What Negative Space has to do with Design Fixations in HCI Research

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ABSTRACT
Human Computer Interaction (HCI) is a design-oriented research field, articulating and contributing to design knowledge. This research field has its own perspective of what a relevant design solution is or which design methods that are suitable, which does not necessarily match how for example industrial designers would understand or describe design. We aim to extract the core of design as an activity, in order to clarify what design skills may involve. This paper describes design activities, and articulates how negative space as an artistic skill is a prerequisite to achieve re-framing a design situation and to facilitate successful co-creation of wicked design challenges. The notion of negative space is traditionally associated to art and perception, for example used in professional practices in music, art and design. We illustrate how making use of negative space supports avoiding design fixations, and increase the chance of successfully addressing wicked design problems, such as sustainable solutions for societal challenges. We argue that HCI research would benefit from understanding and applying negative space in design challenges and illustrate how this can be done.

Author Keywords
Negative space, design fixation, figure ground, design skills, design process.

INTRODUCTION
In this paper, we argue that the ability to understand and address *negative space* is a crucial design ability which needs attention in HCI research.

"*Positive space is what surrounds a negative form, and negative space is what surrounds a positive form. […] This is because positive space can be a background for negative forms, and negative space for positive forms*" Wong [44]

Research in HCI seeks out to explore and understand design in relation to use of computer technology; predominantly concerning change and implications for design of novel computing technologies or interactive systems [4] ,[14]. At the same time, *design* is increasingly becoming acknowledged as a more general process and methodology that can contribute at different levels of more or less "wicked problems" [7, 42] and in innovation work [16, 22, 45]. What challenges do design oriented HCI research face in order to successfully solve societal issues through design?

Imagine this scenario:

A design-oriented HCI researcher works on waste challenges related to households. Several interviews with experts – different stakeholders from the waste industry – all suggest that the problem is that households are not engaged enough in recycling activities. The HCI researchers interviews some households about their recycle practices and then start to explore possible designs - an app and another interactive solution. Several households take part of a study that involves using those solutions in order to increase their recycling activities. The study shows how the design solution reminds households to reduce their waste and do their recycling activities.

This is a fictive case that at first sight might seem unproblematic. In the forthcoming, we will take another viewpoint. We will argue that by addressing negative space, which is a design skill, the outcome of this scenario could have a profoundly different starting point: This would increase the chances of creating a greater impact when addressing this societal challenge. We will illustrate this by presenting a related *real* case where industrial designers are working on a waste management challenge. We will especially describe how they made use of negative space to understand the real underlying problem, rather than accepting the perspective agreed upon in the interviews - that the households would be the given primary target group to address the problem. To clarify negative space further, we will also provide a second case, that illustrates another real case where designers addressed negative space in sewing activities.

There are several confusions related to the theoretical understanding of design knowledge in HCI. First of all, an early perspective in HCI has been to understand and approach *design activities* as the making of artefacts, following Herbert Simons perspective of the Science of Design [39]. This is a fundamentally different compared to design that concerns re-framing and co-creation, which we will describe in the forthcoming. The latter perspective is related to different discourses of *designerly thinking* as a - reflexive practice, - way of reasoning, - creation of meaning, or - wicked problem solving [23]. *Design thinking* is a related notion that has been understood "to describe what designers bring to problem solving and to rationalize why designers need to be included in a project or process" [47]. However, Johansson-Sköldberg et al [24] argue that

design thinking also can refer to a process where people without design education conduct design processes. It is important to note that these different discourses on design knowledge are mutually co-existing, which makes it difficult to understand how artistic and creative training may affect design outcomes.

Another challenge to understand design is that some researchers in the HCI field have argued that everyone is a designer. Similarly to Buxton [9], we argue that such perspectives limits the understanding of design as a competence involving specific skills and how those skills are reflected in practice. When everyone is conducting design and articulating design activities in research, how does that affect our understanding of design in HCI? Several researchers have previously problematized the difference of design practice conducted among interaction design professionals and how it is articulated in research [6, 10, 12, 14, 16] However, when we refer to term *designer* in the forthcoming, we will not refer to HCI practitioners, but to people with professional training and practical experiences industrial design, including training of artistic skills.

