Hommels, Mesman and Bijker 2014). Indeed, many STS works related to feminist literature have been stressing the importance of paying attention to what some philosophers name "ontological vulnerability" (Connolly 2013). When talking about subjects, the use of vulnerability has become central to many feminist students of technoscience, for it summons an ethical repertoire different to the liberal and

modern conception of subjects as autonomous and free individuals. These scholars rather talk of bodies as fragmentary entities in need of constant careful practices to be "held together", as Mol (2002) puts it. But this could also affect how we think about matter: an attention to brokenness and decay mobilizes other theoretical and practical engagements different from the ones available when using the concept of "object," as a closed-down and ready-made commodity – an object "at hand", part of the "furniture of the world" to use the vocabulary of analytical philosophy –. Indeed, we could follow Maria Puig de la Bellacasa's reflections (2011) to foreground how repair, maintenance or other "care for matter" practices might be taken as epistemic repertoires addressing matters that, despite usually remaining hidden or not easily visible, are still crucial and necessary for the fragile continuity of our common but uneven sociomaterial worlds.

Hence, despite the fact that vulnerability is in many practical situations easy to identify – such as when a clear breakage happens while using something, after an accident or as a result of a disaster – it usually emerges out as part of an ongoing process of sensing and practical manipulation, hardly ever recognised at first glance. Hence, although vulnerability and wear are constitutive of any entity or matter, as many feminists writers working on ethics of care have long argued (Tronto 1993; Pérez Orozco 2014; Mol 2008), they are not so evident and perceptible if we do not pay enough attention. And this is, precisely, what the observed mending practices around e-waste do: to experiment and identify material vulnerability through attentive and careful "tests" on matter. In clear analogy with what Latour stated in *Irreductions*:

> […] There are only trials of strength, of weakness. Or more simply, there are only trials. This is my point of departure: a verb, "to try." […] It is because nothing is, by itself, reducible or irreducible to anything else that there are only trials (of strength, of weakness). What is neither reducible nor irreducible has to be tested, counted, and measured (Latour 1988, 158).

Building from this, our aim in the following section would be to describe and read such practices of handling, treatment, repair or maintenance of e-waste as "vulnerability tests": that is, situated and overlapping informal experimental settings allowing practitioners to sense and discuss different meanings, expressions, values and distributions of electronic waste, enacting particular versions of their vulnerability and how it might matter. More specifically, the first test on sensing matter focuses on how matter or functional vulnerabilities are sensed through manipulation. We also refer to a second type of test, consisting of setting up informal experiments whereby epistemic repertoires and methodical knowledge about vulnerability are produced. At a third moment, by intervening in sociomaterial orders, these collectives can "put to a test" the policy regulations

and governmental dispositions that rule, order and distribute our daily and unequal vulnerabilities. That is, the ontologies and boundaries of waste appear as multiple and unstable situated effects of performance (Mol 2002) through explorations, and interventions, very much in line with what Maintenance and Repair Studies have shown (Denis and Pontille 2014a, 2014b; Henke 1999; López and Sánchez Criado, 2015; Orr 1996; Sanne 2009, 2014).

Hence, versions of vulnerability are enacted in these experimental testing activities that produce particular forms of both informal and formal knowledge on matter that might help us think "more carefully" – or care "better" – about the ecological dimension of e-waste. To conclude, we will suggest that such vulnerability tests could be extremely important beyond a concrete analysis of e-waste practices to devise "more caring" analytical tools, especially in STS, allowing us to think more responsibly and carefully about how, under which conditions and effects vulnerability is collectively enacted but, also, how it might be intervened in.

3. Tests: Enacting Versions of Material Vulnerability by Scrapping Metals and Repairing Computers

In this section we would like to delineate empirically three "vulnerability tests" taking place in the observed practices. A first test involving *sensing matter* where vulnerability emerges as a property of materials sensed through manipulation. Second, a form of testing that entails *setting up informal experiments* where vulnerability is enacted as a property of dis/functioning technical systems. And third, a testing regime *intervening in obsolescence*, whereby vulnerability is highlighted as a sociomaterial order related to policy instruments that rule, order and differently distribute our daily vulnerabilities.

