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Can you fix it? An investigation of critical repair steps and barriers across product types.

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Keywords: Product repair; Repair café; Product types; Repair steps; Repair barriers.

Abstract: Effective repair practices are identified as a key strategy to prolong product lifetimes. This study examines how repair practices differ across product categories at repair cafés in Denmark. 370 incoming products are divided into four categories: static, mechanical, electrical, and electro-mechanical, and are then evaluated based on fixers' previous repairability experience. Each type was found to have varying critical repair steps, barriers, reparability likability, and tools needed. Overall, this study highlights the importance of understanding critical repair steps and barriers to promote sustainable consumption practices and may inform future product design and repair support initiatives.

Introduction

One way to reduce the environmental impact of consumer goods is through effective repair practices, as they are viewed as a key strategy to help prolong the lifespan of products and materials (Cooper, 2010; Bakker et al., 2013; Hernandez et al., 2020; van der Velden, 2021; Laitala et. al, 2021). However, research shows that repair competence is one of the main barriers to the repair effort (Laitala et. al, 2021).

Recent studies have found that in order to enable product repair, repair needs to be made assessable, e.g., the design needs to enable the consumers to care for and repair the product themselves (Ackermann et al., 2018; Park 2019); the product needs to enable pre-steps such as diagnostics, assessing, and opening with standard tools, as well as repair steps, which may include tools, skills, and the availability of spare parts (Charter & Killer, 2014; Cooper & Salvia, 2018; Mashhadi et al., 2016).

Repair cafes have emerged to address this problem of product overflow and provide expertise to overcome consumer barriers (Graziano & Trogal, 2017; (Dewberry et al., 2017; Diddi et al., 2019; Moalam & Mosgaard 2021; Yazir-lıoğlu & Doğan, 2021). Consumers are referred to as bringers (Madon, 2022), and seek help from experienced volunteers to gain knowledge and repair their products and avoid them ending up in the landfill (Bracquené et. al, 2018). Previous studies have explored the varying expected lifetimes across product categories (Cox et. al., 2013) and how inheritance behavior differs across product categories (Frahm et al. 2022).

Research of how repair practices differ across product categories at repair cafés has to our knowledge not yet been studied.

Product categories

The repair café experiences a big inflow of products, research shows the most common categories repaired at repair cafés are: Small Kitchen Appliances, Household Appliances, Lighting, DVD/CD Players, and Clothing (Charter & Kieller, 2016). These products are often older with differing properties (Van der Velden, 2021), which can be classified as 1) static, 2) mechanical-, 3) electrical, and 4) electro-mechanical products (see Figure 1, adding on Maestri & Wakkery's (2011) three definitions of an object type including an additional para-meter static.

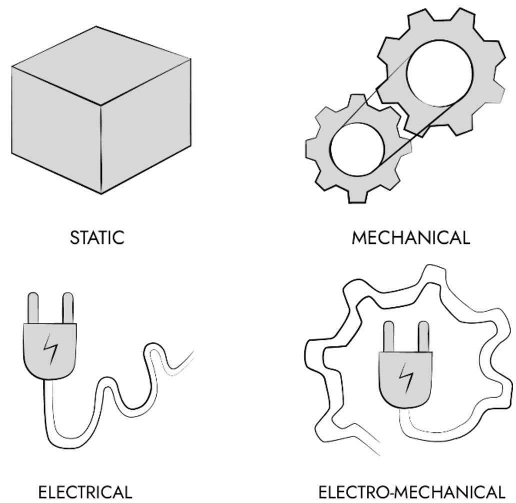


Figure 1. Product types (own illustration, building on Maestri & Wakkery, 2011).

Static: Products that do not involve machinery or movement, such as chairs, interior objects, and clothing items.

Mechanical products: Products that are powered or operated by a machine or tool and are related to movements, such as bicycles, hand tools, or antique or analog watches.

Electrical products: Electrical products are related to or operated by electricity and include a diverse range of complexity, from simple electronic products like lights, chargers, or hair straighteners to more complex components like radios, PCs, sound systems, and TVs.

Electro-mechanical: Products that combine mechanical and electronic systems, including CD players, coffee machines, kitchen machinery, and powered tools.