Our work is related to design oriented research or *research through design* (RtD), as we aim to articulate design knowledge. A few years ago *design oriented research* concerned to articulate and formulate design knowledge related to design processes, such as design methods e.g. [8, 20, 21]. More recently several techniques and approaches within HCI are instead described as RtD. RtD can be understood as design activities that researcher do in order to provide contributions of knowledge, rather than to inform a commercial product [47]. This has also concerned to articulate design knowledge, design methodology and clarifying the role of design in research (e.g. [13, 39, 47]. RtD is still an emerging practice, and there are contradictions and confusion about what it is or might be [3, 17]. Whereas [3] has focused on design as a noun: design as objects, we will here focus on design as a verb: a process. Our approach is related to Fraylings original notion of "Research into art and design" (i.e. providing theoretical perspectives on art and design) [15]. Our goal is to discuss design expertise (i.e. design knowledge and designerly thinking) based on theory as well as studies of design practitioners, and to highlight how negative space should be understood as a core design skill.

This paper focuses on the kind of design activities and perspectives that are needed in order to be able to take a more holistic perspective of design in HCI. Even if HCI research may explore more holistic perspectives on humanistic aspects such as empathy, users and stakeholder needs, the research is essentially oriented on how human computer interaction design may contribute to our lives and society [13]. This brings specific socio, cultural and environmental consequences to our society [4]. HCI research has been criticized to encourage an understanding of needs as implications for design [11]. Other researchers are concerned about the way HCI approaches design and research [5, 30, 37], arguing that HCI research need to consider the negotiation of design in order to understand the limitations and negative effects of technology. For example, Pierce [31] asks to "what extend and in what ways could undesigning technology be an acknowledged and legitimate area of design research activity within HCI" (p. 964). Moreover, he asks for the kind of activities that are available when there is a strong argument for undesigning technology. Sometimes ICT should actively be removed or considered not to be part of a solution [5]. They ask for an increased focus on the problem space, which we here will address. We argue that understanding and applying negative space in design challenges, is a way to deal with the problem space, to understand design fixations and more successfully address societal challenges.

In this paper, we argue that the ability to understand and address *negative space* is an important design skill, that can be used at many different levels. The notion of negative space is relevant for RtD research that aim to construct and communicate design knowledge in the academic field of HCI. In the forthcoming we give an account of existing use of negative space in art, music and design. We will also describe two cases that exemplifies how understanding and addressing negative space is an important ability among designers, and is the foundation for any kind or re-framing of a design challenge.

WHAT IS NEGATIVE SPACE?

The notion of negative space is prominent in many different areas. We will first describe negative space in various areas such as art, music, gardening and psychology, and then describe how negative space could be understood as a central design skill.

In Japanese architecture and design of gardens, the word *ma* is used to describe a negative space; an empty space used to create meaning [46]. Negative space also occurs in dance, when dancers stop moving. In martial arts it is called Maai - referring to the engagement distance in time, angle and rhythm between two opponents in combat [28]. Maai should be maintained and actively considered, to prevent the opponent to maintain maai.

Negative space is used for defining urban space e.g. as the space that is undeveloped or left over after development without a function awaiting redevelopment [10]. Other types of negative urban space are service spaces intended for service needs e.g. car parks and spaces for satisfying movement needs e.g. roads and railways (ibid.). These spaces complement the positive and private spaces.

Negative space is also prominent in non-visual concepts, such as melody and harmony. In music, negative space is called Lacuna, an intentional accentuated silence and/or pause where no note is played. Some of the more well-known uses of negative space in music can be found in the

works of John Cage (incorporated three long silences in *4'33"*).

In psychology, the human ability to move between different ways of interpreting an image has been extensively addressed. Gestalt laws of perception include the ability to change perspective when looking at an image, typically referred to as figure-ground organization (e.g. Edgar Rubin's vase). In art and design education, gestalt theory's laws of perception are one of the early topics that students learn and utilise in their work e.g. in sketching exercises where the students focus on artefacts' silhouettes or borders in order to define and specify the positive and the negative space. This may involve shifting the order of negative and positive space e.g. an artefact is sometimes seen as the negative space, and sometimes as in the positive space.

Negative space surrounds a positive form, but also a positive form can be considered to surround negative space [2, 44]. Negative space can be understood as a void or/and an empty space or background. In visual arts, space is an element that refers to distance or an area between, around, above, below or within things. It involves addressing a holistic perspective where empty space/matter, foreground/background, light/dark, opaque/transparent, and blurred/sharpened relate to each other. For example, positive space can be filled with something such as lines, colors, shapes etc., while negative space can be empty space within a volume.

