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Strategic Design, Sustainability and Multiple Approaches for Textile Experimentation

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Abstract

The underlying context of this research takes into consideration design as an essential component for economic competitiveness and connected to strategic levels of changes; sustainability as a change process; fashion as a broad concept and incorporated into "dressing" and "living" practices or into the “dressed house” and the “dwelling clothing”; textile industry as an economically important sector, but responsible for a high environmental impact. Thus, the purpose of this study is to identify strategies in order for the design to contribute to environmental sustainability using a Strategic Design approach and focusing largely on textile materials. For this reason, a bibliographic and documental review was carried out in the fields of design and textile engineering, along with an exploratory research underpinned by the Material Driven Design method and by the Handstorm and Experimental Draping techniques. Pre-consumer carpet waste was used for experiments due to the volume of carpet waste, its synthetic nature and its recycling difficulty. Therefore, the study is instrumental in suggesting four design strategies at the strategic level to overcome obstacles to adopting sustainability in the textile industry supported by: combination of disruptive technologies, systemic view, knowledge building through creative experimentation and multiple approaches. Furthermore, upon disregarding the limits imposed by specialized subsectors of the textile industry – fashion and interior design – the study shows upcycling difficulties, but it helps to develop metaphoric objects and generate alternatives for form, texture and scale that undermine aspects such as two-dimensionality and horizontality.

Keywords: Strategic Design; Sustainability; Textiles; Material Design Driven; Fashion; Interiors Design; Recycling; Upcycling.

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Introduction

Sustainable design is committed to the triad society, environment and economy, taking on the role of agent of change upon creating alternatives through project-based approach applied to the production cycle, consumption and disposal (Moraes, 2010). In this regard, proximity with the textile industry is suggested.

There is no doubt that this industry – specialized in the production of clothing, fabrics, threads, fibers and related products – plays an important role in the global economy, but it also frequently operates at odds with the environment (Gardetti and Torres, 2017). The textile environmental impact is heavily influenced by the use of raw materials derived from non-renewable sources; by the substantial use of water and energy; by the emission of greenhouse gases; by the toxicity of the manufacture processes; and by production and post-consumption waste disposal (Thompson, 2015; Palamutcu, 2017).

Therefore, the purpose of this study is to identify strategies so that design can contribute to the environmental sustainability based on a Strategic Design approach and widely focusing on textile materials.

It is understood that these materials are relevant because they consist of a variety of products used in different domains, including clothing and floor coverings for domestic use. Many textile structures shape the way of "dressing" and "living" showing a connection point between two creative fields – fashion design and interior design. Thus, the suggestion of this study is to ignore the limits imposed by the specialization of subsectors of the textile industry, thus, it becomes possible to build a broader view of causes, effects and interrelations pertaining to the material in question, in addition to expanding such strategies to other materials and industries.

It is important to explain that a broader fashion concept is used for that purpose. It incorporates the notion that fashion is a form of product life cycle in which ephemeral patterns are created and recreated promoting continued consumption (Kotler and Keller, 2012). However, it also considers a set of practices connected to the idea of changes taking place in different aspects of the everyday life beyond clothing, and expressing the values of a specific social group (Morais and Parode, 2017).

The underlying concept to this research relates to three assumptions:

- Design is linked to economic competitiveness since its origin, but needs to broaden its scope of activity and be proactively involved with contemporary problems (Margolin, 2014).
- Sustainability is a change process in which solutions should be developed as part of the business, because alternatives for clothing and habitation, among other aspects, will be created by them (Hoffman and Ehrenfeld, 2013). Consequently, it is worth establishing that sustainability entails thoughts and actions in favor of

human development, respecting the environment and ensuring the survivorship of present and future generations (WCED, 1987), with the support of three interdependent dimensions – economic, social and environmental (UNIC, 2015), although the focus of this study is only in the last one.

- Design is linked to changes on a strategic level of corporate actions. Therefore, it is important to define the outlines of the Strategic Design and, for that, it is suggested a convergence between Meroni's views (2008) and Magalhães's views (2014). Design is then able to articulate within comprehensive relations systems, which precedes the project concept itself; it is able to design, maintain or question strategies; it is oriented to the future and to innovation, to learning and to building knowledge through experimentation.

The research consists of four sections. The first of them suggests design strategies that contribute to the environmental sustainability of textile materials. The second one, based on the notion of prevention, seeks ways to reduce the negative impact on the environment through the development of disruptive materials, taking into consideration the dialog between fashion and interior design. The third one, based on corrective practices, suggests a brief review of textile recycling processes with emphasis on the characteristics of the Brazilian scenario. Finally, the fourth section presents the results of material experimentation with carpet waste[1] under the upcycling perspective during recycling.

Bibliographic and documental review was carried out in the fields of design and textile engineering. Simultaneously, exploratory research supported by the Material Driven Design method (Karana et al., 2015) was done, including handling of standard materials for residential environments, but other than clothing. At this stage of research, one of the tests includes the convergence between an upcycling project methodology with fashion industry waste *(*Vadicherla et al. 2017*)* and two techniques: Handstorm (Van Gassel, 2016) and Experimental Draping (Yamashita, 2008). For this purpose, carpet was chosen because of the environmental impact generated by the use of oil-derived raw materials, the volume of waste generated by the industrial, trading and post-consumption disposal processes, and, moreover, by the difficulty to implement recycling processes (Whitefoot, 2009; Sotayo et al., 2015; Palamutcu, 2017).

