Brain Power

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Contextual review and concept statement. In the digital transformation era we live in, 3D printing (3DP) has become more accessible to various industries. 3DP enables designers to experiment and prototype their design rapidly without much limitation, especially in the fashion industry (Yap & Yeong, 2014). For example, the fashion designer, Danit Peleg (2017), created innovative 3D printed garments with various 3DP methods and materials. 3DP constructs 3D objects by depositing or solidifying the material layer by layer instead of sculpting from blocks of materials (Prince, 2014; Singh et al., 2017), which offers more sustainable benefits than traditional subtractive manufacturing methods (Sun & Zhao, 2017). The excessive printed objects, failed printing, and rejected support structures from 3DP result in a large amount of material waste, which may hinder sustainability practices in the industry (Griffiths et al., 2016; Mikula et al., 2020; Pasricha & Greeninger, 2018). Incorporating a transformable design approach with 3D printed wearables may be an alternative solution to minimize material waste and extend wearables' lifespan (Farrer, 2011; Koo et al., 2015; Rahman & Gong, 2016).

With transformable design practices, designers are able to reuse or upgrade existing garments by replacing functional components and adapt the design to new requirements based on wearers' needs (Koo et al., 2014; Rahman & Gong, 2016). Although the increasing number of researchers explored the wearable product design and development using 3DP, little attention was given to develop 3D printed wearables integrating with a transformable design approach as a sustainable design solution to address the concern related with material waste from 3DP. Thus, we aimed to create a multi-functional 3D printed wearable jacket through developing a novel 3D printed material with a strong elasticity and an appropriate joint mechanism for different parts. The experimental design, *Brain Power*, was proposed in that regard through integrating various design technologies in the design development process.

Aesthetic properties and visual impact. The design, *Brain Power*, is comprised of five main components: a basic jacket, a removable hood, removable sleeves, an extension panel to adjust the jacket length, and a detachable pocket. With the inspiration from biological brain structures, this design incorporated functional, expressive, and aesthetic attributes into the design development process. As shown in Figure 1, the inspiration of the unique wave and groove patterns in the 3D printed jacket was originated from ridges and fissures on the biological cerebrum of the brain which oversees various activities and performs multiple functions for supporting human life. We developed the basic jacket with

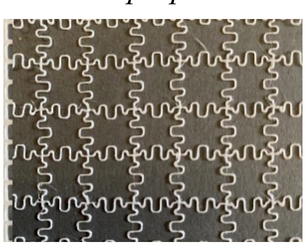

Figure 1. 3D printed wave pattern

combining layers using different patterns of 3D printed textiles and colors, representing the dynamic combination of orderliness and entanglement in our unfathomable brain. The multi-tasking concept of the brain was deeply embedded in this innovative textile pattern development, which emphasized to maximize the material's elasticity. With the incorporation with a transformable design approach, wearers can simply adjust the length of this 3D printed jacket by altering the extension panel based on their preferences or reverse their styling options (e.g., the sleeve length adjustment, interchangeable location of the pocket) by attaching or detaching sleeves and pocket.

Process, technique, and execution. The design process began by brainstorming concepts and sketching. When the final design concept was confirmed, 2D patterns of the basic jacket and other functional components were developed in CLO and then placed, stitched, and adjusted on a virtual male avatar with size 40. The 2D patterns of all components were exported and then imported in Rhino for segmenting the patterns into 74 panels. Two different continuous textile patterns (wave and lattice) developed by the designers were inserted in each individual panel and solidified with a thickness of 0.4mm. A commercial fused deposition modeling (FDM) 3D printer was used to print all of the panels using thermoplastic polyurethane (TPU) filaments, which have high elasticity and flexibility (see Figure 2). With the use of flexible materials and continuous structures in the 3D printed textiles, this design showcases much higher elasticity and flexibility than traditional 3D printed wearables made of rigid 3DP materials. A novel adhesive joint method was used to seamlessly join all 3D printed panels with a liquid stitch. Functionally designed 3D printed snap buttons, inspired by the joint mechanism from LEGO bricks, were placed on the edges of certain panels on the jacket for wearers to easily attach and detach the extension panel and other functional components (see Figure 3). The design process lasted 13 weeks, including 3 weeks for brainstorming and sketching; 3 weeks for developing and testing textile patterns with 3DP; 4 weeks for 2D jacket pattern development, 3D stimulation in CLO, and 3D segmentation in Rhino; and 3 weeks for 3D modeling. Additionally, a total of 72 hours were spent to complete the 3DP process, including 63 hours to print all 74 panels and 9 hours to join these panels.

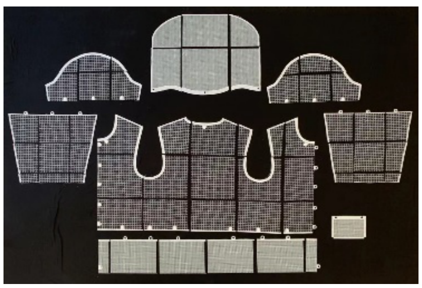

Figure 2. 3D printed panels

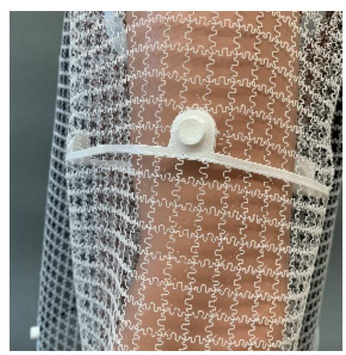

Figure 3. 3D printed snap button

Cohesion. Integrating with a transformable design approach, the design, *Brain Power*, features a convertible concept, which allows wearers to achieve different usages conveniently. This 3D printed jacket reflects the endless possibility of our brain power, here elasticity of the 3D printed material. Various functionalities and styling options of this jacket not only fulfills wearers' functional, expressive, and aesthetic needs but also addresses sustainability practices in the 3DP process through extending the product lifespan and reducing material waste.

Significance, rationale, and contribution. With the use of flexible 3DP material, adhesive joint technique, and continuous wave and lattice structures used in the 3D printed textiles, this design was developed to simulate traditional fabrics and maximize wearers' functional needs (e.g., comfort, movement). By integrating the inspiration from the biological brain structure and function, this experimental design demonstrates the potential integration of a transformable design approach with the 3D printed wearables' development to maximize users' personalization.

Originality and innovation. This design is innovative and original at (a) creating a multi-functional jacket using the novel elasticity-maximized 3D printed textiles that we developed, (b) embedding functionally designed 3D printed snap buttons in the jacket for easy and efficient assembly and disassembly, and (c) providing the potential to promote sustainability practices by reducing material waste and extending product lifespan by integrating a transformable design approach in 3D printed wearable product design and development.

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