The repair steps

When products are repaired, they undergo certain repair steps, identified in a recent study (Braquené, 2018, see Figure 2). The five steps include: 1) Product identification, retrieving information about the product and model. 2) Failure diagnostics, locating the cause of problem or fault(s). 3) Disassembly & Reassembly, opening the product, and ease of reassem-bling. 4) Spare part replacement, finding and changing the spare part and 5) Restoring to working condition, either resetting the product or performing necessary handling to restore it. In this study, we investigate if there is a difference in the repair practice depending on the product types (i.e., groups of products) and if the critical repair steps differentiate based on certain barriers or characteristics.

Figure 2. Repair steps, from Bracquené, 2018.

Methodology

A mixed-methods study has been conducted to examine repair efforts across product cate-gories. This involves qualitative and quantita-tive data collection and analysis. 370 products were gathered using convenient sampling gathered from three Danish repair cafes. These three cafés represent 1) a big city (in Danish context, > 300.000 people), 2) a smaller city (>20.000 people), and 3) the countryside (> 3.000 people). In addition, 16 semi-structured interviews and 38 hours of participatory observations were conducted in the native language to investigate the repair process from both the volunteers' and objective perspectives (Kvale & Brinkmann, 2015; Brinkmann & Tanggard, 2020). All three data methods were used to ensure a legitimate data pool and triangulate and validate findings.

Analysis

In the study, we investigate the repair success and critical steps that differ across the four product types. Previous research has indicated that some product design features can facilitate different repair processes (Mashhadi et al., 2019). *Figure 3* shows the percentages of successful repairs for each category. The data suggest a **connection between repair success and product types,** and the following discussion relates the critical repair steps to characteristics that differ across each product type.

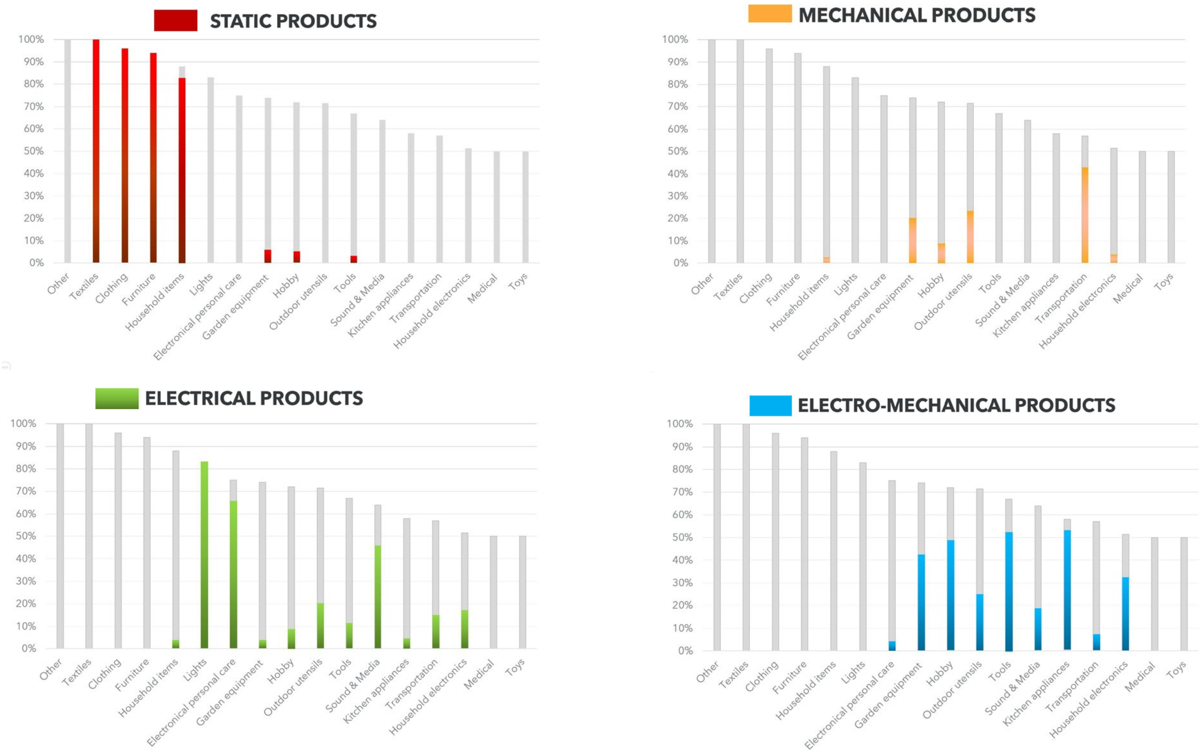


Figure 3. Percentages of repaired products within 17 categories. Static (red), mechanical (orange), electric (green), and electro-mechanical (blue). Categories with >5 products are not included (Other, Medical, Toys).