Design Collaborative Strategies for Environmental Sustainability in Textile Materials

Estimates indicate that decisions taken during design activities represent from 80-90% of environmental and economical costs of a product (Graedel et al., 1995). Such presumption establishes an explicit relation between design and environmental sustainability. Thus, by

[1] Carpet is a textile covering used, in general, over the floor and affixed to it, occupying a large area and accompanying the shape of the space (Berman, 1997).

converging the studies of Baxter (2011), Manzini and Vezzoli (2002), and Bürdek (2006), it is possible to understand that design must assume the implications of its actions, and start to follow ethical and efficient environmental premises when designing to manage the life cycle of a product. There are opportunities to minimize the negative environmental effects in all phases (pre-production, production, distribution, use, and disposal).

In this scenario, especially in the textile industry, design is committed to longevity while expanding the lifecycle of the product, avoiding residue generation and minimizing landfill disposals based on the hierarchy of eco-friendly alternatives explained by Mohanty (2011): Reduce, reuse and recycle. Therefore, design tries to implement three strategies:

- Design for reduction, by minimizing waste both in pre- and post-consumption; by using less resources, such as energy and water; by using less harmful inputs (GFA and BCG, 2017; Earley and Politowicz, 2010).
- Design for reuse, by stimulating textile reuse and used product sales; by designing possibilities to adapt, maintain and fix materials (Thompson, 2015; GFA and BCG, 2017; Earley and Politowicz, 2010).
- Design for recycling, by eliminating barriers to apply large-scale solutions; by avoiding fiber blending; by incorporating recycled materials into the product composition; by designing textiles that anticipate the disassembly of their parts (Thompson, 2015; Bruno, 2016; GFA and BCG, 2017; Earley and Politowicz, 2010).

Focused on the textile industry, strategies of reusing and recycling comply with the typology proposed by Payne and Binotto (2017) in relation to three practices associated to how fashion waste is processed. The first one is elevating and refers to a process of reusing and transforming, which preserves the tangible features of the original material and re-contextualizes it. Therefore, it praises the new product by elevating a previous life cycle. Secondly, is disguising the textile waste for later recycling. It assumes the loss of identity of the recycled material during the transformation trajectory, thus, requires an explicit narrative about the composition of a new product.

These two practices – elevation and disguise – exclude each other, but the third one can be associated to either of them. According to Payne and Binotto (2017), enchanting presupposes sensorial stimulation through physical contact with the material and the emotional reactions that result from the awareness about the proposition of transforming waste in a new product.

Consequently, design for the sustainability of textile materials must address tangible and intangible aspects of such waste, similar to Kazazian's concept of Obsolescence management (2005), which can be revealed in two dimensions: objective and subjective. The first one is linked to technical aspects, where it is possible to program the limitations of the life cycle so that product materials and components deteriorate faster, affecting its practical functionality. The second one

refers to aesthetic and symbolic aspects and, in this case, the obsolescence can be designed in such a way that products lose their meaning to consumers quicker, while their practical functionalities remain valid.

The objective and subjective dimensions of the Obsolescence management (Kazazian, 2005) are intrinsically associated to the economic logic of accelerating production and consumption, and may be associated to Goldsworthy's notions of material and product longevity (2017), respectively. Such relations indicate the possibility of establishing a gap between the physical existence of an artifact and its period of use in service. Ideally, the longevity of materials and products are harmoniously interrelated, providing a balance between material durability and product lifespan (Goldsworthy, 2017). However, from a realistic perspective, design projects experience potential conflicts between economic and environmental interests. This happens because fast production and consumption cycles tend to meet industrial paradigms, but they don't recognize environmentally sustainable values, while slow cycles tend to drive a favorable rationality to the environment and contrary to dominant economic processes (Goldsworthy, 2017).

Inserted in the industrial competitiveness and consumption culture, however, design cannot ignore there may exist conflicting principles between social, economic and environmental elements. In this context, design could possibly develop strategies to reduce the environmental impact of textile waste by creating alternatives that challenge consolidated standards of the mature industry, either to maintain or to transgress them. Accordingly, the study follows focused on two axes. The first one is based on the notion of prevention, where design reduces and identifies disruptive technologies. The second is built on corrective actions, mainly in design for recycling. The next sections will introduce both through an approach transcending textile specialization for clothing and domestic use products.

Design for reduction and the dialogue between fashion and interior design

The concept of prevention orients design for reduction of harmful environmental effects, while presuming to minimize waste and reduce the use of resources by the textile industry. For such, one of the solutions perceived would be the development of materials. The creation of new raw materials helps to avoid the negative impacts of already known inputs, while transcending traditional textile attributes (GFA and BCG, 2017). Another option is the application of plural approaches when addressing evolving complex situations and contexts since a unilateral view tends to generate ideas that replicate standards (Bergmann, 2018).

Thus, integrating the development of materials and interdisciplinary approaches proposes an interaction between fashion design and interior design from a comprehensive perspective, based on two premises: textiles are critical for social practices, such as dressing and housing; these materials enable speculations between emerging technologies and environmental sustainability.

Fashion design and interior design dialogue amongst themselves and influence each other mutually by presenting multiple contact points, including: (1) the expression. through aesthetic languages and the construction of sociocultural identities; (2) the creation of complete life styles through managing integrating brands; (3) the creative collaboration between fashion, architecture and decoration professionals in product and space designs/projects; (4) the application of analogue structural and constructive principles (Souza, 2014; Zandomeneco, 2016).