3.1. Sensing Matter: Vulnerability as a Property of Materials

When doing fieldwork with waste-pickers in Barcelona learning how they weighed the value of their findings, Blanca accompanied Marcel along his daily work of searching for and manipulating scrap:

> In most of the cases, it requires them both to recognize different kinds of materials at hand – especially metals – and to know if the electronic devices found are still functional. These variables help them to mark the right price in negotiating with others. The magnet, as I learnt, is a key tool in all these processes: if the piece attracts some materials, it is ferrous. If not, you just need to scratch a bit to distinguish brass from aluminium. But the best paid is copper, known by its reddish colour. Marcel, the closer informant who has taught me the trade and with whom I have walked most, tells me that it was also very important to know how to "crack open" the

> things you have found: "You never know what you can find inside". A wrong blow on the incorrect part can make the opening and access much more difficult, in terms of effort and time. The most difficult task is to crack open motors. Whether they come from fridges, washing-machines or any other small device, the motor is where the biggest quantity of copper can be found. Today he recalled his first day as a waste-picker, when he found a motor but he had to sell it as a whole: "At the beginning it was very difficult: as I didn't know what to do to extract the motor. Sometimes, it took me a week" (Excerpt from Blanca's fieldnotes).

But how do they face the unknown? How do they tackle and deal with strange "new" devices? The weight is the clue:

> Marcel also explains: "Until now, I didn't know what it was, but if it weighs, you have to break it. Because if it is heavy, it may have a big motor inside. Because the most important [material] is copper. Then, you break it and you can get 2 or 3 kilos of copper from just the motor". And after this, he mutters very quick calculations about how much money he can make if he extracts the motor. "[…] But if you don't even know that this is a motor, how can you know that there is copper inside!?", he concludes" (Excerpt from Blanca's fieldnotes).

Another day, there was a case of a lamp that turned out to be hiding a very big piece of copper inside, and of a CPU (see Fig. 1).

> Marcel suspected there was copper inside because of the sound and the weight when manipulating it. I had asked him before if it might not be better to sell it as a whole. That is, as a lamp. But he shook his head saying it would not sell "because it doesn't "look" like an antique". If it were an antique, it would have some value. In the case of computers, he seemed to know much better what to do with them because of the standardization of their assembly, components or materials. One of the CPUs he found was completely taken apart. The owner told him that it was very old and this was evident because of the external "appearance". The most precious part, he told me, was the electricity supplier – because there was most copper inside – then the hard disk – either because of its aluminium or because some people buy them separately and lastly some small copper pieces welded to the motherboard. If the computers or electronic devices were still functional, he would send them to the Moroccan neighbour traders. The method used to work this out is a pretty simple one: he plugged them in. If they turned on, they are OK. Nevertheless, he maintained that everything is repairable in Africa, quite unlike what happens in Europe. "You are used to throwing things out and buying another one", Marcel said" (Excerpt from Blanca's fieldnotes).

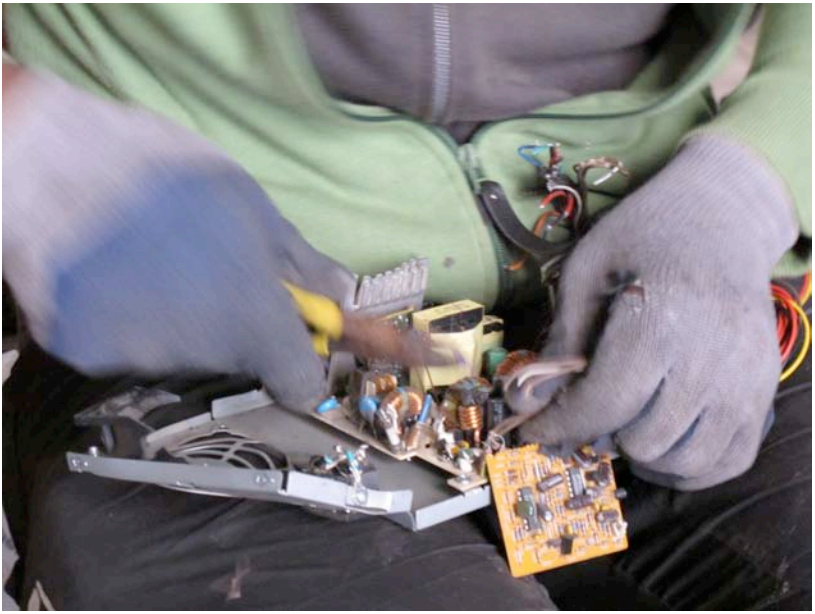

Fig. 1 – Waste-picker in the squatted warehouse in Barcelona extracting some copper pieces welded in a motherboard. Taken by Blanca Callén (14/12/2012) and used with permission.