Static products

Regarding the success rate of static products, the study found that **97% of all static products are repaired.** This could indicate that these products are submitted to lower complexity and that the repair cafés have sufficient skills to repair them. These categories are *Textiles, Clothing*, *Furniture,* and *Household items,* such as blankets, cushions, clothing, frames, and chairs. Through participatory observations, it was observed that static products have product features that are easily decoded by consumers, making them easier to figure out how to repair. As Lefebvre et al., (2018) found, people are more inclined to repair items that they perceive to be easy, which then can turn into gained skills that can be transferred to other items, with static elements. The tools required are standard tools, glue, paint, and cleaning supplies.

The most **critical step** in the repair sequence seems to be **the assessment** for static products, which is located under the **2. Step: diagnostics.** The most important factor related to the assessment, was found to be: "*Can I get the product to the desired level of working?".* This is because the primary function has become insufficient, hence needing repair.

This seems to be related to the product's aesthetic value; if the fixer believed in their skills and ability to restore it to the desired level. This is, for instance, related to material quality, pattern, seam work, or generally handcrafts-manship. Aspects directly related to **the final step 5**, restoring to working condition. This is also present in static components connected to other product types. For instance, electrical speakers encased in textiles can be perceived as a barrier. Despite having electrical issues, the textiles and aesthetic appearance becomes a hindrance, as the fixer evaluates the reattachment of the textile to be unsatisfactory, ending the repair. In such a case, the fixer would recommend the bringer seek restoration expertise from professionals.

Based on the high reparability rate, easy decoding of repair steps such as identification, product faults, and how to retrieve or create spare parts, the authors suggest a start in the repair career with static products. This is applicable for both new fixers and users seeking help, as these products can help create positive repair attempts resulting in confidence that help prompt further repair in more complex products.

Mechanical products

Related to mechanical products**, 61%** of them were repaired. The repair attempt seemed to be highly related to the fixer's skills, expertise, and how frequently the product functionality was present. Many of the found mechanical products were older, such as old cameras, typewriters, etc., or tools and garden equipment. A decreasing product type, as newer mechanical products, have some connection to electricity. Mechanical products have a high complexity related to product architecture. This emphasizes that the **disassembly and assembly, step 3** is a critical element in the repair, as it ensures that complications are met in the repair effort, both in assessing faulty parts or cleaning/maintaining internal parts. Complex architecture has the disadvantage of creating additional faults in the disassembly. "*It is like fixing a car, every gear needs to fit perfectly for most mechanisms to work. It requires precision and product knowledge, so I get not everyone is up to tackle that"- Mechanical engineer.*

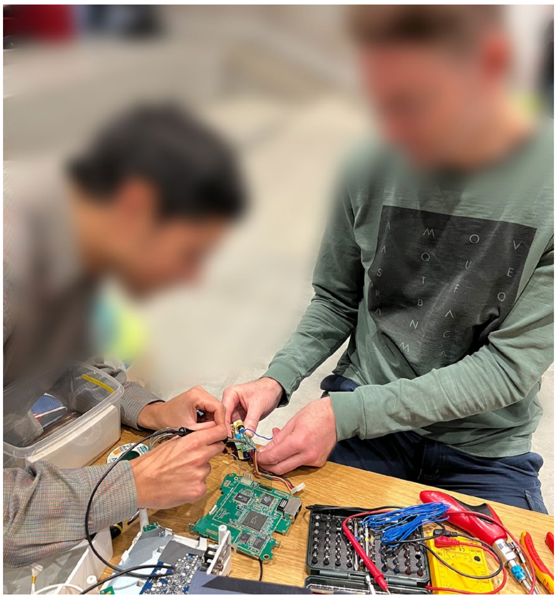
It was found that visibility of the mechanisms leads to greater success in the repair, as observed in bikes or wall clocks. The inability to view the mechanisms creates issues; for instance, mechanical toys, designed to limit the risk of choking hazards, disabled the fixers from opening the toys, much to the dislike of the anxious grandmothers and children hoping to bring home the best play buddy. Similar issues arose from the lack of cleaning of accumulated oil in mechanical products, requiring careful de-clogging and polishing, a procedure not many fixers found amusing. A modular structure, with easy accessibility and overview as well as utilizing standardized parts, would be preferable. However, **the most critical** was **step 4 the retrieval of spare parts**, as these provide difficulty in finding the exact component as seen in Figure 4, where an old mechanical clock was stored at the repair café, waiting for the day when a similar gear would be collected from a discarded product. In some cases, fixers created a similar part, by welding scrap pieces together. However, a welding machine is not a common tool at a repair café.