Based on the last contact point, it is possible to establish a relation between fashion and interior design through textiles. Hypotheses on the origin of the relation between clothing and housing appear in at least three moments. The first one dates back to the origin of humankind, when animal skins were used to protect the body and to use as floor coating for the brute structure of their habitations (Souza, 2014). The second one relates to primitive and nomad tribe tents that were made of the same material used for the clothes of their inhabitants (Barbosa, 2012). The third one goes back to the 18th century, when clothes and domestic spaces used similar fabrics, situation that changed since industrialization (Gordon, 2011; Willbanks et al., 2015).

Therefore, about the intrinsic use of textiles when associating fashion and interior design, two contemporary manifestations are pointed out, although with remote origins – the dressed house and the dwelling clothing.

Textiles are perceived as the clothing of the habitation (Schmid, 2005), and the house – surrounded by textile materials – is seen as an extension of the clothes of their occupants (Rybczynski, 1996). For example, a window (with a curtain) deserves an armchair that requires a sofa (both covered with fabrics), which is worthy of a carpet (Rybczynski, 1996). Not to mention other domestic textiles that became ubiquitous, such as bed and bath linens, and cleaning articles.

Thus, the dressed house is essentially a traditional residence – static and permanent – surrounded by fabrics in its physical structure and objects (Bergmann and Magalhães, 2017).

Differently, the dwelling clothing suggests the existence of less apparent limits between clothing and habitation. It is a portable shelter produced with textiles, ready for use and reusable in temporary conditions and during displacements (Bergmann and Magalhães, 2017). It comprehends the most diverse designs of individual protection and survival casings that adapts to urban nomad practices in situations related to humanitarian architecture, i.e., social focus in providing shelter and equipment to help populations that undergo critical situations (Barbosa, 2012).

To a greater or lesser degree – as an appendix to clothing and/or as an extension to domestic spaces, – textiles play a key role in the link between fashion and interior design, highlighting issues also associated to the impact of waste on the environment. The sustainability issue then arises again and, with focus on the prevention of environmental damage and the implementation of design strategies for reduction, consider three categories of disruptive technologies in the emerging context of the textile industry.

It is important to note that the emerging context of an industry resembles a strategic design space, where design is oriented to possibilities yet to be explored in a near future and pointing out to latent trends. Additionally, they have already been identified in some fields of knowledge, but are still unknown or little known by the featured industrial sector (Bergmann, 2018). In this manner, two technological alternatives exogenous to the textile industry are indicated, demonstrating potential not only to innovate in products and processes, but also to reduce the environmental impact when compared to traditional technologies.

Nanotechnology

The object of nanotechnology is to manipulate material in the molecular level to control properties and performance. Products derived from this set of technologies – nanomaterials – enable the appearance of new textile functionalities (Dent and Sherr, 2014). Examples of innovative properties include the ongoing release of chemical substances (medications or fragrances); alteration of chromatic performance through stimulus, such as light and heat; protection against microorganisms; breathability (Noor-evans et al., 2009; Costa et al., 2011; Dent and Sherr, 2014; Bruno, 2016).

When incorporated to textiles, nanotechnology is capable of enabling the development of materials that reduce environmental impact. For example, nanomaterials allow for the pigmentation without dyes (Costa et al., 2011) and permit the neutralization of body odors, reducing the washing frequency and increasing product durability (DaNa, 2018). In both case, it is possible to save resources such as water and energy. Despite of the potential advantages of nanotechnology, its diffusion depends on progresses in the

increase of production scale and in the investigation of possible side effects to human health and to environmental safety (Noor-evans et al., 2009; DaNa, 2018).

Biotechnology

Integrated to nanotechnology, biotechnology considers a set of microbiological processes to develop materials that incorporate live microorganisms, their derivatives and ecosystems (Myers, 2014; Montana-Hoyos and Fiorentino, 2016). The textile area identified conceptual designs of fibers and fabrics for application in architecture and interior design. These researches propose the development of disruptive functionalities – bioluminescence, self-repair, growth and replication – also to enable a superior ecological performance in comparison to materials produced by traditional industrial systems, which reduces resource consumption and the usage of chemical products (Myers, 2014; Montana-Hoyos and Fiorentino, 2016).

The inclusion of microorganisms – while active design and textile components – faces several type of obstacles. They include the conservation of microbial metabolism when related to technology; humidity integration as an intrinsic characteristic of textile materials as for aesthetics; the deconstruction of preconceived ideas about the relation between human health and microbiology when referring to culture; the adhesion to production paradigms that strengthen the origin of environmental issues as for sustainability (Sawa, 2014; Myers, 2014; Montana-Hoyos and Fiorentino, 2016).

Consequently, some conclusions about the future of textiles when submitted to nanotechnology and biotechnology approaches may be drawn. It is possible to say that innovations in these research areas may expand the boundaries of this category of product. Solutions developed for prototypes, conceptual designs and commercial products launched for market niches enable to foresee the transformation of textile nature and the development of dynamic, mutable and even symbiotic materials in the relation between three level membranes: human skin, clothes and textile coatings for the house.

Materials developed through the hybridization between technologies indicate the creation of a virtuous cycle between textiles and environmental sustainability supported by prevention and design for reduction to establish new relations between fields of knowledge and to change production means.

Design for textile recycling

Design focused on recycling is based on corrective actions, with emphasis on product paradigm and the consequences of environmental problems. In this context, this section starts by briefly introducing a review of textile recycling types, pointing out for the characteristics of the

Brazilian scenario, emphasizing product categories associated to fashion design, but mainly to interior design.

