Discussion

Empowering Sustainable Consumption by Giving Back to Consumers the 'Right to Repair'

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Abstract: Industry has been considered a major actor regarding the actions and changes needed to achieve sustainable development. Different approximations to the topic have been developed to face the challenges of having a more responsible production of goods and services. These approximations include cleaner production, green design, ecodesign, eco efficiency, design for sustainable behavior, sustainable design, and more recently concepts like circular economies among many more. In all these approaches, the attention has been mainly on the production side while consumption has been tackled indirectly. The majority of laws and ordinances that have motivated the emergence of these approaches have traditionally been oriented to producers. However, an European Union (EU) directive launched in October 2019, called "right to repair", could change this paradigm, empowering consumers by giving them more possibilities of repairing their products instead of discarding them. This paper presents a preliminary discussion about the effects this directive might have on how we consume products now and how we will consume them in the future.

Keywords: sustainable consumption; design; circular economy; right to repair

1. Introduction

Sustainable development is making an urgent call to all actors in society to contribute to changing the way in which we satisfy our needs. This change implies a transformation of our production and consumption systems. The linear idea of 'take-make-dispose' is no longer an option [1]. In the last 40 years, and to meet the demands for a better system, industry has developed different approaches to design, fabricate, and sell more sustainable products and services. Some of these approaches include eco efficiency, ecodesign, sustainable product-service systems [2], design for sustainability [3], and more recently, circular economy [1].

In the circular economy model, industries are asked to develop business models that ensure products can have a longer lifespan through technical and biological cascades [1], reducing the need for new resources to make new products; giving the right value to the resources initially used in the making of the products. From a technical point of view, it means that products should be reused, repaired, remanufactured many times, and finally, recycled before final disposal in a landfill is considered. A very important concept for those technical cascades or closed cycles is repairability. The capacity of a product to be repaired to continue its life with the same user or, in some cases, with a new one, depends on multiple variables. These variables are linked to how the product is designed, how the business models behind the product operate, and they also depend on the consumer behavior and practices [4].

Despite the importance repairability has in the attempt to transform our linear production and consumption operations in circular systems [1,4], there are factors that inhibit the capacity to repair a product and keep it going in closed cycles. These factors inhibit the direct repairs users could

do themselves, or the ones third parties could do. Among those factors, we identified five major constraints: 1) lack of knowledge on how products work; 2) lack of spare parts, technical information, and restricted contracts; 3) lack of economic incentives to repair a product; 4) lack of engagement, emotional and economic attachment to products; and 5) lack of design and manufacturing features promoting repairability. Something that can come to help users and give them back the right to repair their products is a new European Union (EU) directive called "right to repair". This was launched in October 2019 and despite the formal documents not being released yet, the initial information about the mechanisms that will be put in place in the EU to strengthen the repairability of products in certain categories, thus encouraging the development of circular economies [4] is very promising.

The new EU directive can reduce and eliminate the factors constraining the repair of products and could also change the dynamics in the relationships between producers, users, and products. In this article, we propose a conceptual discussion on the effects this new directive can have on the capacity to repair products pursuing a transformation towards circular and sustainable production and consumption systems. We also propose further lines of research that we believe are underexplored, particularly about the impact directives like "right to repair" can have on empowering sustainable consumption from a consumer point of view and not only as a production mechanism.

We decided to write a paper about the conditions in which the new EU directive will enter into force in the coming months, because we believe there is space for an interesting discussion about repairability and its contribution to circular economy. As the formal documents of this new directive have not been released yet, this paper aims to discuss the expected conditions under which the directive will enter into force and it will suggest some lines of action we believe the directive should follow to address the current barriers to repairing. In this context, the paper aims to answer the following questions:

1. What are the most relevant barriers consumers face today when they want to repair their products?
2. How can repairability make a substantial contribution to sustainable consumption and the emergence of circular economies?
3. What are the main actors and elements interacting in the repairability ecosystem?

Finally, the paper is structured as follows: In Section 2, we talk about the necessity to make a transformation from linear production and consumption systems to circular economies. This transformation is supported by the idea that extracting all the value of products in continuous cycles through technical and biological actions is one way to reduce waste, use less raw materials, and achieve sustainable standards. In Section 3, we discuss the concept of repairability from a consumer point of view. In Section 4, we explain briefly the EU regulatory framework that has implications on durability and repairability of products. In this section, we also introduce the new directive "right to repair", as part of that EU regulatory framework, and we present few headlines coming from the information already published about this directive. Finally, in Section 5, there is a discussion about the expected areas of action this new directive on "right to repair" should follow, and considerations we believe it should take into account.