Figures 4. Mechanical watch, unable to retrieve spare parts.

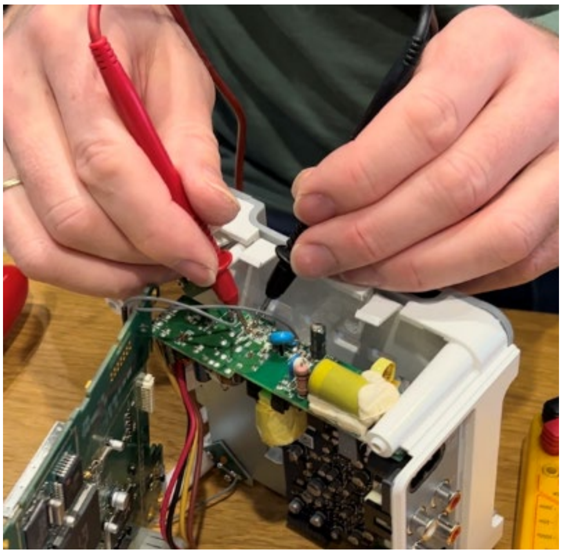
Electrical products

For electrical items, **67%** of the incoming products were repaired. Due to the wide range of complexity in electrical products, **the diagnostic step (2) was critical** as there are often no indicators of what aspects are faulty. Repair fixers look for burnt parts or connections to increase the processes, however, highly complex products often still need a longer diagnostics process, such as a *Sonos* amplifier, where three PCB boards were identified to find the fault (Figures 5 & 6). In this instance, two volunteers spent over two hours trying to locate a potential fault. *"I am trying to run power through several parts of the system, to locate which part is not responding"* – Radio engineer. This shows a barrier, as repairing electrical products requires knowledge related to power theory and tools such as multimeters, soldering iron, and secondary batteries. This constitute a high learning curve and a potential risk, which has previously been identified as a risk on the consumer's side (Terzioğlu, 2021). Further repair barriers are related to lithium batteries, a power source extremely common in wireless products, unfortunately extremely difficult to repair, as skill level exceeds most fixers.

A secondary critical step was found in cheap electrical products, where **disassembly, step 3**, often was impossible, due to stamping or gluing in the production method. Expensive products faced similar issues, as screws or connections were purposefully hidden to create a more simplistic look. The lack of accessibility in the constructions also posed another barrier, as accumulation of dust creates overheating causing the electrical components to fail, which is present in products like TVs.



Figures 5. Two fixers repairing a Sonos amplifier.

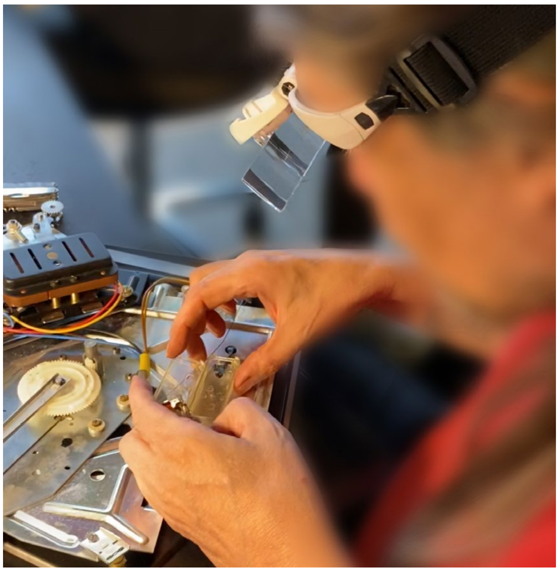


Figures 6. Close-up of diagnostics process on three PCB boards.