Textile recycling can be classified within technological profile processes used for transforming materials. For such, the following are identified: mechanical recycling involving cutting, grinding and defibering; chemical recycling, comprehending fiber degradation through alcohol and acids; thermal recycling, which refers to producing energy from combustion and biogas; and, still, the combination of all the processes previously mentioned (Zonatti, 2016).

In Brazil, recycling suffers with the inappropriate management of textile waste since collection and selection, as well as with the lack of skilled workforce and absence of tax breaks and incentives (Zonatti et al., 2015). Among several types of recycling, mechanical methods prevail to reprocess the disposal of remainders of clothing, shoes and accessories as many chemical recycling technologies are not widely used (Zonatti et al., 2015). Mechanical recycling reduces the disposal of textiles in landfills and lowers the cost with the acquisition of virgin raw material, but, on the other hand, limits que quality of the final material, as it has shorter fibers than the original, resulting in a lower economic value (Zonatti et al., 2015).

The transformation intensity applied to the materials also define the classification of recycling processes. Whereas downcycling promotes radical changes, upcycling carries out incremental changes (Vadicherla et al., 2017).

Transforming the product (or part of it) through downcycling is intense and done by dismantling components, which generally results in recycled products with less quality and lower economic value (Vadicherla et al., 2017). These are some examples of downcycled textile applications in Brazil: geotextile fabrics, composites for industrial purposes, coatings for civil construction, among others (Sinditêxtil, 2013). Nevertheless, there are cases when a decline is not registered. For example, it is possible to keep a similar quality to the initial material when using chemical recycling on synthetic fibers (Fletcher and Grose, 2011). This is the case of polyamide recycling that goes back to the textile productive chain to use them in clothing, rugs and carpet items, in addition to car inner-liners.

On the contrary, recycling through upcycling adds value to byproducts, to used products and to waste (Vadicherla et al., 2017), as such processes generally perform less intense transformations in the material to be recycled (EMF, 2017). After the dismantling process, waste becomes raw material for new products, while preserving technical properties to a greater or lesser extent (EMF, 2017). As a result, waste is adapted, so it does not fit in the strict definition of reuse, which implies in using the artifact several times, but in its original state (Mohanty, 2011).

In this manner, downcycling and upcycling can be associated to the typology proposed by Payne and Binotto (2017), where downcycling is about the notion of disguising textile waste produced by the fashion industry, and upcycling aligns with the concept of valuing these materials.

In the Brazilian fashion industry, manufacturers and large retailers, as well as small companies and cooperatives, promote upcycling actions. With different competition conditions and sustainability strategies, they invest in the textile reverse logistics pre- and post-consumption associated to social and environmental innovation programs (Rebouças and Salgado, 2011; Uniethos, 2013; Carvalhal, 2016; Fonseca, 2017). New clothing and domestic use articles are produced from the reconfiguration of trimming leftovers and fabric rolls, fabrics forgotten in plants and remainders, deadstock clothing waste, used clothing articles and others (Rebouças and Salgado, 2011; Uniethos, 2013; Carvalhal, 2016; Fonseca, 2017).

There is not much data on recycling textile waste in Brazil, probably because of a scenario marked by a theoretical proposal aligned to sustainable principles, but with limited actions. For example, enactment of the relatively recent National Policy for Solid Waste took place in 2010; the lack of proper environmental laws for the industry and for regulating disposal and specific reverse logistics (Carvalhal, 2016; Zonatti, 2016). In this setting, the profile of specific textile recycling for domestic use is even less known. A reason for this could be a reflex of the supporting economic condition of the textile product category for homes in comparison to the clothing category.

Despite its absence as a protagonist in the revenue of the productive chain for the clothing industry in Brazil for 2015, when wearing apparel contributed with 79% and domestic textile participated with 13% (DEPEC, 2017), the same is not supposedly true with respect to their environmental impact, especially regarding waste management. The home textile category comprehends fabrics for bed, bath and table, curtains, wall and floor coverings, which are all susceptible to environmental issues during their life cycle (Moxon, 2012).

Anyhow, among home textiles, carpets stand out. Although they have a limited economic expression, the environmental impact is significant. According to estimates, this product category accounted for less than 1% of the total revenue for this industry in 2016 (Bruno, 2016, Abritac, 2018). At the same time, it is possible to assume that the volume of discarded carpets in landfills annually in Brazil total some millions of square meters[1].

In addition to volumes, characteristics of the product aggravate disposal consequences. As carpets are generally made of petroleum-based fibers (Whitefoot, 2009; Palamutcu, 2017), their raw materials have an average degradation period in nature of approximately 40 years (IWTO, 2014), while the average life cycle of a carpet ranges from 5-11 years (Wang et al., 2003). And almost 20% of the carpets produced by national manufacturers (Abritac, 2018) have a construction structure based on multiple overlapping layers fixed with adhesive tapes, which neglects the component dismantling process, thus, making recyling very difficult (Sotayo et al., 2015). Consequently, it is possible to state that the contemporary Brazilian carpet demonstrates the instability between material and product longevity.

The house is mutable and goes through phases, according to the transformations of its occupants, building a notion of temporality related to objects, materiality, authenticity and identity (Bergmann and Magalhães, 2017 - DPP). This makes textiles susceptible to renovation cycles, but following a particular interior design logic that establishes different rhythms compared to the fashion product life cycle.