In such explorations, waste-pickers tried many different methods before knowing if a given object was a valuable find or before stating a clear diagnosis. It would seem clear that all electrical devices have some copper inside but one never knows how much. The act of weighing things, such as in the example of the lamp, gives some clues – there might be a transformer inside and, hence, also copper. But despite the expertise of people such as Marcel, for him distinguishing the different kind of metals that the lamp was composed of required a new test involving the use of a magnet plus scratching. Through these actions, he could know first the existence and then the value of something of worth inside the lamp. In this case, the objective was not to repair a physical breakage or an electric vulnerability, but to extract something valuable from it.

These vulnerability tests are related to sensing the object's properties, creating conditions to let "matter speak" in order to know about it – to use Sanne's (2009) wording in his analysis of the on site diagnostic work of railway maintenance technicians –. For instance, a great part of waste-pickers' tasks consist of checking the things they have found in order to determine their properties, or to know if the devices work properly or not, leading to troubleshooting moments where practitioners must decide what to do, guided by preliminary diagnosis.

Many of these repair and maintenance situations are indeed sensory practices (Dant and Bowles 2003; Dant 2010) in which practitioners engage in "[…] rhythmic repetitions of gesture entailed in handling tools and materials […] set up through the continual sensory attunement of the practitioner's movements to the inherent rhythmicity of those components of the environment with which he or she is engaged" (Ingold 2013, 115). Indeed, this is what happens when weighing findings or when scratching and observing emerging colours under the scratch, or when carefully listening to whistles from the CPUs. To use Leroi-Gourhan's words, these waste-pickers' practices entail "a dialogue between the maker [or repair practitioner] and the material employed" (quoted in Ingold 2013, 115), where material nuances and potentialities emerge. Through situated and sensuous cognitive practices "in the wild" (Hutchins 1995) that almost never follow "logical" or "standard" procedures of thought (Denis and Pontille 2014a), waste-pickers produce a particular version of vulnerability: entailing practical knowledge over the material weaknesses and potentialities of those things they are putting their hands on, in order to know if they can keep on manipulating them or if their ontological status must be shifted and altered to continue exploring the life of materials (see Ingold 2013).

3.2. Setting Informal Experiments: Vulnerability as a Property of Technical Systems

Nevertheless, vulnerability tests are not limited to the materiality of technologies discovered through sensing and manipulation. Sometimes they also entail opening up apparently "closed" objects or technical systems (see Fig. 2). The guys from Obsoletos know this well, as it became evident in one conversation with Blanca, telling the story of a computer found in the bin:

> Fernando said, "It was only the graphic card that was ruined". Probably, Fernando continued, the owners had thought that since they could not see anything it had stopped working. And, as they state, the same thing happens with the 90% of the computers that they find. Indeed, the cause of their breakdown is not "material" or "physical" but "human", as they say. In that particular case, they just changed the graphic card replacing it with a reused one that was extracted from another obsolete computer. "In any case, if you rescue two obsolete computers, you have 98% of possibilities of getting a working one. If you have three computers and it still doesn't work, you are a jinx". This is why, as they say, in order to repair and refurbish computers, or even for hacking, it is extremely important to have plenty of functional spare parts and components. But having a huge amount of them, without knowing if they work or not, has absolutely no value (Excerpt from Blanca's fieldnotes).

