CIRCE

Germany – Creative Impact Fund

embrace3

Developing a needs-based design framework for breast support clothing

CIRCE Creative Impact Research Centre Europe

u-institut GmbH & Co. KG

Federal Government Commissioner for Culture and the Media

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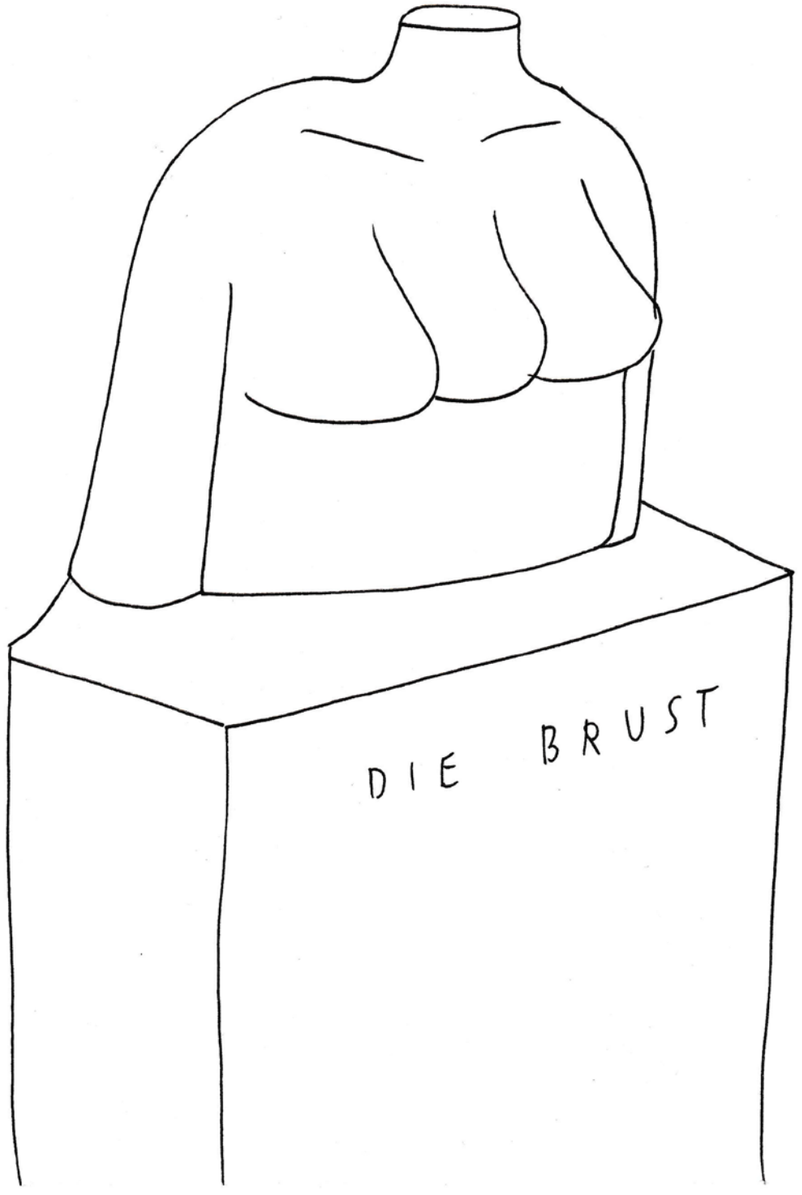

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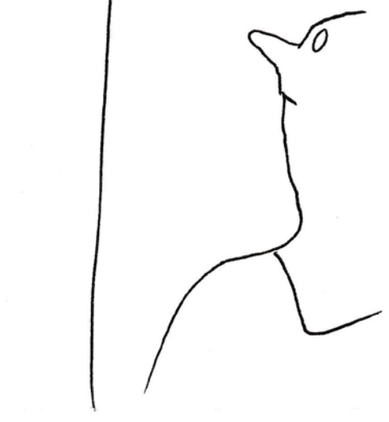
Photograph of the final embrace3 prototype, front detail (Hofmann, 2023)



Graphic recording illustration, created during an embrace3 team meeting entitled: The Breast (Die Brust) (Benz, 2023)

Authors note

The project *embrace3* evolved from my praxis-driven PhD research at the Royal College of Art; this research investigates the clothing needs of diverse and underserved wearers with a specific focus on breast support clothing needs in the context of breast cancer and breast asymmetry. While I instigated and managed the embrace3 project, the product development, prototyping processes and project learnings were based on teamwork, and the project outcomes are the achievements of the embrace3 team as a whole.

This project report was written by me independently. I have paid careful attention to accurately describing the team's joint observations and learnings, and have either paraphrased or directly quoted individual team members. Furthermore, I have summarised our communal learnings. A list of all embrace3 team members can be found in the *Team credits* section at the end of this report. I would like to extend my heartfelt thanks to everyone on this list for their incredible talents, diligent work ethics and their tireless efforts to evolve embrace3 into a meaningful project and a useful product.

Terminology

In this project report, I use the term *breast(s)* without referring to gender. It is essential to clarify the use of this term because the embrace3 approach to product design aims to consider all underserved breast support needs in the context of breast cancer and breast asymmetry, regardless of an individual's sex or the gender they identify with.