The Brazilian carpet case illustrates the contradiction identified by Goldsworthy (2017), i.e., textile processes with high environmental impact linked to short life cycle products and confirms the relation of recycling with corrective proposals, even if they are still not in place. In these circumstances, design for recycling is submitted to the linear, specialized and standardized industrial principle when oriented to actions in the operating level, i.e., linked to practices of short term projects, fulfilling predefined proposals, and to obsolescence management.

Material Experimentation with Carpets and Upcycling

The study continues with the object to carry out upcycling-driven experiments, considering experimentation as an inquiring characteristic of Strategic Design, according to the views of Meroni (2008) and Magalhães (2014). The choice is justified by the contradiction observed between production volumes for upcycling and design for recycling.

The Material Driven Design (Karana et al., 2015) was the procedure method chosen. This method consists of fully understanding a product to identify its qualities and limitations, comprehending several levels. This research emphasizes the sensorial level as physical contact with the materials may positively influence creative processes (Karana et al., 2015).

All three types of experiments used pre-consumption carpet waste. Obsolete samples for sale were used due to the dynamic fashion cycle of interior design and are described in Table 1. The discarded volume in Brazil[2] is yet unknown, but the type of waste affects the environment negatively as they are synthetic products and hard to dismantle (Whitefoot, 2009; Sotayo et al., 2015; Palamutcu, 2017). Another aspect considered when choosing the material is the absence of upcycling as a conventional alternative for recycling processes (Zonatti, 2016).

Table 1 – Description of pre-consumption carpet waste.

Experiment	Characteristics of textile waste				
	Manufacturing process	Type of construction	Surface raw material	Pile height (millimeter)	Dimensions (centimeter)
1 – Deconstruction	Tufting	cut pile; loop pile	polyamide; polypropylene	6 a 40	7 x 7; 15 x 30
2 – Three-dimensionality	Tufting; Needle punch	loop pile; plain	polyamide; polyester	2,2 a 6	15 x 15
3 – Metaphoric objects	Tufting; Needle punch	cut pile; loop pile; plain	polyamide; polypropylene polyester	2,2 a 6	15 x 30

Source: Organized by the authors.

Find below a brief summary of the experiments.

Experiment 1: Deconstruction

In total 72 chemical and physical manipulations[3] were conducted to alter the surface and the construction structure of the carpet. The level of transformation in the material was directly proportional to the power of weariness of the thermochemical processing in relation to synthetic raw materials, and of mechanical processing on the logic of carpet layers. In sensorial terms, the supposedly softness of the threads associated to the palpable touch of the carpet (Bergmann and Magalhães, 2017) was not confirmed through the manipulated samples since they resisted to the configuration change. The results confirm the robustness of the product, but indicate perspectives when integrating different manipulation processes. See some results in Figure 1.

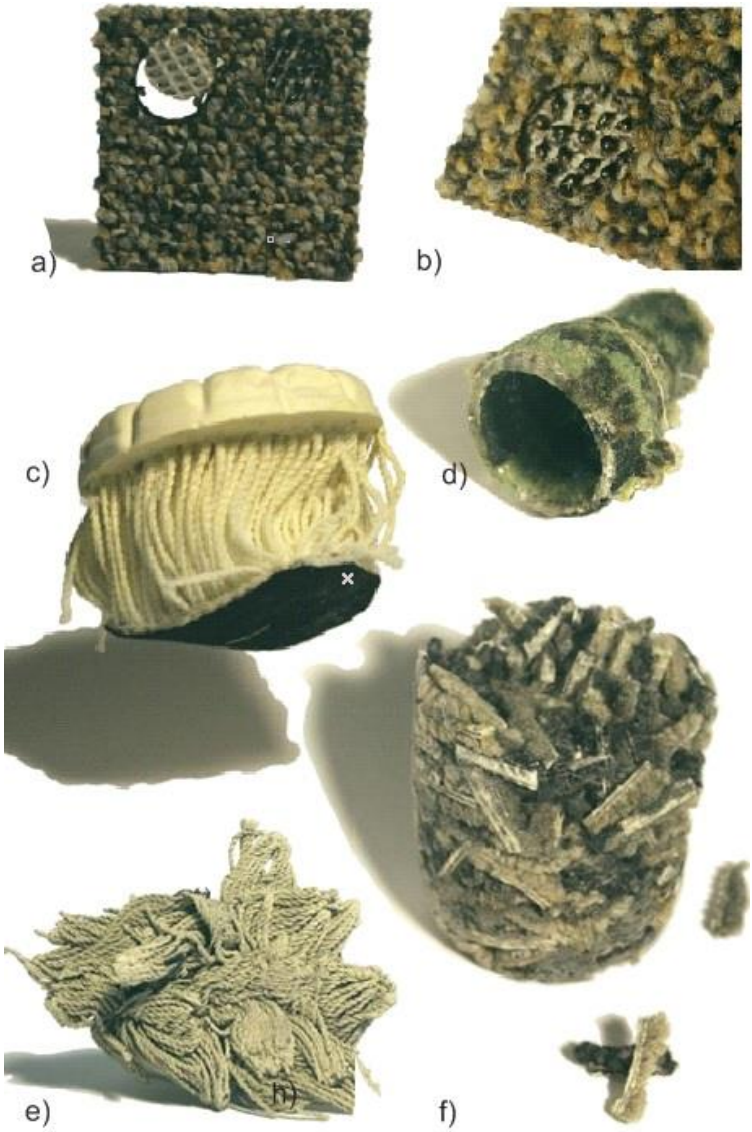

Figure 1 – Examples of experiment results 1 – Deconstruction. Processes used: a) laser cutting and engraving; b) laser engraving; c) plaster mold casting; d) resin mold casting; e) matte acrylic paint; f) molding with PVA glue. Source: Photos produced by the authors.