2. Transformation towards Circular Economy

During the last decades, different approaches have been created to pursue sustainable development. Many of the approaches taken by industry have focused on how products are designed, manufactured, used, and then disposed. This has made significant changes in our production systems. Those approaches include ecodesign [5], eco efficiency, design for recycling, design for disassembly [3], design for sustainable behavior [6], sustainable product-service systems [2,7], and design for sustainability [3]. The advances in this search for a more sustainable way of satisfying our needs have been motivated by different sources like new regulations and directives, supply concerns and limitations, costs and convenience, and social and market pressure, among others.

In terms of regulations and directives, the European Union (EU) has marked a point of reference, developing a series of ordinances that define how products for certain categories should be designed, made, used, and disposed in order to be commercialized in the EU [8]. In particular, they have tackled energy-related products at different levels. These directives include the End of Life Vehicle Directive, the Waste Electrical and Electronic Equipment (WEEE) directive, the Restriction of Hazardous Substances (RoHS), the Batteries Directive [3], and the Ecodesign Directive [9]. These directives have pushed producers to change the way they exploit raw materials, how they design and manufacture their products, but also to take responsibility for their products after their use. It is why those directives are recognized as part of an extended producer responsibility perspective [10].

Despite these directives being oriented primarily to producers, they have also produced indirect effects over consumption. Mostly, they have provided consumers with more options in the market to satisfy some of their needs, and also with better ways to disregard products after their use. For example, in the case of white goods, refrigerators, and washing machines, it is more common for buyers to choose them according to their level of energy use. Other options have come in the form of new services and systems instead of physical products [7]. In terms of disposal scenarios, now it is possible to find recycling facilities in most cities around the world. Facilities could even be specialized by type of waste like electronics, plastics, glass, and metals. Many of those recycling plants have been created because of the quotes directives and laws have put over producers in terms of percentage of products and materials that they should recover at the end of their products' life cycle.

In spite of the important and significant savings and efficiencies achieved by the mentioned approaches and directives, it is recognized that more profound and long lasting transformations are needed [11]. This is partially why, in the last decade, a new approach called circular economy emerged. This approach collected experiences and concepts from the last forty years of research and practice in the area and presented them in a holistic view of the challenges we have to face to be a sustainable society [1,12]. Some of the most important ideas behind a circular economy are the elimination of the concept of waste and the need to procure closed cycles of products and services through technical and biological cascades [1,8]. Technical cascades refer to: cycles of reuse, reconditioning, repair, remanufacture, and recycle. It means that, at the end of the product's life cycle, products keep going in cycles in the system through different technical strategies, postponing the final disposal of the product in a landfill or in another way. Among those strategies, the lesser investment of resources, time, and energy in the product to have it back in the system, the better. Thus, repair is situated among the most desirable strategies and recycling should be the last option [4].

The more time the product circulates in the system without changes or with just small repairs, the most value is extracted from the materials and energy invested initially to make the product. Despite the importance of repair as a means to support the development of circular economies, it is not necessarily a default condition in every product. For different reasons, products once failed are not repaired even if the required repairs are small, and in many cases, those products end up as waste, losing their value after just one use. If the route that we should follow, as it is suggested in the circular economy, is the one that favors closed cycles, product repair is fundamental. Users should have the capacity and also the motivation to repair their products before considering a replacement [4].

3. Repairability from a Consumer Point of View

Repair is a constitutive part of humans' life on Earth, however there are many ways to conceive and to manage how repair is actually performed. As Jackson [13] stated: "the world is always breaking; it's in its nature to break [...] And it is always being recuperated and reconstituted through repair. The question then becomes what we make of these facts, and what we do next" (p. 223).

More often than not, repair soon becomes improvement, growth, and innovation [14]. Maintenance and repair are ongoing processes that can be designed in many different ways in order to produce many different outcomes with different levels of efficacy [14]. Thus, there are politics of repair and maintenance that must be attended to [14]. Nonetheless, to this date, the literature has not provided a

systematic and organized ordered framework with the fundamental conceptual distinctions and key relationships involved in repair as a social activity.

Repair is not a set of unified actions. Repair, in opposition to maintenance, is defined by the event of malfunction [4]. Because of this, maintenance is anticipatory in nature, while repair is reactive. Terzioglu et al. [15] propose the following types of repair (p. 235).

1. **Assembly repair:** This repair type does not require any skill or knowledge. A good example here would be putting product parts together, gluing, or binding them.
2. **Medium level repair:** This repair type consists of activities which require some level of skill and knowledge like glue knowledge, material knowledge.
3. **Advanced level repair:** This repair type includes activities that require advanced skills and knowledge, such as changing the screen of a laptop.