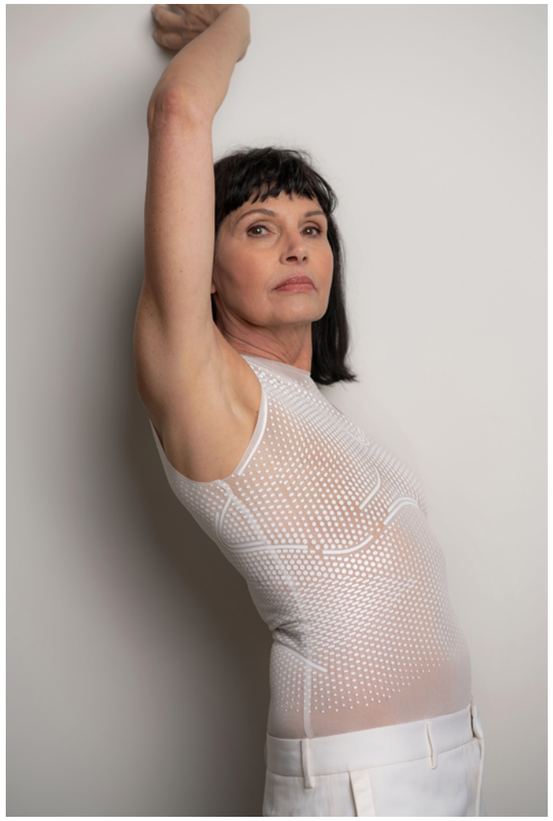
In the context of breast cancer, it is important to acknowledge that of all diagnosed people, 99% have breasts that are classified as female (breasts with working lobules and milk ducts), and less than 1% have breasts that are classified as male (breasts without working lobules and milk ducts).[1] Therefore, any medical or scientific information (unless otherwise specified) is based on findings relating to breast health classified as female. Throughout this report, the term *breasts* is thus used to refer to breasts classified as female, regardless of an individual's gender identity.

[1] Breast cancer affects people with breasts that are classified as female and male. While treatments are similar and factors such as gene mutations are shared risks between all genders, breast cancer is most diagnosed among individuals with breasts classified as female. Unlike breast tissue classified as male, which primarily consists of fatty and fibrous tissue, breasts classified as female develop working lobules and milk ducts during puberty, the tissue in which breast cancer most commonly develops (WHO, 2023; Mayo Clinic, 2023).

Graphic recording illustration, created during an embrace3 team meeting entitled: The woman is going flat (*Die Frau is going Flat*) (Benz, 2023)

Summary

This section of the final report introduces the embrace3 project; it summarises how the project came about and where it is positioned in the clothing design and breast cancer spectrums. This section also provides an overview of how the project team was set up and the design process organised, as well as the societal and technological problem-solving objectives of the project in the context of CIRCE.



Photograph of Jacobe wearing the final embrace3 prototype (Kurth, 2023)

Project introduction

As a clothing design investigation, embrace3 was inspired by a friend‘s breast cancer experience and her underserved bra needs after a lateral mastectomy. This third iteration of an ongoing, in-depth clothing design exploration (embrace1, embrace2 and embrace3) investigated specific structural aspects of alternative breast support clothing in the context of breast cancer.[2]

The intention was to systematically oppose the bra as a structural breast support concept and instead experiment with decentralising breast support through a parametric algorithm that reacts to an individual’s torso topologies based on body scans. This mass customisation approach offers the technical ability to consider wearers‘ specific breast support needs within the clothing design industry and manufacturing processes.[3] The desire to deliver more diversified and customisable breast support clothing is founded on the hypothesis that a broader product assortment is needed in the context of breast cancer. After breast cancer treatments, body topologies can change and people “may have differently sized breasts, be single-breasted or flat (without breasts)” (Hofmann, 2023) after surgery.[4]

The breast support needs of individuals who “may choose not to have breast reconstruction or wear external prostheses” (Hofmann, 2023) are significantly underserved by the underwear industry, which almost exclusively caters for symmetrical bodies. Similarly, post-mastectomy bras are almost exclusively designed to re-establish body symmetry and to be worn with external breast prostheses.[5] Therefore, embrace3 explicitly focuses on individuals who feel overlooked and whose needs are unmet by available breast support products.

[2] In this report, the term *bra* is replaced by the more general term *breast support clothing* to encourage thinking about products beyond the bra’s conventional forms and functions. The term *breast support clothing* includes bras as one form of breast support clothing in the larger category.

Photograph of Jacobe wearing the final embrace3 prototype (Kurth, 2023)

[3] Mass customisation is a manufacturing method that combines the personalisation and adaptability of bespoke products with the industrialised development of mass-produced products.

[4] The term *flat* is jargon for the surgical procedure aesthetic flat closure, in which the chest wall is remodelled to create a smooth and flat appearance following a single or double mastectomy, or breast implant removal.

The embrace3 project was funded through the Creative Impact Fund (CIF), an initiative and entrepreneurial testing ground of the Creative Impact Research Centre Europe (CIRCE). CIRCE supported eight projects which focus on devising creative impact prototypes and enabled them to reach the proof of concept stage in an eight-month timeframe (CIRCE, 2023). As a European think tank, CIRCE aimed to explore creative impact at the intersection of practice, research and social entrepreneurship. To address the complexities of multiple ongoing global crises, the centre investigated "how policy can support the cultural and creative industries and strengthen their impact in Europe" (CIRCE, 2023). In this context, embrace3 aimed to reach beyond the development of an innovative product and to also trial and test possible and necessary structural changes in standardised clothing industry processes. The embrace3 project approach towards design team work was therefore multidisciplinary and collaborative. Teamwork took place within a needs-based design framework that was developed and trialled during the predecessor projects, embrace1 and embrace2.