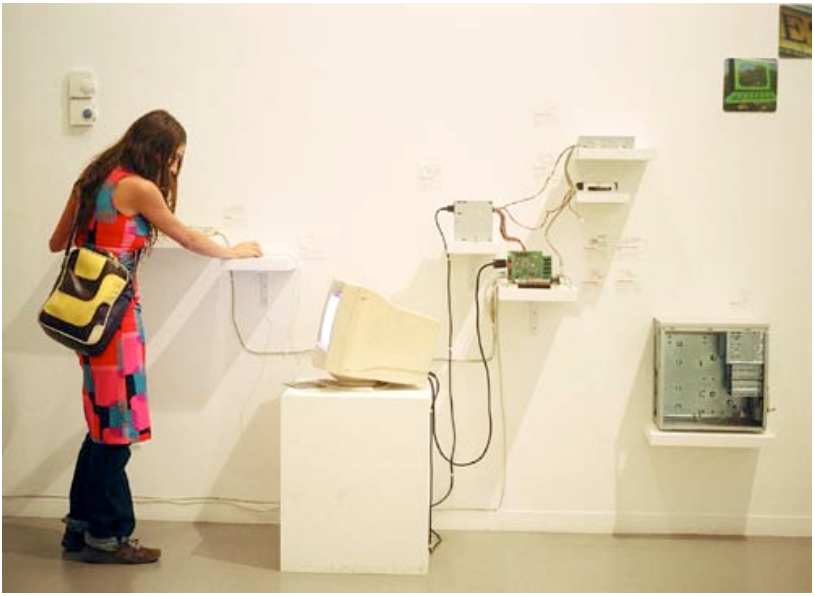

Fig. 2 – Exhibition in La Casa Encendida (Madrid) in May 2005 where Obsoletos displayed an opened-up but still running computer to show its functioning to public. Taken from http://obsoletos.org/2008/05/ordenador-abierto-mayo-de-2005/ and used with permission.

Indeed, another day in Madrid around that same time, visiting the Cyclicka workshop Blanca suggested throwing away a damaged hard disk from a broken computer:

> Javier, Cyclicka founder, appears out of the blue and tells me not to do it. He explains me that they could still use it as an external data hard disk. The same happens a while after when collectively exploring a damaged CD player, whose motor could still be useful to make or hack new devices. Or with several old-fashioned keyboards, whose printed circuits could still be used for videogame consoles (Excerpt from Blanca's fieldnotes).

This way, a computer is not treated as an entire closed part or standard object with a unique function, but as a "system" of heterogeneous components. This is the basis for testing computers' functionalities as, in an analogy with a particular version of the scientific method, the isolation of different variables through "trial and error" becomes crucial for detecting problems and finding solutions. After repairing the aforementioned computer, that with the damaged hard disk, people from Cyclicka put a sticker on it with the name of the collective to whom it was going to be donated. When they came to pick it up, the repairer asked them as

soon as they arrived: "What exactly are you going to use it for?". "Editing texts and designing some flyers," they answered. "In that case, it's OK". Probably, if the future functions of the computer had been much more complex, the power or CPU's outputs would not have been enough.

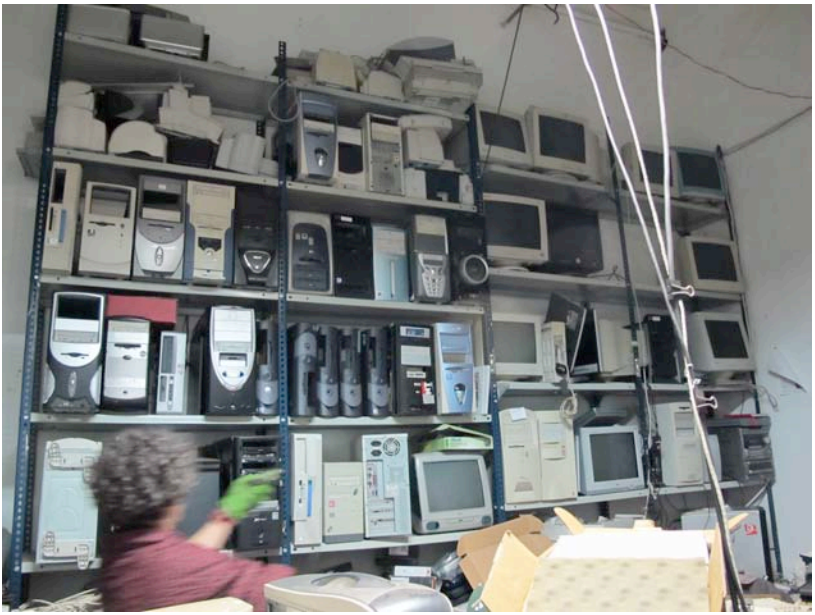

Fig. 3 – Shelves with donated computers, in Cyclicka's workshop, waiting to be refurbished or cannibalized. Taken by Blanca Callén (4/11/2012) and used with permission.