For Ackerman [4], in contrast to the waste hierarchy, all types of repair and maintenance can be classified under the term "product care". Product care is defined as any behavior that prolongs the lifespan of a product, and it includes (as stated) repair, maintenance, but also preventive behaviors, such as using a smartphone case [4]. Ackerman [4] states that caring is a fundamental step towards achieving circular economies. Repair, in particular, is an environmentally friendly option in relation to other recovery activities (remanufacturing, refurbishing, and recycling), because it avoids going through a complex reverse logistic process and take-back systems to return product to remanufacturing facilities [16]. The ability to repair supposes a shift of duty of value recovery of products to end users and repair shops which creates a significant cost reduction in the supply chain [16].

3.1. Repairing, an Opportunity for Industry

Despite its environmental benefits, there has not been a particular interest in promoting repair from an industrial design point of view. Quite on the contrary, there have been incentives to avoid repair through technical barriers and even through design. First generation American industrial designers such as Norman Bel Geddes, Henry Dreyfuss, Walter Dorwin Teague, and Raymond Loewy usually justified their design decisions in terms of creating a better world through the creation of "user friendly" designs. However, as Whiteley [17] documented from their interviews, presentations, and writings, it was ultimately about sales. By giving a product a friendly and fashionable design, the "designer was virtually guaranteeing it would look old fashioned in two- or three-years' time, and so was building-in style obsolescence" [17] (p. 3). To this day, many products are deliberately designed to foreclose the possibilities of maintenance and repair [14]. This phenomenon is widely known as planned obsolescence [18].

Nowadays, artifacts "lack any kind of transparency so that their functioning cannot be restored if they break down" [14]. There is also a perception that manufacturers must sacrifice product repairability in order to compete at high technological levels. Furthermore, the economic cost of repair is also discouraging consumers from trying it. Previous research estimates that consumers are willing to spend, on average, 20% of the replacement cost on repair of a product [19–21]. However, repair is also a market opportunity for manufacturers to increase consumers' loyalty and to also create a new market for repair services [22].

3.2. Design for Repair

Environmentally friendly interests of consumers have placed new demands on industry. New trends are evidenced in initiatives like Fridays for Future movement or B corporations that are appealing to a new consumer profile. As a new market opportunity or as an environmental duty, repair as an integral part of product usage places new constraints on product design. Design for repair as a concept is, nonetheless, an understudied subject [16]. Design for repair "simply refers to a set of design efforts to facilitate fixing devices by end users and repair shops during the initial product's life cycle" [16] (p. 1). Huang et al. [16] discuss design features that may increase repair behaviors. These

include openability, accessibility, standardization, publication of repair guidelines by manufactures, and modularity. Sabbaghi et al. [23] found with 8.403 online survey participants that repair manuals, useful repair information and knowledge about the repair process also have a positive impact on future repurchase and purchase recommendation of a repairable product.

3.3. Factors Inhibiting Repairability

Despite the importance of the concept of repairability to achieve closed cycles and circular production and consumption systems [1,4], there are factors that have inhibited the capacity to repair products in the last decades [15,24]. These factors have prevented users from engaging in habits of repairing. This is especially the case for electric and electronic products which end, in their majority, in a landfill. The factors for this are diverse. Some that we have identified are, as follows: the result of the way business models have evolved, indirect effects of regulations, and factors attached to behavioral trends.

Other authors have explored the barriers and motivation to repair from a consumer point of view related to different types of products [15,16,24–26]. From a methodological point of view, for this article, we categorized the barriers that discourage consumers from product repair by reviewing academic articles from different fields of study. These fields involve design, consumer, production, and sustainability studies. We considered peer-reviewed articles published in the last 10 years that explicitly address barriers to consumers to repair their products. We guided our search using keywords such as: product repair, repair, circular economy, circular design, sustainable product design, sustainable behavior, and ecodesign (see Figure 1). As the genre of the present article is discussion-driven, we will also comment and discuss some of the historical and contextual underpinnings of each of the barriers identified. In the following sections, we present a brief understanding of each of these factors.
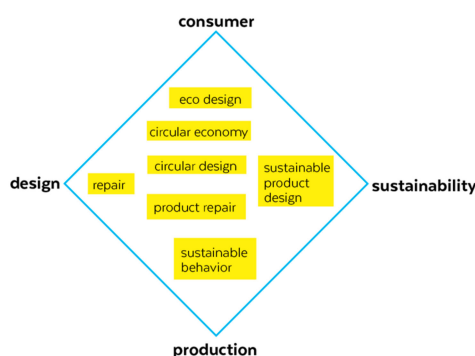

Figure 1. Themes reviewed in this article.