This approach to clothing design differs from conventional fashion design methods, which steer creative processes from designer-creator directives. Fashion designers who envision and shape clothing collections often follow individual-specific design methods to find inspiration. In contrast, the needs-based design framework centres on the experience of wearing clothing. Design deliberations are guided by the directive of the wearer and the design team takes inspiration from the clothing wearers‘ lived reality and their actual clothing needs.

To open up discourse and knowledge exchange beyond the traditional boundaries of the discipline, the embrace3 team invited clothing wearers into the design process. The design team therefore consisted of a clothing wearer with experience of breast cancer alongside design and engineering specialists. The team also trialled and tested alternative design methods and communication strategies through applied knowledge-sharing methods, such as storytelling, sensitive listening, wearer tests, reviewing a wearer’s experiences via video report, and visualising complex experiences and emotions through graphic recordings.[6]

Collaborative prototype fittings represented a central method and a communal learning strategy; this involved pooling the expertise of all team members to create a joint body of knowledge. Besides the technical fitting process, each prototype iteration also created an opportunity and space for joint creative explorations, debate and lively discourse, which thus led to an exchange of knowledge.

[5] Post-mastectomy bras are specialised bras that have internal spandex pockets to hold breast prostheses. They are commonly available at specialised shops (Johns Hopkins Medicine, 2023).

[6] Graphic recording is the process of capturing conversations visually via illustration and text.

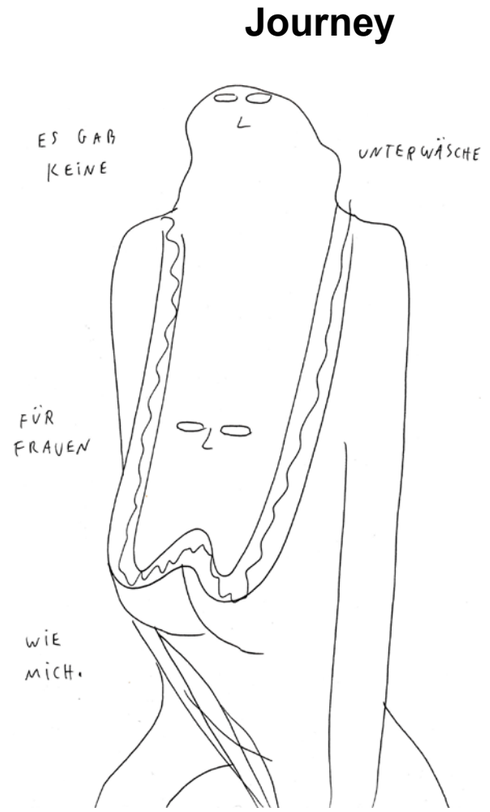
Katharina Sand described the collaborative design approach of the preceding project, *embrace2*, which formed the methodological foundation for embrace3 as follows:

> Hofmann uses collaborative processes to recenter the garment wearers, their emotional needs, and their bodily experience within the manufacturing process. Producing the prototype became a curative tool for wellbeing. By integrating and encouraging self-expression, manufacturing becomes a way of creating physical and emotional comfort.… Hofmann's research integrates and welcomes the garment wearer in the circle of experts. As she points out, "they have the knowledge of how a garment needs to feel and perform." But the project extends far beyond the traditional functionality of clothing. By designing a highly empathetic exchange with the wearer, the making process addresses more than only aesthetic and ergonomic needs: it furthers emotional wellbeing. (Sand, 2021)

To gain a broader understanding of specific breast support clothing needs beyond the embrace3 team, an online study was developed and launched during the project timeframe. The study (which is still ongoing beyond the project timeframe) addressed the breast support preferences of people affected by breast cancer and received international responses from seven countries and three continents. In parallel to quantifiable multiple-choice questions, the study concentrated on qualitative experience reports, clothing needs narratives, visualisations of DIY creations and breast support clothing hacks.

Illustration, with working QR codes, for the embrace3 online study (Hofmann, 2023)

Graphic recording illustration, created during an embrace3 team meeting entitled: There was no underwear for women like me (Es gab keine Unterwäsche für Frauen wie mich) (Benz, 2023)



This section of the report details the reasons for the project's inception and discusses the circumstances that frame the urgent need for innovative breast support clothing as an alternative to bras in the context of breast cancer. This section also outlines the arguments that support the embrace3 team's approach to the clothing industry and the methodological framework used to develop the embrace3 prototype during the project.

Breast cancer facts
and product framework building

Before delineating the product development activities for the project, it is essential to outline the specific clothing design context of breast support in relation to the spectrum of breast cancer. Although clothing design may not generally be considered a factor in breast cancer recovery processes, as the first layer of material that comes in contact with people's skin every day, "clothing plays a constant role in our perceptual experiences of touch – while dressing and undressing, going about our daily life, performing everyday tasks, doing sports or sleeping" (Hofmann, 2021).