Experiment 2: Three-dimensionality

The object was to investigate the two-dimensionality typically associated to a textile coating. For such, three-dimensional modules were developed from two rounds of tests. Each round used one type of carpet and one module format – square or circle –, but both used a creation process with paper studies preceded by carpet handling; in addition to low complexity manipulation processes, i.e., cutting, bending and fitting. As for the results, all tests ratified the handling difficulties, however, to a lower extent in needle punch samples because of its monomaterial construction. From another perspective, the modules – when rotating around their own axes and combined among themselves –, generated complex three-dimensional structures with potential to value textures and colors for both faces of the material, and to investigate the typical horizontality prevalence in carpet use. See some results in Figures 2 e 3.

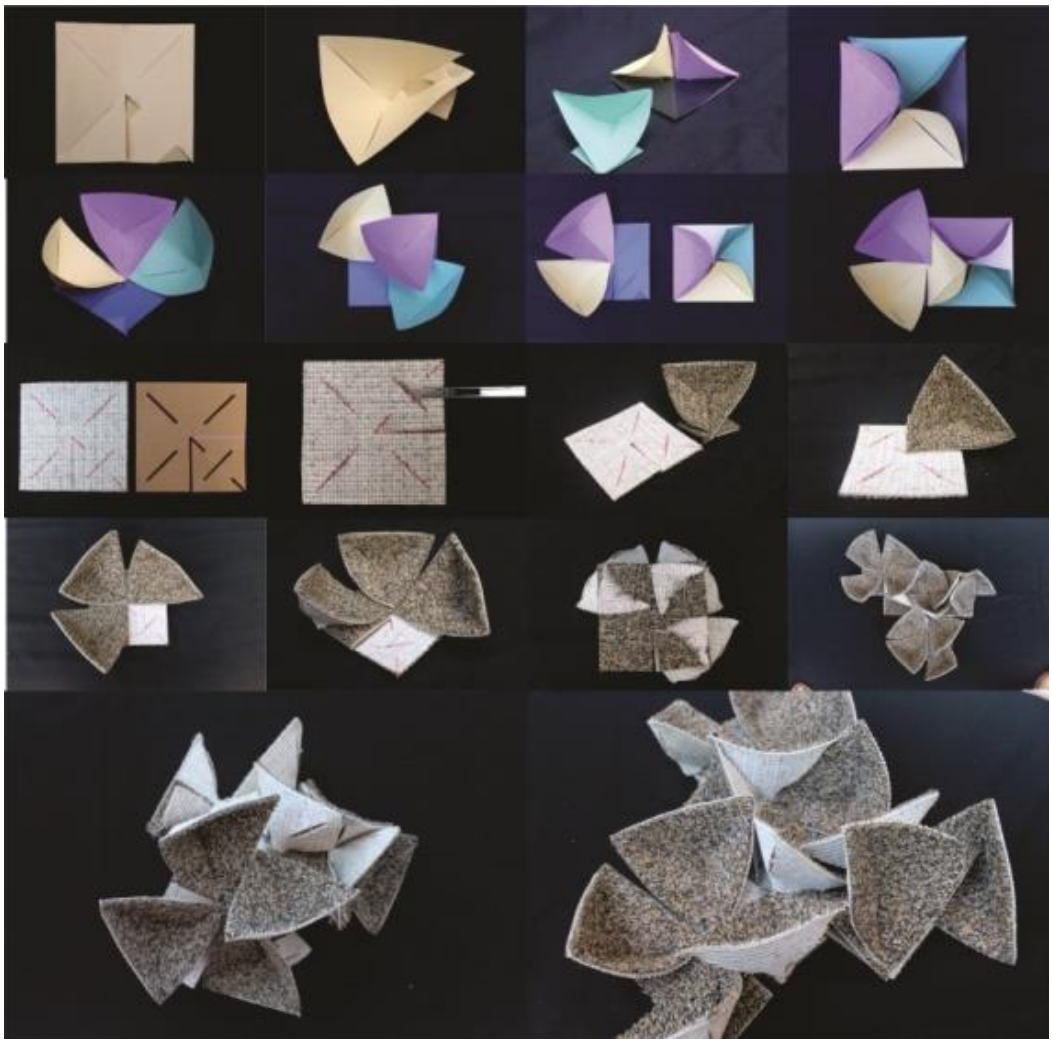

Figure 2 – Details of square modules with tufting samples.
Source: Photos produced by the authors.