3.3.1. Lack of Knowledge on How Products Work

Over the years, and in line with the explosion of electronics and new technologies in the market, the layman knowledge on how products work has decreased substantially. Many mechanical products have been replaced by their electronic equivalents, or by new products performing functions that are not any more evident for the users. There are multiple examples about this transformation. A remarkable one took place in the music industry less than forty years ago. During the 1970s and 1980s, one of the most used devices to record and listen to music was the cassette tape. An analog device used to record music tracks to then be reproduced at home or in the car. With the introduction of the compact disk (CD) at the beginning of the 1980s, the music industry was transformed and rapidly a new dominant design was established. With the cassette tape, users were able to repair broken tapes, rewind them manually, detangle tangled tapes, and even make mixed tapes on their own. With the introduction of CDs, this knowledge disappeared and few people actually know how a CD works. Lack of knowledge can be a strong barrier against repairability [15].

The replacement of technology in some sectors also came with a desire to focus the design process on the users and their interactions with products. A trend of designing more user friendly interfaces resulted in making the experience of final users much easier than in previous times. This user-centered design brings many positive consequences, but it also brings indirect effects. Products started to be encapsulated in minimalist 'boxes' with just the minimum of buttons needed to operate the products, leaving behind the curtain all the mechanisms and parts that were actually making the products work. Technological products became, in many cases, black boxes where things happen unnoticed by the users and this phenomenon contributes in large measure to the decrease in knowledge about how products work. Smart phones, computers, cars, watches, even TVs became products with very friendly interfaces, but with almost every possibility of intervention blocked by lack of deeper knowledge among average users or even by third parties other than the producers.

3.3.2. Lack of Spare Parts, Technical Information, and Restricted Contracts

In many industries, including electronics, computers, and white goods, producers are not necessarily obliged to provide spare parts or technical information for their products beyond warranties. That means that users only have the chance to repair their products for short periods of time and only through the service provided by the producers in order to keep up with the product warranties.

Even in well-intentioned offers like product-service systems [27], that have the potential to be sustainable [28,29] and that in some cases work under the requirements of a circular economy, there is no need to provide the parts and information to repair a product. Even more, repair is frequently part of the business model [30] and there is no real incentive for producers to provide parts and information for someone else to perform the repairs that for them could represent income. In this scenario, there is a capacity to repair products but only to the level established by the producers and restricted to their defined repairs.

On the other hand, the Internet and open source technologies have enabled a lot of users desiring to repair their products themselves. Their contribution has come in diverse ways. On the one hand, they provide a platform to share technical information and instructions for repairing a diversity of artifacts, in addition to providing a wide market to find spare parts and tools needed. In the case those parts are not available, they can even be printed with open source plans and models. These repairs related to the DIY (Do it Yourself) movement can work for the tech savvy individuals, but are not a generalizable solution. The scale is limited by factors like guaranties, costs, and rapid cycles of development of the technology. Additionally, the environmental value of emergent technologies such as digital manufacturing is still up for debate, considering that, for example, 3D printers are not necessarily less wasteful and their waste is not necessarily more recyclable [31].

3.3.3. Lack of Economic Incentives to Repair a Product

A major obstacle to repairing a product is inherited from economical models in which it is, in many cases, cheaper to buy a new product than to repair a failing one. Even in scenarios with spare parts and information available, replacing products can be economically more attractive than buying the spare parts and finding someone with the knowledge to perform the repairs. This has been happening especially in the electronic and computing industry due to the fast cycles of development and innovation. Products are upgraded in a few months by development and manufacturing companies. New versions with better technological features are launched cheaper than what the cost to make the upgrade for older models would be.

In this context, business models still favor linear production and consumption systems that profit from making and selling the larger number of products. There are no clear incentives for producers to facilitate the repair of products when their objective is to sell more new units. Also, for the users there are no clear incentives to repair a product when they can buy a new one with a renovated look for a lesser cost. Even for users interested in repairing their products for environmental and social reasons, there is an economic punishment in the form of waiting times, costs, and tasks required to get their

products repaired. Motivation is a fundamental issue in the case that products have to be repaired [4], and that motivation can come from economic, social, or environmental incentives.

3.3.4. Lack of Emotional and Economic Attachment to Products

One particular feature playing an important role in repairing activities is the level of attachment users have with their products [32]. This attachment can be emotional or economic. The emotional attachment occurs when users develop deep feelings for their products [33] due to reasons such as the moment when they got the products, how these products arrived into their lives, or because those products remind them of someone important, among many more. In the economic attachment, what mainly happens is that users can experience a high level of attachment and care for products that they consider expensive and in consequence valuable. In both cases, a sense of care emerges, and it is manifested in the way people use their products and also in the time that they are willing to have the products with them and in many cases, especially with the emotional attachment, their desire to pass those products to the next generation. This can be seen in diverse categories like furniture, clothes, cars, radios, and tableware, to mention just a few.