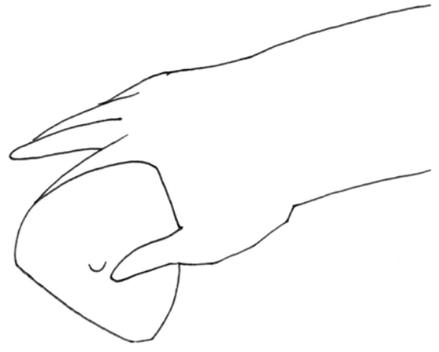
Breast support clothing is generally worn daily and in direct contact with skin; these garments (bras in particular) structurally create pressure and tension in order to support the weight of the breasts. Their design thus has the potential to impact everyday comfort and affect quality of life positively or negatively. Within the context of wearers who have experienced breast cancer, this is even more significant: cancer treatments often cause sensitive and irritable skin while surgical procedures may change breast and torso topologies and create scar tissue, which may also increase skin sensitivity. Lymph node extractions are often necessary during breast cancer treatments and this can also cause problems in relation to breast support clothing as an insufficient or blocked lymphatic flow can lead to *lymphedema*.[7] Therefore, after breast cancer treatments, snug-fitting, tension-creating clothing – such as bras – can increase the risk of lymphedema (Alberta Health Services, 2023; Taylor, 2019).

[7] ***Lymphedema*** **occurs when the lymphatic system is impaired or overloaded, causing inefficient drainage of lymph fluid that results in its build-up and swelling of body parts due to this accumulation (Breastcancer.org, 2021).**

On an emotional level, self-perception and reconnecting with an altered and traumatised body is an intimate process that can create its own set of aesthetic clothing needs. A homogeneous assortment of symmetrical breast support clothing can cause an individual to feel marginalised and overlooked. When designing clothing in the spectrum of breast cancer, it is therefore essential to sensitively listen to and understand the narratives and clothing needs expressed by affected individuals.

When the embrace3 team raised these concerns in conversations with industry professionals and pointed out the urgent need to supply more diversifiable breast support designs to respond to clothing needs in the context of breast cancer, these arguments were generally met with interest but also with hesitance. The concern most often raised was that this customer group is too small to make the development of specific products financially viable or to be relevant for industrial clothing design processes. This customer group refers specifically to people who have had treatment for breast cancer and who have differently sized breasts, one breast or no breasts, and who choose not to have breast reconstruction or wear external prostheses.

During internal team conversations about building the product framework, two counterarguments emerged in relation to the clothing industry approach; these counterarguments focus on an existing greater need and a different reality in terms of the future demand for breast support clothing. In more extensive discussions about the embrace3 breast support alternative, conversation partners expressed a strong interest and recognised the importance of these aspects.



Graphic recording illustration of a hand holding a breast (Benz, 2023)

The first argument is relevant beyond the context of breast cancer: breast asymmetry is a commonly occurring breast form; biologically female breasts, including the areolae and nipples, naturally vary in shape and size. Breast characteristics are dependent on genetics, age, weight and hormones. While breast asymmetry commonly occurs during puberty and often resolves, persistent asymmetry exists in 25% of people (Eske, 2020). A number of individuals in this generally overlooked consumer group contacted the embrace3 team to express their interest in a diversified breast support alternative.

In the context of breast cancer, the second argument is related to the increasing number of breast cancer cases and the corresponding rise in breast cancer-related clothing needs. It is estimated that breast cancer cases will double by the year 2040 and will affect one in four people with breasts (Arnold et al., 2022). Breast cancer affects people from puberty onwards and the rates increase with age, with the highest rates occurring between the ages of 45 and 69. Breast cancer is the most common cancer overall and leaves individuals with more disability-adjusted life years (DALYs) than any other cancer. This means that the everyday burden of illness in a state of less than full health is heightened and extended amongst individuals affected by breast cancer. Due to early detection and treatment advancements, the overall mortality rate is falling and, with a rise in average life expectancy, people live increasingly longer with breast cancer-related discomfort. It will therefore become even more important to improve breast support clothing and expand options to cater for a growing consumer group.

The preliminary results from the project's ongoing online study about breast support preferences showed high levels of dissatisfaction regarding diversity in breast support options in the context of breast cancer. More than 80% of study participants said that they had difficulty finding bras for their breast support needs. Only 13% found bras for their breast support needs and 0% were completely satisfied with the available bra assortment for people affected by breast cancer. Another indicator was that 18% of the study participants said they altered their purchased bras to meet their specific breast support needs.

Based on the above arguments, the embrace3 team structured the project prototype development into three iterative testing cycles. Each prototype iteration explored different aspects of the decentralised breast support concept. The wearer (Jacobe de La Tour) tested each prototype in different everyday situations and recorded her experiences in a video report. Following the wearer tests, the embrace3 team reviewed each prototype in a joint fitting session, also taking the video report into account. Together, the learnings and conclusions were then translated into the next prototype iteration.

In a continuous process, the knowledge gained from one prototype iteration informed the next stage of the development process combining the real-life, daily wearer experience data provided by Jacobe and the designers' specialised technical knowledge regarding clothing and engineering. The results of these prototyping cycles are outlined in the innovation section of this report.