Arnheim argues that artists are typically trained to "perform perceptual reversals routinely" when working (p. 236), which is a basic difference in the vision of the artist and in everyday behaviour [2]. Arnheim describes how figures in a painting only can be understood if the spaces that separate them also are as well-defined and worked through as the figures. "Negative space must be perceivable in their own right." [2] (p. 236). Negative and positive space are typically used and seen simultaneously during sketching activities, e.g. in croquis as well as in industrial design concept sketching. This suggests how artistically trained practitioners, such as industrial designers, have developed skills in flipping or switching perspectives of foreground and background in a design situation. It is likely that this ability is used in other situations than sketching. Designers may pay detailed attention of what someone is expressing as taken for granted or are underlying practices when observing or interviewing people [26]. Designers should develop an understanding for underlying principles and practices that structure a situation, and how those affect how people resonate or act for example when using work tool in a specific way. Lawson [26] describes how given structures may limit thinking, and how skilled designers apply methods to trigger lateral thinking (applying different perspectives) instead of being fixated through vertical thinking in a design situation. We argue that "seeing" foreground as background could be understood as a specific kind of lateral thinking that address negative space.

Our perspective of negative space in design is that it is not an empty space, but a space that is currently considered as a background, rather than a foreground in a specific design activity or design challenge. In the forthcoming we will argue that it is useful to differentiate between *unidentified negative space* and *identified negative space* in design. Unidentified negative space has not been understood or acted upon, whereas identified negative space is acknowledged and can thus be acted upon. Our two design cases will illustrate how unidentified negative space becomes identified, and then how it can be turned into positive space.

DIFFERENT PERSPECTIVES ON DESIGN EXPERTISE

Definitions of design and descriptions of design skills vary greatly in different strands of design theory. Below we describe three different stances to design, that we find can apply to design activities done in HCI research. What the different theoretical stances below have in common is that designers are working either through using systematic methods or in a reflective conversation with the situation (individually or in interaction with others. Whereas the first perspective; *problem solving*, does not open up for understanding negative space, *design as re-framing* and *design as co-creation* are perspectives that open up for understanding and addressing negative space.

Design expertise as problem solving

Central developments in design theory and methodology were rooted in seeing design as problem solving. One of the major objectives in this perspective was to systematise design work and make it "less circular and more linear" [24] (p. 52). This view set the scene for design methods movements that took off in the 1960s, formalising design with the same standards that science has from a rationalist doctrine.

"Problem solving is often described as a search through a vast maze of possibilities, a maze that describes the environment. Successful problem solving involves searching the maze selectively and reducing it to manageable proportions." Simon [40] (p. 54)

In one early text that influenced this view, problem solving is defined in terms of reconciling the solutions of the sub problems with each other, requiring evaluation, judgement, and intuition, while the beginning and end of the process is rendered as analytical and executive [1]. Various phase models of design were proposed in this vein, e.g. Jones'[25] analysis, synthesis, evaluation model that involved (i) analysing the design problem, its constraints and criteria to formulate requirements, (ii) decomposing the problem into pieces, solving them separately or in parallel, and putting the pieces together in a new way, (iii) evaluating the appropriateness of the solutions with the help of formulated requirements to meet the problem criteria and constraints, and testing to see whether they conform.

Within this perspective of design, negative space can be challenging to understand and successfully address. This is because this perspective concern to identify a problem, and then divide the problem into sub problems and to solve those. This limits the understanding of why and how to reframe an overall design challenge.

Design expertise as reframing

The problem solving view was based on the assumption that design problems were definable and easily decomposable. However, many design problems are not possible to decompose; they are not fully defined, they involve uncertainty, confusing information, and value conflict among different stakeholders, and as a result do not have a solution, they only have temporary resolutions (cf. wicked problems in Rittel and Webber [32]. The methods of the problem-solving view did not suffice for finding resolutions to these unique problems. Furthermore, the notion that one general approach for solving problems was viable did not capture the artistry involved in designing when dealing with wicked problems. This view also assumed a dualism between knowing and doing that ignored the tacit mode of knowing-in-action. As a reaction to these assumptions, radically new ways emerged for describing how wicked problems were addressed in design practice.