Unlike other devices, the preliminary diagnosis of computers is easier because of their similarities: all have the same type of components with their same respective functions, are made from the same kind of materials, and everyone knew it. Their accumulated knowledge about standard functions and dysfunctions allowed them to very quickly identify the reasons for the damage. If the computer's screen in the bin was completely black and there had been current coming into the CPU, then, it was likely that it would have to do with something technical related to visualization, such as the graphic card. However, there is usually not just one reason for the failure and there are not straightforward ways to know what they are. The connection between the event (e.g. a black screen) and its potential cause (e.g. graphic card) is a very direct and common one. In many cases, the diagnosis is also based on sensory and attentive bodily dispositions by repairers. As Tilan, one of the waste-pickers who worked also as repairer explained, "Often, you know what the problem is because of the whistle it makes. You remove what

doesn't work and put in components that work. And if it doesn't whistle then it works". But when the failure signal is not so obvious or even there are no signals, the possible causes multiply. In that case, repairers and refurbishers manage several hypotheses and, as in scientific trial-and-error practices, they try to isolate causes, one by one, rejecting options and clearing up reasons for damage (if possible). Whilst these practices also entail sensing matter, we believe that here lies another form of vulnerability test, related to setting up informal experiments.

Although in much STS literature the experiment as experimentum or controlled setting is cast off from the world of experientia – or the "sheer liveliness and messiness of quotidian practices" (Tironi 2014, 116), we could consider these informal sites and events as experimental settings of a kind, whereby a particular enactment of vulnerability emerges out. In fact, most of the recent literature on experimental cultures in STS (Knorr-Cetina 1999) signals the very particular, situated and non-standard conditions of experimentation, involving active testing, that take place in many spaces beyond "the lab" (Gross and Krohn 2005), and which could help us reframe experimentation as a methodical learning device about matter using different probes (see Dickel et al. 2014).

In the case of waste-pickers, if computers seem to work after a precarious check – i.e. plugging in – it means that they might sell them, for instance, as a whole to Moroccan traders. If through these tests a useless or dysfunctional device emerges, its matter is requalified: it is dismantled for components or materials. A similar thing happens in Obsoletos and Cyclicka's cases: once they have checked that the computer does not work properly, a diagnosis is needed in order to know which part to change. Except for the motherboard which, "if it is burnt, then everything is burnt and there is no option of mending. That [computer] can already be taken to the scrapheap, to be destroyed", Tilan, the waste-picker/repairer told Blanca. Afterwards, they might be "cannibalized" and broken down into disperse spare functional parts that will be used for reviving other, better machines. But if the processor and motherboard are in a good enough state and have reasonably good capabilities – which can be known by the age of production – then repair might be attempted.

Through these trial and error moments, if successful, computers appear as a "system" composed of a myriad co-functioning components. And in this practical recognition of the computer's openness and modularity resides the possibility of reuse, repair or hack. Then, the computers' states are transformed from pieces of matter into functioning devices, from "black-boxed objects" into "modular systems". Just by daring to open it and start working on experimental hypotheses about the role of components and variables, by isolating them and testing different combinations, the observed participants can manage to reuse their obsolete computers and parts and transform them into a completely different functioning entity. Such informal menders are establishing and

proposing different ontologies for electronics that emerge in the space they open between apparently non-working computers and potential realms of waste. In this sense, they experimentally prove the possibilities of material existence and resistance: a computer is not valued and considered here "for what it is, but for what it "might become" (Gregson et al. 2010, 853). And these electronic components still have a life due to their 'fluid ontology' (cf. de Laet and Mol, 2000), that is, because of the adaptation, reconfiguration and changeability they allow in practice.

Isabelle Stengers's (2010) arguments on the importance of experiments might be of great interest to apply to these situations: experiments enable us to pose new questions, whereby if successful we grant different agencies the power to allow us to say something new about the world. This is what happens in the transformation of e-waste residues into electronic or metal resources, or in turning passive consumers into daring hackers and menders. Indeed, we would suggest referring to the aforementioned empirical stances as informal "atmospheres of indagation," "unfolding", "multiform" and "ambiguous ambiences", "meticulous, open and agonically needed" inquiries (Tironi 2014, 118-119) whereby material vulnerability is enacted through informal experimental settings. In these settings discarded computers are submitted to functioning-tests in which they are re-valued, engaging in the production of relevant knowledge to hack, mend, circulate or extract metal from them.