Electro-mechanical products

Related to electro-mechanical products**, 64%** were repaired. The duality of the product type creates increased complexity resulting in collaborative repair, between two or more fixers often with specialized tools (see Figure 7). The **most critical step, Step 2 diagnostics,** were found to be the most critical step as these products are often subjected to secondary faults caused by exhaustion of the internal motors. For instance, this is present when blending frozen goods, cutting down a tree, or when drilling into a wall. The original blockade or exhaustion causes overheating, leading to the failure of the electrical components.

"*It is often difficult to know what part is broken… you often assume which part is potentially broken, or you locate the area of the fault and try to fix it, but the machine is still not responding. So, either it didn't need that first repair, or it is a case of multiple ghost faults. Hard to know."* – Electrician.



Figures 7. One fixer in collaborative repair. Electrical focus with specialized glasses. [An old B&O record player]

If the faults were not related to issues related to the diagnostics, it was found to be connected to **step 3: maintenance.** The lack of product care and the presence of dust and liquid showed to be important factors in the repair. Many electro-mechanical products were subjected to either oil, water, petrol, or ink and had some issues related to clogging. For instance, ink in printers can cause the cartridge to clog automatically. "*You actually need to print every week for the ink not to dry up… Printing one sheet of paper is cheaper than the automatic cleaning setting in the printer…nobody is aware that by not using your printer, you are purposely ruining it... happens to a lot of products*" – retired engineer.

Products with old liquids can be difficult to clean once they have solidified, often requiring chemicals and additional space, something that not all repair cafés possess, as they are not in their own accommodations (see Figure 9). Dust, which is present in CD players, angle grinders, and especially vacuum cleaners, also poses a significant issue as it fills the space needed for ventilation, causing a component shutdown – often a recurring problem even if fixed. Both steps 2 and 3 are related to tear and wear, which increases over time.

Figure 9. Declogging of a steamer

Product category	**Specifications**	**Critical repair steps** *Assessment, an aspect placed in step 2, has been excluded from the general diagnostics step and will be referred to as *Step 0, assessment.*
Static	**Complexity:** Low **Tools:** Standard tools, Glues, paint, cleaning equipment **Repair**: 97%	**Step 0: Assessment.** The fixer evaluates the ability to restore to the desired level of working, which is linked to step 5. (An evaluation of skill level, and expertise in relation to the product)
Mechanical	**Complexity:** Medium to high **Tools:** Standard tools, Welder, compression air dusters, cleaning equipment. **Repair:** 61%	**Step 0: Assessment.** Same as static products but influenced by previous experiences and the perceived complexity. **Step 3: Disassemble and reassemble.** Is vital, influenced by product architecture and composition, especially the use of visible or hidden mechanisms. Disassembly can cause further faults when repairing and maintaining gears with the use of oils. **Most critical step: Step 4, retrieval of spare parts**, as mechanisms often require a specific part that needs replacement, which can be hard to retrieve due to the product's age.
Electrical	**Complexity:** Medium to high **Tools:** Specialized tools, Multimeter, soldering iron, compression air dusters. **Repair**: 67%	**Step 0: Assessment.** Previous points apply. The range of components and the applicability determine the product's complexity which is influenced by product architecture and aesthetics. **Most critical step: Step 2: Diagnostics.** The complexity requires extensive time, effort, and special tools and confidence to repair. **Step 3: Disassembly, reassembly, and maintenance**. Both cheap and expensive products face issues with either stamping, gluing or hidden screws
Electro-mechanical	**Complexity:** High **Tools:** Specialized tools, Multimeter, soldering iron, compression air dusters, glues, cleaning equipment **Repair**: 65%	**Step 0: Assessment.** The product type requires expertise in both electric and mechanical knowledge, limited to a few individuals, often requiring collaborative repair. **Most critical step: Step 2: Diagnostics.** Differentiates from electrical, as these products are often subjected to high impact during usage, resulting in various errors with multiple causes, difficult to determine. **Step 3: Maintenance.** The products are subjected to a lack of maintenance, especially related to liquids, which adds complexity.

Table 1. Specifications and critical repair steps across product types.

Concluding discussion

The investigation into four product types suggests that there is a hierarchy in repair complexity. Our study sheds light on the critical repair steps across product types, as these pose varying barriers to the repair effort, with the assessment acting as a universal critical barrier (Table 1). Although the repair movement is growing, our study highlights the vital role of skilled volunteers in capturing learnings that are essential to companies and legislators to promote and contribute to future repair-focused product development.

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