A perspective of design practice that is even more closely connected to negative space is discussed by Schön [38]. He is taking the notion of wicked problems into consideration, and is describing how designers approach these problems and navigate between their conflicting values and constraints through problem setting; a process that *involves looking at the problem from different angles*, and setting a frame for the problem situation. In this process, the designer conducts move experiments for *reframing the problem*, oscillating between design of details and reflection on the implications and consequences of each experiment on the whole. This leads to questioning assumptions about the problem situation and gives rise to new insights and reconstruction of the initial framing, which can then be tried again. In this view, "problem solving is a part of the larger experiment in problem setting" [38] (p. 165). This involves reflection-on-action (rooted in Dewey's learning by doing) that happens after having engaged in an activity and reflection-in-action that occurs during the practice where knowing and doing are interwoven components of knowledge generation.

The language of designing is a parallel process of sketching and speaking about the design used to teach, learn and communicate. This is carried out in a fluid manner where sketching extends thinking in the moves experiments, and reflection supports making subsequent marks on paper. Schön's dialectic theories on professional artistry, was based on a close inspection of conversations between students and supervisors using sketching, where demonstrating, advising, questioning, negotiating and criticising directed the learning experience. He argued that designers' competence, understanding and feel for the material and media is crucial for constructing and manipulating representations which enables rigorous experimentations and reflection-in-action. We will in the forthcoming argue that that reframing also can occur before any kind of design material is considered. Moreover, we argue that whenever reframing occurs early in a design process, it concerns to address negative space in a way that can lead to more radical innovations.

For designers, looking at a problem from different angles and reframing the situation, can be supported by sketching or other activities to understand and articulate for example flows and more holistic perspectives.

Design expertise as facilitating co-creation

Design and development of new products is a complex task that requires integration of different skills, viewpoints and values from different disciplines. According to Minneman [29], evolution of design solutions depends heavily on negotiating strategies and social interactions among individuals as they strive for establishing, maintaining and developing a shared understanding.

Apart from intensive collaborations between various stakeholders within boundaries of a firm, design processes may also involve user participation. Participatory design practice aims at empowering user and reducing the gap between the designer's conception of the problem, and the real needs and goals of the users [27]. This may take various forms: (i) treating users as sources of information and using methods from social sciences in order to understand gather that information, and engaging in ad-hoc evaluations and analysis of the information gathered in user tests, (ii) borrowing marketing techniques and ethnographical approaches e.g. in probes to elicit user needs, (iii) engaging in creative collaboration e.g. in workshops for design of possible futures [36]. In the latter form, participation is a key element where users become active stakeholders and bring their [19]own expertise to the design process.

In this view, design expertise "is distributed among all stakeholders, and that the design process has an argumentative structure in which one had to make up one's mind in favour of, or against, various positions on each issue" [12]. The sources of ideas in such a process, according to Bucciarelli [6], are found in the conversations between participants. Designers, in this collaborative process of reflection-in-action facilitate for the people to share experiences and knowledge, and partake in the decision-making [36]. Collaboration between different stakeholders with different perspectives, values and skills is an information-intensive process, organised around design representations [19].

The stakeholders can be experts in certain areas, and have a specific perspective of looking and understanding a design

challenge. Here, a designer's ability to support others to change the perspective of what is foreground and background is essential in order to avoid that stakeholders get fixated on certain perspectives or solutions that might hinder to understand the real underlying problem.

Design fixation

We find that the ability to make use of negative space, is the prerequisite for being able to reframe design situations. Skilled industrial designers actively work to avoid fixating on solutions or perspectives early in the process, and use different methods to understand a design situation from different perspectives. The terminology used in academia and in engineering to describe this fixation are *design fixation* and *functional fixedness*, which are both considered a cognitive bias [23, 32].

Functional fixedness concerns the tendency to be rigid in how one thinks about an objects' function which hinders divergent thinking. Jansson and Smith [23] found that design fixations among engineering design students are due to precedent solutions that they have looked at, preventing them from finding innovative alternatives. Fixation on precedent solutions can be seen in two ways: (i) already existing products, and (ii) designers' own representations of potential solutions. The latter has been discussed by [34], however, only regarding CAD models causing resistance for making major changes. In the present study, premature fixations occurred not only in CAD, but also in sketching and physical modelling. Another study found no fixation effects among industrial designers, whereas this occurred with mechanical engineers [32]. The study concluded that the industrial designers worked with a greater number of designs and more types of designs.