Photograph of Jacobe wearing the final embrace3 prototype (Kurth, 2023)

Still from a video of an embrace3 team meeting with design team members and graphic recording illustrator Johanna Benz (Hofmann, 2023)

Innovation

This section highlights the innovative aspects of the embrace3 project. The team‘s achievements are categorised into innovations related to the design process in the context of team building interactions, as well as to the technical product innovations based on the three stages of the prototype development process.

Still from a video of Jacobe during an embrace3 team meeting (Hofmann, 2023)

Still from a video of an embrace3 prototype fitting (Hofmann, 2023)

Photograph of design team deliberations during a prototype fitting (Hofmann, 2023)

Still from a video of embrace3 preliminary design deliberations (Hofmann, 2023)

Process innovation

Insights into the structural process were collected by the project design team throughout the prototyping process. They reflect on successful team forming and trust building processes and delineate how embrace3 prototype fitting practices differ from conventional fashion design fittings. One of the key findings from the trial of a wearer-centred design process within a needs-based design framework was the positive impact of the team's communication strategies on the design results. Two types of situation were most relevant: team meetings and prototype fittings.

The breast support needs of individuals who "may choose not to have breast reconstruction or wear external prostheses" (Hofmann, 2023) are significantly underserved by the underwear industry, which almost exclusively caters for symmetrical bodies. Similarly, post-mastectomy bras are almost exclusively designed to re-establish body symmetry and to be worn with external breast prostheses. Therefore, embrace3 explicitly focuses on individuals who feel overlooked and whose needs are unmet by available breast support products.

Team meetings

The embrace3 design team held several team meetings during the project timeframe. The first meeting was primarily a brainstorming session between the design specialists to decide on the technical path for the prototype iterations. A second and particularly important team meeting introduced the design specialists to Jacobe de La Tour; Jacobe joined the team as the embrace3 expert wearer based on her experience of wearing clothing in the context of breast cancer.

The team met for brunch to eat, drink and discuss the project. This setting was purposefully chosen to bring everyone together on an equal plane, outside the design studio setting – to meet as people rather than as professionals. The team also invited Johanna Benz to attend and illustrate the conversations as graphic recordings. During later reflections as a team, we learned that Jacobe's storytelling – whether as a monologue, a conversation or when answering questions – provided the other team members with a unique insight into the design challenge and a deeper understanding of her experiences. Each participant remembered relevant moments from that meeting and when these individual pieces of information were brought together during the project timeframe, they provided a rich context which went beyond spoken words and reflected real insights into Jacobe's lived experiences.

Prototype fittings

The communicative team meetings laid a foundation of trust and collective experience for the embrace3 prototype fittings. Fittings are central to any clothing design development and the embrace3 fitting processes were modelled on those used in the clothing design industry, where garments go through several iterations of corrections before they are released into industry manufacturing cycles.

The embrace3 team added the element of garment wearer testing to these processes. Jacobe wore each prototype for a few days going about her everyday life and she reported back to the team about her experiences, ideas and needs through video reports. The team members then met Jacobe for the fitting of the prototype on her body. The knowledge gained from the wearer testing and the fitting was visually documented on the prototype, which then served as the starting point for creating the next prototype iteration and for beginning the next iterative cycle. The team went through three prototyping cycles within the embrace3 timeframe before the final prototype was completed to everyone's satisfaction. This final breast support garment incorporated Jacobe's specific body topology and addressed the design challenges outlined in the technical innovation section of this report.

Still from a video of an embrace3 prototype fitting (Hofmann, 2023)

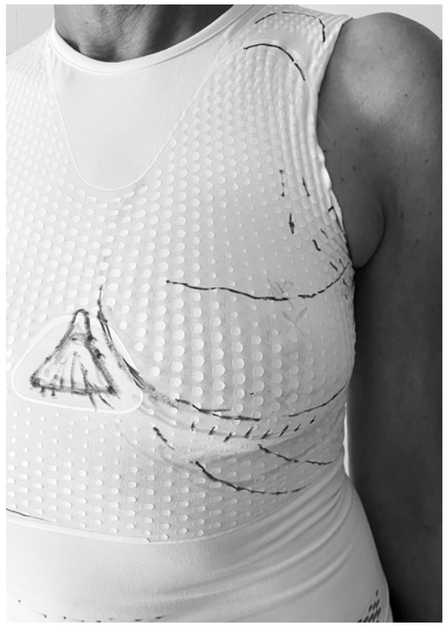
The trust building exercises that preceded the prototype fittings were essential to creating a safe and comfortable environment for Jacobe and the team during the fittings. These sessions involved close contact and would certainly be an unusual experience for anyone outside a clothing design context. Communal conversations and thinking processes were transferred from the more relaxed atmosphere around a table while eating, drinking and chatting, to the setup of the fitting. In an unpublished manuscript, Felix Rasehorn described his observations from similar embrace2 prototype fittings as follows:

> A fitting is in itself a technical process in which those involved come together to try a variation of the prototype on the wearer‘s body and evaluate it. In our case, specialists from different disciplines met, and brought their varied vocabularies, ideas, and backgrounds to the discussion. How does one ensure that in this situation, the most important information is shared and discussed? You [Silke Hofmann] planned the fittings to be almost like happenings, which gave the situation an air of lightness and positivity. This provided the perfect environment for cultivating a shared understanding and also helped us to develop the self-conception of a team with a common goal. Thus, the fittings were situations in which individual competencies could take a step back and common interests could be highlighted. It was on the physical prototypes that these communication and development processes were intensively negotiated. (Rasehorn, 2022)

Adenauer and Petruschat (2012) argue that a new emerging generation of design prototyping is not owned or directed by anyone. Instead, these prototyping processes are a communal effort where the prototype itself is a common resource and beyond an artefact (Adenauer & Petruschat, 2012). They outline a process-based approach towards prototyping that encourages participation, play and intuition in design development processes, and which fosters problem-solving strategies rather than methodical product development. Thus, the prototype becomes a matrix and a developmental communication tool for the collaboration of the design team.