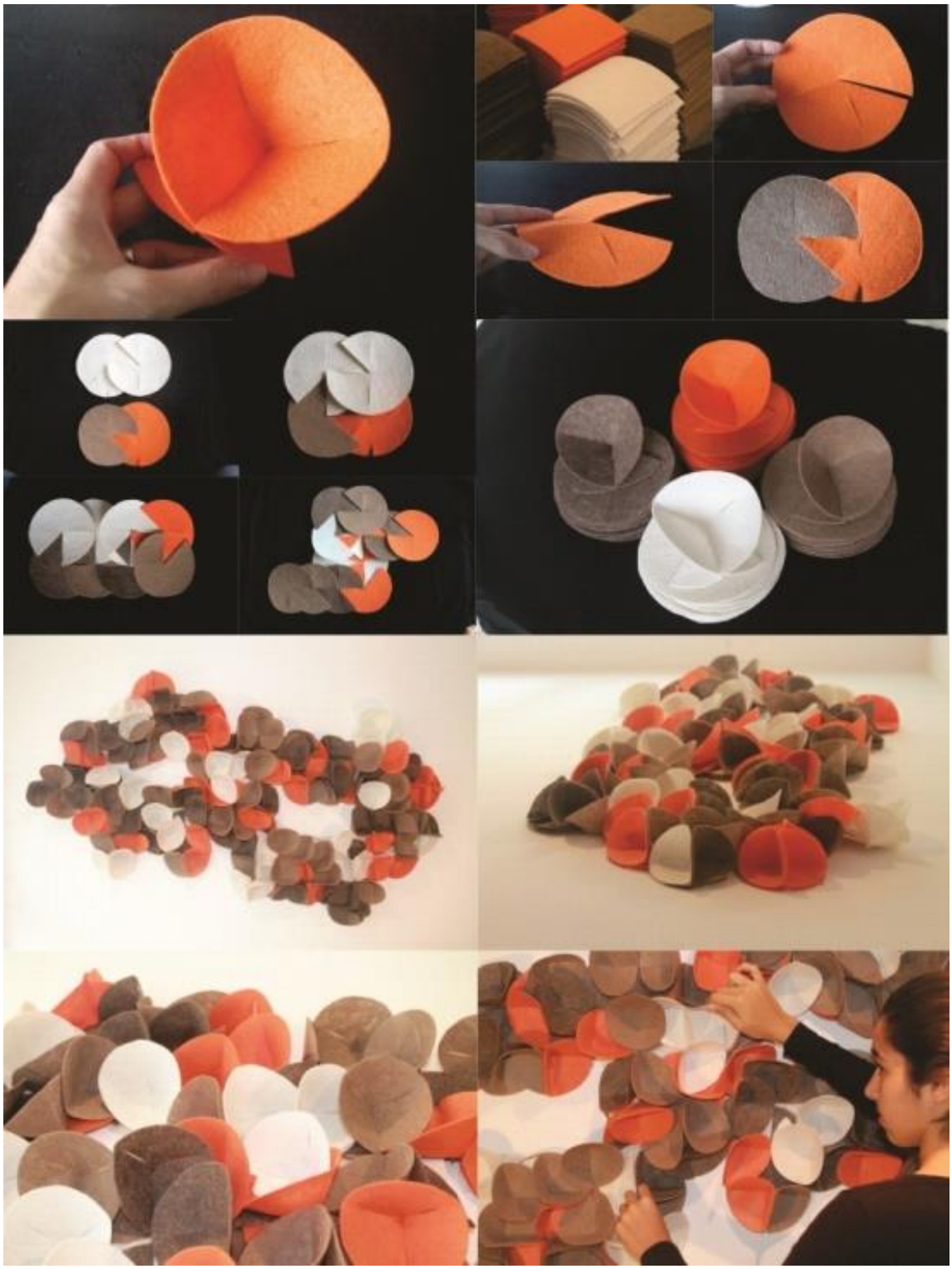

Figure 3 – Details of circle modules with needle punch samples, in addition to a vertical structure with 195 units and dimensions of 135 x 70 x 7.5 cm.
Source: Photos produced by the authors.

Experiment 3: Metaphoric objects

This experiment proposed the creation of metaphoric objects, i.e., artifacts in which carpet samples are used as fabrics for clothing through the convergence between Handstorm (Van Gassel, 2016); Experimental Draping (Yamashita, 2008) and an upcycling project methodology with post-consumption clothing waste *(Vadicherla et al., 2017).*

Handstorm comprehends a set of principles to support creative processes mingled by action and reflection, such as brainstorming, but with the hands, and providing tangible alternatives (Van Gassel, 2016). Experimental Draping is a creation and experimentation technique supported by the 3D modeling to develop clothing items *(*Yamashita, 2008). Vadicherla's (2017) methodology for a recycled clothing item project assumes the selection and identification of material restrictions; the creation by adapting waste; and the construction and proposition of a new meaning.

The methodology and techniques were adapted upon the completion of five creative self-oriented exercises, as shown in Figures 4 and 5. However, in Handstorm no collective and collaborative sessions were used, while Experimental Draping did not consider the markups required by traditional constructive methods, and, finally, Vadicherla's (2017) methodology did not use previous studies for either drawing or sewing.

The samples were spontaneously manipulated to build objects for the dummy by using nail pins, cotton threads, string, thermoplastic tape and wire. The use of these materials highlights the ephemeral nature of the process, since the object was dismantled at the end of each exercise to build the next one.

Deconstruction, three-dimensionality, modernization and verticalization previously tested anticipated the limitations and possibilities of the material. However, when building similar objects – in different levels – with clothes, but that are not clothes, different perspectives appeared involving forms, scales, textures and transparencies.

Figure 4 – Registration of the metaphoric object preparation for experiment 3, the first four creative exercises.
Source: Photos produced by the authors.

Figure 5 – Registration of the metaphoric object preparation for experiment 3, the last creative exercise. Source: Photos produced by the authors.

Initially, the difficulty in handling the carpet questioned the potential of carrying out the experiments, but other creative solutions started to appear from the physical contact with the material and from the gradual testing with manipulation methods. Sensorial stimuli were the starting point to analyze the behavior of the waste, and to reinterpret its characteristics in consonance with the typology proposed by Payne and Binotto (2017). The first experiment verified the possibilities of disguising the material's identity, while the second and third experiments stressed the potential of elevation and enchantment, enabling the product to assume a new meaning and a new context.