3.3. Intervening Obsolescence: Vulnerability as a Sociomaterial Order

By collecting, repairing, refurbishing or taking apart e-waste, the observed menders and waste-pickers are not only addressing material vulnerability through sensory gestures or building some knowledge around breakages and wear through trial and error. Alongside the aforementioned vulnerability tests, they also, more importantly, engage in world-making interventions. In putting their hands on these devices and objects they are affecting and displacing what is understood as the core of e-waste, that is, obsolescence. And we believe that in these interventions, a third enactment of vulnerability emerges in the shape of an entire socio-material order. In other words, a particular regime governing socio-material conditions that regulates how electronic vulnerabilities are tackled and distributed – through uneven epistemic repertoires and divisions of labour, legitimacy and responsibilities – is put to the test. Sometimes, such vulnerabilities suddenly emerge from a very quick glance. In other cases, they are disclosed in the shape of the waste-pickers' tools. No matter how big, this socio-material order can be revealed in very mundane gestures:

> "[…] there are many people that see [us] as miserable or think that we are stupid", explains Marcel. And "sometimes it bothers me when you are working and someone looks at you in a way… as if you were scrap", just as the same waste that they collect (Excerpt from Blanca's fieldnotes).

Using the magnet or plugging in the devices to see if they work, in the case of waste-pickers, become indexes of alternative ways of dealing with and constructing knowledge on what would be called "e-waste":

> Most of their tools also come from the streets: "We find them, as scrap. But sometimes we have to buy tools such as pliers, because they are not so easy to find", Marcel explained. They also need to use maths and economy… and physical capabilities, "to break things". Because, "if you find a fridge on the street, who is going to help you? One day [...] I had to take one over my head" (Excerpt from Blanca's fieldnotes).

Nevertheless, such knowledge is not necessarily based on formal education, such as some Obsoletos and Cyclicka's participants have. In the case of waste-pickers, they pass through self-teaching processes just by:

> "[…] being near of people with a higher level than yours […] That's why I've learnt [to repair computers]", Tilan said. He lived with some Eastern European housemates whom he learnt from just by "watching, watching…". Like the case of Marcel, who learnt from his times in Libya, where he used to work as labourer and also "watched" and "paid attention to what the technician did"" (Excerpt from Blanca's fieldnotes).

In this way, such epistemic settings speak of their vulnerability, as illegal migrants, that urges them to take advantage of dumped objects in order to make a living through irregular methods and informal circuits. So, leaving aside the fact that many of them do not necessarily know about electronics, the urgent need for money and the lack of proper tools or space, can also explain why most of their finds are more likely to become spare parts and extracted metals than repaired devices.

But something analogous happens the case of Cycklicka and Obsoletos, where what was a black computer's screen for the original owner became the component of a refurbished computer, or where two useless computers for their respective owners were decomposed and recomposed into a completely refurbished computer for a cultural project plus spare parts. Such interventions and ways of dealing with e-waste speak of their conditions of possibility and the very particular "epistemic culture" (Knorr-Cetina 1999) of these mending projects, more or less closely connected with access to education in science and technical areas.

Despite the differences between the waste-pickers and the menders' approaches, as an effect of both alternative ways of dealing with these materials and technological systems, electronics' obsolescence is

intervened in by displacing its limits, and the "consumerist economy" category of waste[7] is put to the test. Indeed, as one of the waste-pickers once said: "I've never accepted the word "rubbish" because everything has been found in the street and has some value". Only if you submit it to particular vulnerability tests, we could add. Then, while for original owners those old or broken devices had entered the realm of "waste", for these informal and precarious menders a potentially new next shape is attempted through several different troubleshooting efforts. And through these scrapping and repairing practices they are revalued and might be reused as, for example, raw material for industry, in the case of scrap and metals sold by informal trash collectors, or as old refurbished computers.

In the same vein as in Garfinkel's (1967) "breaching experiments," the kind of vulnerability tests that are set up when intervening in obsolescence might reveal underlying orders that we had taken for granted. They reveal the orders ruling how to describe such things as computers, and how to manage them at a certain point as waste. And in doing so, these mending practices put to the test what counts as "vulnerable" and in need of repair, who has the legitimacy to deal with our infrastructural vulnerabilities, or under which conditions this can be done. Such tests reveal to us "who," "in what way," "under which conditions" and "exposed to what risks" is making the fragility and vulnerability of our everyday material infrastructures[8], such as electronics and computing networks, matter. That is, the sort of epistemic agencies and knowledge production that can be fostered in alternative repair practices.