Adenauer and Petruschat's (2012) concept is reflected in the experiences of the embrace3 team during the fittings; the prototypes became more than material artefacts, instead they became a form of visualised knowledge transfer. Because Jacobe decided independently about how and when to wear the prototypes in her everyday life, they evolved to become documentary tools providing a wealth of information in each specialist's discipline. During the fittings, each prototype iteration became a visual map on which all the specialists were free to manifest their design deliberations and insights, and on which Jacobe visualised her aesthetic and ergonomic clothing needs. This accelerated the design process and took the team's quest to find a solution beyond the defined goal of the project, which was to test decentralised support (as described in the next section).

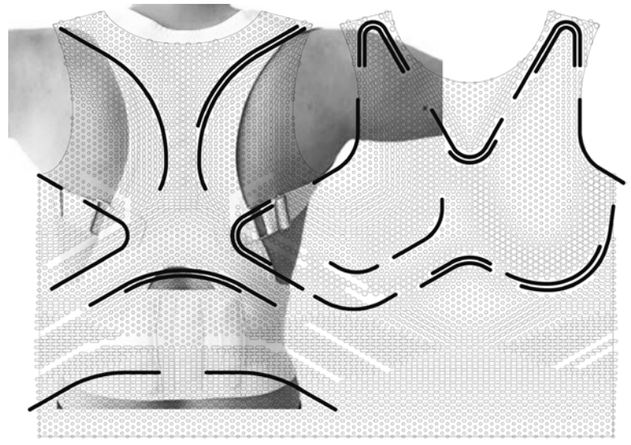
Photograph of an embrace3 prototype worn by Jacobe (Hofmann, 2023)



Technical innovation

The innovative technical development of embrace3 builds on the concept of embrace2: a decentralised breast support system based on a parametric algorithm that reacts to the torso topologies of individuals based on a photogrammetric 3D body scan. Parametric algorithms are based on mathematical models to outline input-output relationships. They impose more limitations than nonparametric algorithms, however, they are also faster and simpler to train, and they are well-suited to scenarios featuring clearly defined, predictable input data.

The decentralised approach emerged from the design principle of tessellation. The Tessellated Material Systems (TMS) research group is conducting foundational research as part of the "Matters of Activity" Cluster of Excellence at the Humboldt University Berlin. Felix Rasehorn from WINT Design Lab is exploring the relationship between form and function in TMS in collaboration with material scientists, morphologists and engineers as part of the research group. His practice-based doctoral research focuses on the transferability of form-function principles to parametric design concepts and manufacturing processes.



Collage of the parametric algorithm computer illustration imposed over a photograph of a back brace (Hoske, 2023)

Tessellation principles are particularly suited to the creation of decentralised breast support structures. These small variable tile shapes provide gradations of opposing functions (soft and hard) while responding to individual body shapes to create a gentle yet protective structure around an individual's topology. Directed by a parametric algorithm, tessellated support structures have the technical ability to accommodate a wearer's specific breast support needs while being mass-customised in clothing industry design manufacturing processes.

Jacobe's specific clothing needs and body topology defined the design challenge for embrace3. The embrace3 team created a breast support for her left breast; the right side of her torso is flat. The breast support garment has a symmetrical deep v-neckline positioned in the centre of her torso. Alongside providing support for a single breast, achieving a symmetrical neckline on an asymmetrical torso was one of the main design challenges during the project. The team balanced the neckline through three prototyping iterations by fine-tuning the differently sized tile shapes to control the stretch of the textile by either blocking or releasing the textile's elasticity around the torso. In addition, the parametric algorithm was calibrated to support Jacobe's posture by guiding her to lift her upper back and reduce her lordosis (hollow back) through strategic tessellated tile placements. The final embrace3 prototype design and the parametric algorithm have been registered with the German Patent and Trademark Office.

Photograph of the embrace3 tessellated support structure, detail (Hoske, 2023)

Photograph of the final embrace3 prototype, back detail (Kurth, 2023)

Photograph of the final embrace3 prototype, front detail (Kurth, 2023)

Learnings

This section of the report summarises the knowledge gained from structural insights and technical developments achieved during the project timeframe.

Project analysis

The two strands of the embrace3 research project – process innovation and technical innovation – led to mutually conditional experiences that can be summarised as two main strategies: sensitive listening and the triple constraint paradigm. The findings from these strategies were reciprocal and operated in an equilibrium – a balance between a relationship-building practice (such as listening) and a framing strategy (such as managing a project). The quality of the final prototype and the level of product innovation were improved by creating a stabilising framework around the artistic endeavour and guiding the design process through deep insights gained in this safe space.