Genuine attempts of material experimentation with pre-consumer carpet waste were not able to conciliate upcycling and large-scale design solutions for recycling. However, tests indicated potential for knowledge building and learning through creative handling of textile waste. Results and processes from the three experiments indicated continuity and changes. From the perspective of design for recycling – empiric evidences enabled a better understanding about the carpet as a waste, ratified the difficulty in dismantling it with simple technologies and confirmed the need for design to act in a preventive manner with reference to product and material longevity. On the other hand, in terms of upcycling for pre-consumption waste, promising alternatives to make aesthetic and symbolic changes to unusual materials were recognized with the application of fashion design techniques associated to interior design products.

Final considerations

In the 21st century, the importance of design is emphasized by its ability to deal with difficult situations and face challenges: innovation becomes obsolete, solutions turn into problems and objects become rubbish. In this context, the environment suffers deficiencies or excesses, and it is claimed that design fosters the development of strategies to reduce the impact of textile waste by concentrating on finding alternatives that question the consolidated standards of the mature industry – especially the textile industry. Thus, the purpose of this study is to identify design strategies that contribute to environment sustainability from a Strategic Design approach.

Therefore, in an attempt to reconcile economic development, respect for Nature and creative vision, four design strategies at a strategic level are presented to address changes and essentially overcome obstacles to the adoption of preventive and corrective actions in the textile industry. The first one is in the core of the elimination of imbalance sources in the environment from the very beginning and the reduction design. The second and the third strategies are associated to the core of the development of solutions for environmental problems already in place by manufacturing processes and the recycling design. All of these can be used jointly, and it is believed that they can be leveraged by the use of the fourth and last strategy, which refers to a wide and generic approach of the triad relation among design, environment sustainability and textiles.

Technological mapping strategy and hybridization of technologies

To foresee problems, a design action is required at the organization's strategic level by interpreting the technological scenario that allows for questioning of consolidated technologies and the identification of alternatives capable of promoting changes in contexts outside the industry in question.

Strategy for incorporating a systemic view of recycling

Although recycling is associated with the implementation of the design project, theoretically, it can eliminate barriers for the application of large-scale solutions, as long as a systemic view of recycling problems is incorporated into the design. For that purpose, it is important to add value beyond interventions only at the textile product level and reorient the focus of the design to planning, coordinating, implementing and controlling the actions inherent to the recycling process as a whole.

Strategy for building knowledge by means of waste material experimentation

Building knowledge and learning through the creative manipulation of textile waste establishes a connection with design approaches at the strategic level of organizations because they are forward-looking actions: (1) when employing skills to make creative strategies flexible according to material behavior; (2) when testing ideas acting and thinking about the way of using textile waste and, therefore, considering previous practices; and (3) when learning to design expanding the foreseeable limits of disposed materials.

Strategy for developing multiple approaches

Strategic Design points towards the perspective of positive changes directed to preventive and corrective actions, while ignoring the limits imposed by the specialization of subsectors of the textile industry. This happens after an interdisciplinary and transdisciplinary dialogue about technologies, materials, processes and approaches so innovation can take place, and where a proactive view of sustainability is shared.

The study also contributes when pointing out design challenges by looking for project effectiveness that combines marketability and environmental sustainability. Thus, it is necessary to take into consideration the relationship of design with the following: industry, consumer, professionals from different areas, and other dimensions of sustainable development. In the first relationship, conflicting objectives between design and the organization may arise if concern with the environment does not permeate the strategic orientation of the organizational structure. In the

second relationship, consumer resistance to products considered extremely innovative has to be taken into account. In the third relationship, design should be part of a collective effort in which dialog might demand knowledge sharing and disputing the protagonist role in the production chain should be treated as relative. Finally, in the fourth relationship, design cannot ignore the connection between environmental aspects and other sociocultural and economic aspects, besides recognizing the impact of regional and local differences.

The study indicates possibilities of conducting new experiments by reversing logic and experiencing textile waste from fashion industry applied to interior design artifacts in an unusual way. Ultimately, in the context of industries that are not used to disruptions, where most of their efforts take place within known limits, it is the designer's responsibility to develop variations on the same topic. Nonetheless, the strategic dimension of the design makes it possible to expand the possibilities by admitting that design is a changing discipline, as much as the area of operation is variable. That is when creative and sustainable solutions become crucial.

Notes

1. Although there are no consolidated data on carpet collection, disposal and recycling in Brazil available, apparently every year millions of square meters are discarded. This is based on the following: (1) the production for the carpet industry totalled 14.2 million square meters in 2017, but this figure was higher in previous years (Abritac, 2018); (2) a carpet has an average life cycle of 5 to 11 years (Wang et al., 2003); (3) carpet recycling in the country is still in the initial phases.
2. Carpet is a textile commodity; however, some similarity between the Brazilian Market with the disposal percentage of pre-consumption textile waste in the United Kingdom was observed, that is, 6% as a reference (Bird, 2014).
3. The experimentation included: mechanical polishing; painting with car, enamel and acrylic paints; chlorine bleaching; combustion; polyester film application; liquid plaster application for stiffening and additional manual fragmentation; corrosion by contact with sodium hydroxide and phosphoric, fluoridric, sulphuric, chloridric and nitric acids; screw/thread, magnet, bicomponent fixture, adhesive joints; hot welding; manual and machine sewing; weaving; machining/drilling; manual winding, thinning and folding; delamination; cutting and torsion; fraying; lashing; molding; laser cutting and engraving.

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