This way, both daring to take something negligible from the streets and recovering discarded old electronics interfere with e-waste ontologies and social legitimations, making space for other possibilities than the contemporary "e-waste regimes"[9] (Callén, unpublished; Gille 2010) that regulate societal relationships with discarded electronics. With "e-waste

[7] Involving end-users' ready-made conceptions of how a computer functions, mostly reduced to higher speed computer processing, bigger capacity, lighter weight and newer aesthetics. These make devices "more vulnerable" – as unknown, closed-up and inaccessible ready-to-use objects that rapidly turn into waste – and very dependent on service economy circuits, mostly limited to guarantees from manufacturers and the expertise of official technical services.

[8] See Sánchez Criado et al. (2015), for an analogous development of design experiments showing the vulnerability of their makers and things through the prototyping of DIY technical aids.

[9] The utility of this concept lies in framing: "waste regime is a macro-level concept but is concerned with the production, circulation, and transformation of waste as a concrete material" (Gille 2010, 1056). For a more detailed description about the Spanish "waste regime", in a transition point between a "metal regime" – where e-waste did not exist as a particular category –, and a promising but limited "e-waste regime" presenting several failures and margins for improvement, see Callén (unpublished).

regimes" we refer to those regimes and orders that rule the transformation between different ontological states of things and their circulation along formal or informal circuits and channels. The current "e-waste regime" that these waste-pickers and menders practices intervene in is also a very particular legal arrangement. Based on a European Directive[10], the actual managerial system of e-waste pivots around the Extended Responsibility Principle, which puts producers in charge of their own products' environmental effects, engaging them in the prevention of contamination due to wrongly or irregularly treated hazardous materials and components. These policies practically foreground "recycling" as the main solution to the problem of e-waste. In this equation citizens only play a role as consumers who have the right and duty to dispose of their electronic appliances using specified circuits of recollection (partially paid for by them through invisible fees on purchase). Once the devices are thrown out, their legal status changes: they are formally considered "waste", in custody by administration, and cannot be put back into circulation, no matter if they are still functioning. The status of this waste can only be changed by the producers, who have the right to make profit from it, as recycled raw matter. The "selection and extraction of waste placed in the public thoroughfare" is in many places considered a "minor infraction" prosecuted and fined[11] but also condemned through scornful, degrading gazes.

Nevertheless, practices of recovering, reusing, repairing or refurbishing obsolete devices resist and test the limits of this current order while pointing to different ones, more connected with circular and "green" economies (McDonough and Braungart 2002; Ellen MacArthur Foundation 2013). Hence, they make perceptible some of the vulnerabilities of our unsustainable patterns and cycles of production and consumption, re-materializing electronics and problematizing the attached utopian imaginaries of innovation and progress (even bringing other more materialistic utopian imaginaries to the fore (Callén, forthcoming). By putting their hands on them, they intervene and subvert the electronics' material-semiotic core: "obsolescence", the quality of being out of date, in disuse or devalued due to a depletion or loss in its original functionality, desirability or value; a key factor in increasing consumption, fostering innovation and, as a consequence, producing waste. Obsolescence might indeed be the most powerful mechanism ruling our economic, industrial and symbolic relations to electronics from the 1930s onwards (Maycroft 2009, 26). A mechanism that defines the

[10] See Official Diary of the European Union (2003).

[11] For instance, the Municipal Ordinances of Barcelona – similar to other city hall measures in the country – play an important role here as another legal layer, charging these illegal extraction activities with a 450,76€ fine (BOPB 2001).

ever-increasing need for new objects by stressing their value of power, speed, novelty, high-performance, lightness or mobility.

However, these practices of mending might indeed bear witness to how the capitalist logics of consumption is not entirely deterministic on our relationships with things and, in fact, can be altered. Proving, in a nutshell, that the current "e-waste regime" cannot be taken as a final step but as a disputed, unfinished and temporary system whose effects, at different levels – human, material, economic or ecological –, should be contested and mended, not without great effort. Through these practices obsolescence is put to a test: hence, the kind of vulnerabilities that appear as relevant are not only related to material properties or to dis/functioning technical systems, but rather to socio-material orders as a whole. That is, to particular policy regulations about how material vulnerabilities are unevenly distributed through power relationships, different epistemic repertoires and divisions of labour, legitimacy and responsibilities.