The emotional and economic attachment people develop with their products and the sense of care can be important motivations to repair them and extend their life cycle. Design plays a major role in this aspect. Aesthetical features of a product can inspire the feelings needed for people to be willing to repair and keep a product or to throw it away. Products with strong temporal identities can become obsolete very quickly not because of the failure of their functional side but because of the design and the emotions they produce in people. Something similar can happen with the design of functional parts. In circular economies, good products should last in time and be able to be repaired many times before they have to be recycled, with just few exceptions (e.g., when old technologies´ energy consumption is too high in relation to the energy consumption of newer technologies, making replacement more efficient than repair—as was the case with old refrigerator models). Design for durability is then a feature that also influences the relationships people establish with their products. Cases in which products do not generate strong links with people favor quick replacement and short life expectancy.

3.3.5. Lack of Design and Manufacturing Features Allowing Repairs

A major obstacle to repairing a product is linked to design and manufacturing features. Products have to be designed while keeping in mind their repair process, otherwise products will end up in landfills [4,34]. In consequence, design and manufacture should favor processes like disassembly, cleaning, replacement of parts, and upgrades [3,24]. Due to bad design and manufacturing processes overly focused on costs, many times the resulting products are the opposite of a product intended to be repaired. This is manifested in glued attachments, parts that cannot be removed, cases that break when opened, and products that require special tooling, among many other characteristics in a product which make it non-repairable. Decisions made in the design process have strong influence on the impact products have on the environment and society [8]. If the design is not planned from the beginning with the environmental and social effects of the product in mind, repairability usually ends out of consideration. Among these design decisions is also the selection of materials, a fundamental part in the resulting impacts a product will produce over the environment and society [8].

There is a tradition in design and manufacturing that has developed protocols and guides to help manufacturers to design for disassembly, design for remanufacturing, and design for recycling [3,24], that well support the idea of products made to be repaired. However, the existence of these guides does not mean they are being applied. Moreover, sometimes the features developed in the design process to make a product easy to repair are overruled by decisions made in the production process. These two areas have to be aligned and coordinated to achieve products that will consider, in their life cycles, repair as one of the possible scenarios to extend their life span and keep the product in a circular system.

4. 'Right to Repair' a Push Forward Sustainable Consumption

A recent EU directive called 'right to repair' has, in our opinion, the capacity to give back to the users the right to decide what to do with their products when they fail and before they have to dispose of them. Even if it is a directive oriented to producers, we believe it will empower consumers to behave in a more sustainable way, directly and indirectly.

"Right to repair" is not the first and unique directive related to topics like durability and product lifespan. Actually, there have been different initiatives already put in force in the United States (US) and in the European Union (EU) during the last decades [35]. Most of those initiatives have been pushed by consumers associations and the "right to repair movement" dealing with issues like short lifespan, especially of electric and electronic products, and difficulties to repair products directly or by third parties different to the original manufacturer [35].

In the case of the EU regulatory framework, it has different policies and directives that have a direct or indirect relationship with concepts linked to durability and promotion of extended product lifespan. Those directives are grouped by large priority themes including climate, energy, circular economy, pollution, and consumer protection [36]. These policies include the Sustainable Industry Low Carbon Programs, the Energy Efficiency Directive, the EU Energy Labelling Directive, the Zero Waste Program, the EU Action Plan for the Circular Economy, the Air Quality Directive, the EU Consumer Rights Directive, and the Product Safety Law, among many more [36]. In this regulatory framework, there are also horizontal policies that deal with topics that are related to durability and product lifespan, working from perspectives that involve more than one priority theme. Among these horizontal policies, we have, for example, the Ecodesign Directive 19/125, the EU Ecolabel, the Eco-innovation Action Plan, the Integrated Product Policy (IPP), and the Product Environmental Footprint (PEF) [36].

Despite all these policies and directives, according to [36], "the concept of longer product lifetimes is currently not explicitly present in policy and regulations in the EU". Moreover, they recognize there can be some contradictions between the support of fast pace innovation and actions promoting the extension of products' lifespan. In this context "right to repair" in the EU comes as an addition to the current EU Ecodesign Directive. This upgrade of the Ecodesign Directive will rule explicitly on energy efficiency, durability, and repairability of ten categories of products, some of them already covered by the original Ecodesign Directive [37]. Both in the US and in the EU, large manufacturers have made explicit declarations against directives and policies on right to repair arguing issues related to customers safety, cyber security, and intellectual property. Those arguments have stopped legislation processes and, in the US, despite that some states have adopted measures to support the right to repair, other federal laws have limited their implementation [35].

´Right to Repair´

The EU directive "right to repair" is already approved but the official documents have not been released yet. However, with the information provided by the press release, we think interesting points of discussion have been raised.