Photograph of Jacobe wearing the final embrace3 prototype (Kurth, 2023)

Sensitive listening

The embrace3 team applied sensitive listening skills during team meetings and prototype fittings, as mentioned earlier in this report. The team was thus able to involve the wearer in the creative design process in a caring and attentive way. The embrace3 team learned that this inclusion increased the wearer‘s self-efficacy and that involving the wearer in the creative design process also increased the wearer’s consciousness of their clothing needs and deepened their understanding of design process latitude within material and method constraints. At the same time, immersing the designer in the wearer‘s perspective and their lived reality deepened the designer’s understanding of the wearer’s specific clothing needs (Jones & Ficklin, 2012).

Active listening or sensitive listening is "simply a way of approaching problems" (Newman, 1987, p.1). The sensitive listening strategy relies on the capacity of the listener to value the speaker’s narrative, viewpoint and self-direction. This method emphasises the acknowledgement of feelings and non-verbal forms of communication beyond verbal cues in order to understand the full meaning of a story. “Despite the popular notion that listening is a passive approach, clinical and research evidence clearly shows that sensitive listening is a most effective agent for individual personality change and group development” (Newman, 1987, p.1). Thus, sensitive listening encourages mutual listening and a willingness to consider different perspectives; this reduces the causes of arguments and promotes introspection enabling individuals to be more attentive and to express their thoughts and feelings more clearly.

The embrace3 team actively experienced how this form of listening surpasses mere information sharing. At some point during the project, all team members described how these encounters had a long-term impact on their experiences of working individually, in pairs or as part of a group. The team members agreed that they were able to develop design ideas more effectively because of their deeper level of understanding of Jacobe’s circumstances and clothing needs. Moreover, Jacobe’s positive responses to each evolving prototype iteration during the wearer testing are testimony to the effectiveness of this empathetic strategy.

Triple constraint paradigm

The triple constraint paradigm is a theory that originated from the discipline of project management. As a method, the triple constraint paradigm provides a model for the connection between a project‘s scope, cost and time in relation to the quality of the project outcome. The theory argues that every project has limitations to its resources. Scope, cost and time are interrelated components of a whole, similar to the three sides of an equal-sided triangle. When all three constraints are balanced, they produce a high-quality project outcome. Any change in one of the triple constraints, however, also affects the other two and requires a balancing response in order for the workflow to function effectively and efficiently (Van Wyngaard et al., 2012).

This theory was an essential aspect for the successful management of the embrace3 project and team, as well as the technical product innovation. Levelling and harmonising resources alongside the embrace3 prototyping process helped the team to deal with unforeseen modifications to the process while ensuring high quality results and maintaining the space needed for collaborative wearer-centred design processes. Through working with this theory, it became apparent how much time and money were needed to balance out unpredictable circumstances, such as the sudden illness of a team member or changes in deliverables and timelines by the funding scheme.

Photograph of Jacobe wearing the final embrace3 prototype (Kurth, 2023)

Linking back to CIRCE

This section of the report summarises how insights from the embrace3 project relate back to CIRCE's effort to support creative impact in creative and cultural industries. This section also presents an outlook for the next developmental steps of the embrace3 project.

Project conclusion

As an ongoing, in-depth clothing design exploration at the intersection of breast cancer, female intimate health and wearer-centred clothing design, an overarching aim of all three embrace iterations (embrace1, embrace2 and embrace3) was to develop and test design practices that exemplify the potential for structural change in design processes within the European clothing industry. This structural change is especially desirable in the durable medical equipment sector, in which European manufacturers are global market leaders; this sector includes Amoena, the German post-mastectomy bra and external prothesis manufacturer. Improving and advancing operational structures in this sector with regard to approaches such as wearer-centred clothing design and collaborative processes could potentially expand the relevance of the European clothing industry and improve innovative developments and partnerships in a global context.[8]

In this respect, the triple constraint paradigm could be a useful tool, especially in the context of wearer-centred clothing design processes, which require different development timeframes to conventional clothing design processes. Based on my background in the international clothing industry, I believe that these findings are scalable and transferable to larger clothing design and manufacturing processes.[9] In the context of policy development in European cultural and creative industries (CCI), specifically in Europe's clothing industry, the triple constraint paradigm has the potential to provide a useful measurement framework. Achievable project deliverables could be estimated on the basis of budget and time restrictions when considering funding call structures. In addition, desired scopes of project results could be taken as a starting point, and budgets and timeframes could be allocated according to the triple constraint paradigm.

Project outlook

The final embrace3 prototype developed within the Creative Impact Fund timeframe will now be prepared for the next phase of industry viability testing. In this developmental step, the embrace3 team will generate technical datasets that measure the breast support capacity of the decentralised tessellated structures in order to calculate and predict their precise functionality. This information will also inform and improve the parametric algorithm that responds to individual body topologies and posture. The scientific textile tests will be carried out in collaboration with the Swiss Federal Laboratories for Materials Science and Technology (Empa). The test results, along with the final results of the online study on breast support preferences, will form the basis of a joint research paper and provide further insights into the potential commercial relevance of the current embrace3 prototype.

[8] Durable medical equipment (DME) encompasses essential items, including wheelchairs, ventilators and walking sticks, as well as mastectomy bras and breast prostheses (Carlos, 2020).