4. Concluding Remarks. Matters of "Care for Matter" in Mending e-Waste

Summing up, through an empirical ethnographic account of the practices of different informal menders – waste-pickers in Barcelona, and the Obsoletos and Cyclicka workshops in Madrid – we have tried to understand the important role that "vulnerability tests" play in reckoning the different meanings, values and distributions of vulnerability through exploration. Indeed, we have tried to explore three sets of vulnerability tests, namely: (a) sensing matter: manipulative practices of electronic waste whereby vulnerability is enacted as a property of materials; (b) setting up informal experiments: more or less methodical practices of trial and error whereby vulnerability appears as a result of dis/functioning technical systems; (c) intervening in obsolescence whereby sociomaterial orders regulating how electronic waste vulnerabilities are distributed are put to test.

These tests might help us reframe how we approach material vulnerability, not as something to be avoided, dismissed or "repaired", but as something to think more responsibly. That is, not incurring in "one size fits all" obsessive vindications of safety and security (Bijker 2006). In fact, through these tests – or through other variations and innovations on them – we are indeed taught how to "think carefully" about material vulnerability (Puig de la Bellacasa 2012, 204): that is, being attentive to how vulnerable matters are performed (Denis and Pontille 2014b). As we see it, carefully thinking about vulnerability could very well point to a more careful way of empirically and materially intervening in knowledge production in STS (Munk and Abrahamsson 2012; Ratto et al. 2014).

Indeed, we would like to suggest an engagement in the production of what might be called matters of "care for matter".

Care, in the broad sense given to it by Joan Tronto as "[…] everything that we do to maintain, continue and repair "our world" so that we can live in it as well as possible" (Tronto 1993, 103), involves not only "care-giving" or "care-receiving" activities, but also forms of "taking care of" and "caring about". Very much along the same lines, "thinking with care" for Maria Puig de la Bellacasa implies developing "matters of care", that is accounts that count in: "[…] participants and issues who have not managed or are not likely to succeed in articulating their concerns, or whose modes of articulation indicate a politics that is "imperceptible" within prevalent ways of understanding" (Puig de la Bellacasa 2011, 95).

In our case, we have considered that the main result of the different vulnerability tests performed by informal menders make perceptible to us not only some of the vulnerable effects but also the ecologies of practices (see Stengers 2010) necessary to take care of vulnerable things, such as electronic objects that have been thrown away. And in doing so, they show us how to think carefully is closely related to how we might care about such things, beyond e-waste. In dialogue with STS and repair and maintenance literature (Jackson 2014; Rosner et al. 2013), these variegated tests to "care for matter" show not only how the object of mending might go beyond "materials" but could also include socio-material orders.

Echoing feminist care ethics reflections (Tronto 1993), we could say that the mending interventions of waste-pickers and the Obsoletos and Cyclicka workshops also test how "care of things" regimes bring to life and sustain particular sociomaterial orders (Denis and Pontille 2014a), helping to politicize the regime of obsolescence's way of impeding that abject and discarded matters might be intervened in to change their status beyond "waste", together with its "differential distribution of vulnerability" (Butler 2004) and its North-South divides. Indeed, these mending practices bring about a different nuance to maintenance and repair going beyond the conservation of given socio-material orders – repeatedly reinstalled through sensory and attentive negotiations or attunement with people and materials, such as in much infrastructural repair work (Denis and Pontille, 2014a; Henke, 1999; Orr, 1996) –. In deploying their particular vulnerability tests menders intervene and engage in active alterations, or even subversions, of the vulnerable social-material orders of electronic waste, showing us powerful ways to care about material vulnerability, and alternative forms of engaging in its maintenance and repair.

Acknowledgements

Our special thanks go to Jonnet Middleton, Daniel López, David Pontille and Jérôme Denis, Aviv Kruglanski and Vahida Ramujkic for the stimulating discussions about repair and maintenance practices. Special thanks to the people who have helped us and passionately showed, through the fieldwork, how to repair our everyday infrastructure with care and pride: En torno a la silla, Obsoletos, Cyclicka and the waste-pickers in Barcelona. We want to give special thanks too to Becks Smith for her generous and sharp English proofreading. This work has been possible thanks to the economic aid from the Spanish Sub-Program for Postdoctoral Mobility in Foreign Centers (2011) to attend Lancaster University, in the case of Blanca, and the Alliance 4 Universities Postdoctoral Fellowship at Universitat Autònoma de Barcelona, in the case of Tomás.

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