The release says: "In a continued effort to reduce Europe's carbon footprint and to make energy bills cheaper for European consumers, the Commission today adopted new ecodesign measures for products such as refrigerators, washing machines, dishwashers, and televisions. Improving the ecodesign of products contributes to implementing the 'Energy efficiency first' principle of the EU's Energy Union priority. For the first time the measures include requirements for repairability and recyclability, contributing to circular economy objectives by improving the life span, maintenance, re-use, upgrade, recyclability, and waste handling of appliances" [38].

The first interesting idea in the press release is the articulation this new directive has with a broader regulatory framework in the EU that has legislated about the design, manufacture, use, and disposal of products during the last decades. The articulation of this new directive with other laws and regulations ensures it will complement the current situation instead of generating conflict with measures already in place. The new directive called "right to repair" will work with specific product categories considering

the white goods most used at home, and the products that use an important amount of energy in households. A second interesting point is about the novelty of the directive legislating for the first time about repairability. Despite the importance of repairability for the development of circular economies and through them achievement of sustainable development, little has been done to motivate repair and to influence producers and consumers in this area. The objectives in the new directive are clear: products should have longer life span, and they should be suitable to be repaired, upgraded, reused, and recycled. It is remarkable the directive mentions explicitly the contribution these new measures will have on the development of circular economies. It validates the relevance and importance of the concept and shows the interest of the EU to move towards that type of circular production and consumption systems seeking a sustainable way of living.

In terms of incentives, the new directive promises to generate important savings for households. Moreover, even if it is not explicit in the press release, the new directive, in our opinion, can also create interesting new streams of income for producers. About these savings, the European Commission Vice-President for Jobs says: "Whether it is by fostering repairability or improving water consumption, intelligent ecodesign makes us use our resources more efficiently, bringing clear economic and environmental benefits. Figures speak for themselves: these measures can save European households on average €150 per year and contribute to energy savings equal to annual energy consumption of Denmark by 2030. It is with concrete steps such as these that Europe as a whole is embracing the circular economy to the benefit of citizens, our environment and European businesses" [38]. Other studies indicate that extending the lifetime of the toaster in the EU by 10% could save around 4000 tons of C02 and prevent 60 tons of waste per annum [36]. An extension of 10% in the T-shirt EU market would, in turn, reduce about 100,000 tones of CO2 [36]. Repair and maintenance activities are crucial to achieve this goal [36].

Something also remarkable in the press release is the recognition that there is currently a wrong practice of replacement of products caused partially by products that fail too early. About this condition that is linked with how products are designed and manufactured, the Director General of BEUC, the European Consumer Association, said: "The new repair requirements will help improve the lifetime of everyday appliances that currently fail too quickly. It is crucial we bin the current 'throwaway' trend, which depletes natural resources and empties consumers' pockets", [38]. This is one of the most relevant barriers nowadays for the product repair. As we mentioned in Section 3.3.5, products have to be designed and manufactured to be repaired if repair is truly considered as an option. Wrong practice of design for programmed obsolescence has to disappear if we want to achieve real long-lasting sustainable development. About this, we believe there should be clear incentives for producers to provide the spare parts, the tooling, and also the knowledge to allow users to repair their products, but there should also be a clear legal framework to verify the compliance with the laws, as it is mentioned in the press release: "The new, ambitious, ecodesign requirements on improving resource efficiency are a tool to ensure that all actors play by the same rules and advance the Circular Culture concept. Provided that market surveillance authorities could have enough resources and coordination to face new difficulties in verifying the compliance with the law" [38].

At the end there are many questions we cannot answer yet. We need to wait until the official documents are released to know the exact actions that will be put in force. We have to wait to see if the new directive can create the right conditions to convert the product repair into a real first choice for consumers. In any case, we believe it is very positive that the new directive has turned attention towards a concept that has great potential to support the development of circular economies, and that has been neglected in the past. In terms of the areas that this directive should tackle, we think at least it should remove the barriers mentioned in Section 3, paying special attention to the actions that will give the users the capacity to make the repairs themselves or to approach third parties to do it excluding the original producers. The market of repair has been hit by monopoly practices during a long time and the directive should look to provide a positive and transparent repairability environment.

Finally, something remarkable about the research we did to talk about this new directive was to realize that repairability is a complex concept, and the "right to repair" understood, as all the possible options users should have to repair their products and the conditions needed to make it happen, is a multivariable area of research and practice. Based on the available information from the 'right to repair' communication and the 'European Green Deal', we can infer the most likely approach this directive will take on consumer policy. As the European Commission [39] communicates: "The circular economy action plan will also include measures to encourage businesses **to offer**, and **to allow** consumers to choose reusable, durable and repairable products. It will analyze the need for a 'right to repair', and curb the built-in obsolescence of devices, in particular for electronics" (p. 8, emphasis added). The wording here is relevant as it implies that one of the main orientations will be to make repair possible for consumers through availability and technical re-design.