[9] I studied Fashion Design at the Fashion Institute of Technology, New York, USA (BA) and Central Saint Martins, London, UK (MA). I have over 15 years of experience as a designer in the prêt-à-porter industry.

Team credits

Jacobe de La Tour	Project designer and clothing wearer
Silke Hofmann	Project manager, researcher, designer, final report author
Robin Hoske	WINT Design Lab, project designer and parametric algorithm designer
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Bibliography

Adenauer, Julian and Petruschat, Jörg (2012). *Prototype! Physical, virtual, hybrid, smart; tackling new challenges in design & engineering.* Form + Zweck.

Alberta Health Services (2023). *Preventing lymphedema after treatment for breast cancer: care instructions.* https://myhealth.alberta.ca/. Retrieved December 15, 2023, from https://myhealth.alberta.ca/Health/aftercareinformation/pages/conditions.

Arnold, M., Morgan, E., Rumgay, H., Da Costa, A. M., Singh, D., Laversanne, M., Vignat, J., Gralow, J. R., Cardoso, F., Siesling, S., & Soerjomataram, I. (2022). Current and future burden of breast cancer: Global statistics for 2020 and 2040. *The Breast*, 66, 15–23. https://doi.org/10.1016/j.breast.2022.08.010

Benz, J. (2023). Die Brust [Illustration].

Benz, J. (2023). Die Frau is going Flat [Illustration].

Benz, J. (2023). Es gab keine Unterwäsche für Frauen wie mich [Illustration].

Benz, J. (2023). [Illustration of a hand holding a breast].

Breastcancer.org. (2021, April 30). *Lymphedema: symptoms, treatment, and risk factors.* Retrieved December 15, 2023, from https://www.breastcancer.org/treatment-side-effects/lymphedema

Carlos, B. (2020, December 5). Durable medical equipment? *Curetoday.* Retrieved December 15, 2023, from https://www.curetoday.com/view/durable-medical-equipment

CIRCE. (2023, November 29). *CIRCE – Creative Impact Research Centre Europe | CIRCE.* Retrieved December 15, 2023, from https://creativeimpact.eu/en/

CIRCE. *Creative Impact Research Centre Europe, Prototyping Collaboration* (1st ed.). (2023). Creative Impact Research Centre Europe (CIRCE). Retrieved December 15, 2023, from https://creativeimpact.eu/en/publication-prototyping-collaboration/

Eske, J. (2020, February 27). *What to know about breast shapes*. Retrieved December 15, 2023, from https://www.medicalnewstoday.com/articles/breast-shapes

Hofmann, S. (2023). embrace3 online study illustration [CAD illustration].

Hofmann, S. (2023). embrace3 online study illustration [CAD illustration].

Hofmann, S. (2023). embrace3. Design team meetings and prototype fittings [Stills from video].

Hofmann, S. (2021). *Needs-Based Clothing Design and Textile Preferences – Re-FREAM*. Retrieved December 15, 2023, from https://re-fream.eu/needs-based-clothing-design-and-textile-preferences/

Hofmann, S. (2023, June 21). *embrace3 | CIRCE*. CIRCE. Retrieved December 15, 2023, from https://creativeimpact.eu/en/creative-impact-fund/embrace3/

Hofmann, S., Rasehorn F. (2022). Sensitivity in the Design Process [Unpublished manuscript]

Hoske, R. (2023). embrace3 tessellated support structure [Photograph].

Hoske, R. (2023). embrace3. Parametric algorithm computer illustration imposed over a photograph of a back brace [Collage, CAD illustration, photograph].

Johns Hopkins Medicine. (2023, December 1). *Post-Mastectomy prosthesis.* Retrieved December 15, 2023, from https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/postmastectomy-prosthesis

Jones, B., & Ficklin, L. (2012). To walk in their shoes: Recognising the expression of empathy as a research reality. *Emotion, Space and Society,* 5(2), 103–112. https://doi.org/10.1016/j.emospa.2010.10.007

Kurth, I. (2023). embrace3 photographic production. [Photographs].

Mayo Clinic. (2023, September 8). *Male breast cancer – Symptoms and causes – Mayo Clinic.* Retrieved December 15, 2023, from https://www.mayoclinic.org/diseases-conditions/male-breast-cancer/symptoms-causes/syc-20374740

Newman, R. G. (1987). *Communicating in business today.* D.C. Health

Sand, K. (2021). *Diversifying Clothing Design through Additive Manufacturing – Needs-Based Clothing Design by Silke Hofmann –* Re-FREAM. Retrieved December 15, 2023, from https://re-fream.eu/pioneers/needs-based-clothing-design/

Taylor, A. (2019, July 4). *Lymphatic Decongestion and Breast Health – Kalon Spa.* Kalon Spa. Retrieved December 15, 2023, from https://kalonspabellevue.com/blog/2018/10/4/lymphatic-decongestion-and-breast-health

Van Wyngaard, C. J., Pretorius, J., & Pretorius, L. (2012). Theory of the triple constraint – A conceptual review. Institute of Electrical and Electronics Engineers IEEE. https://doi.org/10.1109/ieem.2012.6838095

World Health Organization. (2023, July 12). *Breast cancer.* Retrieved December 15, 2023, from https://www.who.int/news-room/fact-sheets/detail/breast-cancer