Additionally, reliable and objective information will also seem to play a crucial role in the new consumer directive: "For instance, an electronic product passport could provide information on a product's origin, composition, repair and dismantling possibilities, and end of life handling" [39] (p. 8). Information is crucial in changing people's behaviors, but current policy theory has stretched systematically its insufficiency as a driver for public engagement [40,41].

As we have discussed, in Section 3 of this paper, motivation and human cognition are as crucial as pure information to promote sustainable behavior. In other words, without comprehension and motivation, information does not necessarily produce change. Furthermore, if the policy directive aims to "empower consumers to make informed choices and play an active role in the ecological transition" [39] (p. 8), it will most likely involve a high level of concerted actions among different people and institutions [41] and strong practice communities [42], sharing knowledge and involving people at the grassroot levels. This has been the case with the 'right to repair' social communities that made this directive possible. Empowerment, we believe, will be based on fostering more community action and autonomy. Finally, at the highest level of policy, social learning [41,43] through public engagement is produced when i) change has taken place in the individuals involved, ii) this change goes beyond the individuals and into wider social units or communities of practice, and iii) as a result of socio-technical reframing of our current institutions and cultural habits.

Given the current information available, it seems that the directive will most likely involve the first two lower levels of consumer-driven action (see Figure 2). However, other levels of policy could come into play, especially if communities of citizens, researchers, and policy-makers lobby for more systemic and complex actions. In the discussion, we will talk about the possible implications of this new directive and some potential recommendations to engage in more integrated and systemic policy actions.
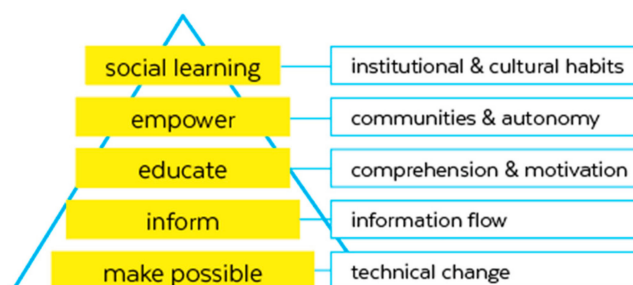

Figure 2. Possible policy approaches to repair behavior.

5. Discussion: Guidelines for a More Comprehensive "Right to Repair"

Repair, as we have presented it, is a multidimensional and multi-agency activity. In the emergent literature we revised, we can observe different conceptual distinctions that authors have proposed to achieve a more nuanced notion of repair. All of these conceptual distinctions should be integrated into

general frameworks in order to unify efforts and build over previous work. Scott and Weaver [25] proposed a three factors (or actors) model to understand repair propensity, aligning different hypotheses from the available literature. Lefebvre et al. [26] expanded the model and disaggregated consumer factors into "consumer traits" and "consumer capital". In both models, we find three significant actors: (1) Consumers, (2) Markets and/or producers, and (3) Product design and characteristics. We argue that these models need to include more of the fundamental distinctions present in the literature. For instance, there are many levels of repair and, repair may be performed by the user or by an external entity. We propose complementary dimensions of repair to account for repair as a complex activity.

We agree that repair, as an activity, must be understood in relation to three major actors: Consumers/Users; Product/Design; Manufacturer/Market and four dimensions (Repair level; Repair agent; Repair outcomes; Repair barriers). At the most basic level, for repair to occur, two distinct things must happen: the manufacturer must make a repairable product and the user must decide to repair it. Nonetheless, as we have discussed in the previous sections, repair is more complex than that. The proclivity to repair is increased as the manufacturer provides more repair opportunities and the design of the product promotes the desire to repair. The evidence also shows that users that have repaired a product will also change their perception towards the product and the company. In that sense, repair is a complex and relational concept.

Our revision, as displayed in Figure 3, seeks to help readers navigate this complexity. Repair level refers to the magnitude and type of repair ranging from maintenance (which includes preventive measures) to advance level repair that may be hard for most users to perform by themselves. Repair agent is who is actually repairing the device, it may be the user or an external entity or some form of combination between the two. Repair outcomes refer to the end-results of the repair activity in the short and long term. They may be financial (such as user saving money or manufacturer charging for the repair service), environmental (waste reduction, energy reduction, etc.), emotional/cognitive (such as increased product attachment or changed perceptions on repair), and product outcomes (product modifications, innovations, or other changes to the product itself).

Repair Level	
	Maintenance
	Assembly
	Medium
	Advanced
Repair Agent	User
	Commercial
Repair Outcomes	Financial
	Environmental
	Emotional/ Cognitive
	Product
Repair Barriers	Lack of knowledge
	Lack of parts, information and open contracts
	Lack of economic incentives
	Lack of emotional attachment
	Lack of design for repair

Figure 3. Proposed dimensions of repair.

Repairability is a multidimensional concept as we just explained; it means that any directive or law promoting repairability should have a wide vision of the concept considering all the actors and dimensions involved. As a consequence, we hope that the new directive "right to repair" includes different configurations on how a repair actually happens, contemplating, for example, repairs done by users at an assembly level, but also repairs performed by third parties at an advanced level. Directives should regulate and legislate over all the possible links between actors and levels of repair, considering all the possible barriers that can hinder the process, and all the variety of potential outcomes.

Another very important aspect to keep in mind is the influence design can have on the chances a product has to be repaired and be part of circular systems. Responsible design should not promote or support practices like design for obsolescence. On the contrary, design should advocate for products that display features that facilitate the repair. From the design stage, decisions made about the product design should favor elements such as modularity, disassembly, and repairability. Furthermore, the design of the products should include features to provide information about the state of the product such as when maintenance is required or when a part should be replaced. This is very important considering the benefits of timely maintenance and repair but also concerning the psychological and motivational dimension of the repair decision. Also, design should consider how the product itself or something supporting the product can generate the technical information to perform a repair, like cars, indicating when a system is failing and an action is required from the user or from the producer.

The conditions we believe are required to have the right environment for repairability to become the most used way to keep products in circular systems of production and consumption should include, in one way or another, what we mention in the next points. Those points should be the result of the influence directives and laws can produce on the market and most specifically on producers and users:

1. Producers should support repair done by the users, providing a market of spare parts, technical information, and avoiding obstacles like specialized tooling required to perform the repair.
2. Producers should allow third parties to perform repairs of their products for the benefit of the users and also as a business strategy to build networks that facilitate the development of circular systems of production and consumption. This will, in turn, open up new challenges to redesign legal responsibilities and economic obligations (e.g. warranties) around repaired products.
3. Businesses should consider repairability as a desired condition of their products. Instead of perceiving repairability as a potential risk for their economic survival, they should design business models where repairability constitutes a new stream of income and an attractive way to approach and get to know their users and their own products better. This change will likely be motivated by new political directives and increased awareness of consumers. It must be noted that an increase of repair services could have significant effects on the economy overall. It is estimated that an increase of 1% of this sector would increase the EU Gross Domestic Product (GDP) by 7.9 billion EUR through direct and indirect impacts [36].
4. New directives about repairability as a viable alternative to extend the lifespan of products and keep them rotating in circular systems should influence curriculums and academic programs. This influence should be manifested by designers and engineers being better prepared to make products that will be repaired, make products that people want to take care of and are motivated to repair for emotional and economic reasons, and to understand repairability as part of a larger system (circular economy).
5. Laws and directives should provide physical and digital infrastructure to promote repairs. It means spaces to perform repairs, to share knowledge and experiences, to hold tools and develop strong community relationships around repair. Some of these initiatives already exists, like repair cafes, and websites like ifixit. These have proven to be attractive initiatives for tech savvies and also for novice users. They have to prove that repair communities are not a niche issue, as we argue that all people benefit from a better repair space. A recent EU report showed that 64% of over 12,000 EU nationals who participated in a survey repair broken products and 12% have previously self-repaired products [44]. It is a myth that overall repair is a niche issue.

6. Product design should consider embedding features that facilitate repairs, giving, for example, information to the user when a product is failing, or when a part needs to be replaced. This information system can go directly into the product or in supporting services.

7. Warranty contracts should be more flexible to allow third parties to participate in the repair process without punishing the user for doing so.

8. Markets should be regulated to avoid the emergence of perverse incentives favoring replacement of products over repairing. In economic terms, to repair a product should be cheaper than to by a new one. This condition can be different in some cases, but in general, materials and energy embedded into a product should be protected, keeping the products in the system for the longest time possible.

9. Directives and institutions should help re-frame repair as an exciting and innovation-driven activity. It is often the case that the language of innovation is reserved for the new "bright and shiny tools" [13] (p. 227) and not for conservation and maintenance duties. Integral repair policies should help to change our usual perceptions of repair as a tedious and mechanical experience by stimulating innovation and creative ways to showcase and practice repair.

We believe this set of points can help designers, producers, and policy makers interested in repairability. They can be used to promote the design of products suitable to be repaired and also products consumers want to repair. When the formal documents of the new EU directive "right to repair" are launched, we expect to do a comparison between the points we believe this directive should address, as we mentioned before, and the real implications of it.

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