Overall, without specific design skills there is a risk that fixations affect how we understand a design situation and thus also how we approach it. We believe that design fixation is an important concern for the HCI research field, where we agree with several researchers that aim to problematize and open the design space of HCI research [i.e .5, 31, 37].

DESIGN CASES

Using the concept of negative spaces, we will now analyse two different design cases, and highlight how designers engage in different activities and explore different solution spaces. The authors have conducted several studies of design processes and designers as well as design students during the past five years. This includes observations, interviews and diary studies.

We have previously described three different perspectives of design expertise: problem solving, reframing, and facilitating co-creation. Our first case addresses waste management challenges. It can be clarified with both a design expertise as reframing and facilitating co-creation. Our second case concerns the design of a sewing machine. It can be described and understood from a reframing perspective.

The cases are presented to concern certain stages of a six stage model of the design process. The model should be read as a very simplified overview of the design process, where potential iterations and a variety of activities is left out. We will also use these stages or phases in our final discussion on how to address negative space in HCI. These are:

Briefing: initial question, scope and type of the project, design brief, requirements.

Research and investigation: for interpreting the problem or the brief e.g. market research, user research/studies, workshops, discussions, etc.

Interpretation, analysis, setting an agenda.

Idea generation, sketching, modelling, writing, making inspiration boards, etc.

Evaluation, initial testing

Presentation. Concept presentation for receiving feedback and input for further evaluations

Re-framing Waste Management

Waste management concerns activities and actions to manage waste, such as collection, treatment and disposal of waste. There are also specific laws and regulations that affect the system. Also manufacturing, use and disposal of products play a role. This case will concern a *pre-study* in a larger project aiming to produce innovative solutions related to waste managing practices in Sweden. We will focus this case on the phases: briefing, research and investigation, interpretation, and idea generation. The researcher took part in several project meetings and activities, and held an interview only with the designers.

Project group

The designers were part of the *project management team* who planned and organised the pre-study. The other members of the team included two research institutes related to environmental research, water and circulation and city administration. One of them had coordination responsibility in the project. The management team included two research institutes related to environmental research, water and circulation city administration, a municipality owned company providing a city with district heating, cooling and waste-management, and the other was a recycling company converting waste into raw material and the design agency. The *extended project group* (other stakeholders) included representatives from the overall waste collection system, such as civic waste management clients, waste collector actors, a nationwide company that collects newspapers and product packaging from households, a waste management association for private and public waste management and recycling, the national environmental protection agency, a town planning actor.

We will now exemplify how the designers worked in the project and made use of negative space.

Briefing

The project had received funding to conduct a pre-study in order to bring together a project group and develop an initial understanding for a specific societal challenge in Sweden. The project was set to focus on solutions that could improve the current system for waste management and drastically reduce waste, increase re-use and support re-cycling from the perspective of household needs and behaviours. The pre-study was conducted to understand the current management system, its challenges and the opportunities through the eyes of different stakeholders, and to plan for an application of a larger project.

Research and investigation

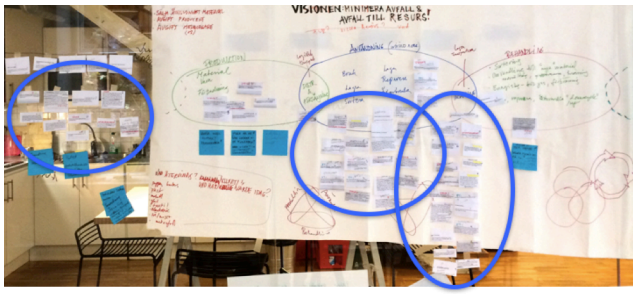

Figure 1. The designers categorized all interview answers in a sketch illustrating the overall circular system of products and waste management as three overlapping circles: From left: *Production (logistics), Use (collection), Treatment.* This revealed positive spaces (blue circles) and negative spaces in the respondents' answers.

The designers' role in the project management group concerned project planning and to arrange the overall activities. This involved to arrange data collection activities with the other team members, such as planning and conducting interviews. Interviews with actors in the extended project group were held. This material would then be analysed to frame the challenge and the forthcoming workshops. Already in this phase, the designers had ideas for the first workshop, and mentioned that it then might be useful to place each stakeholder in a larger context, such as placing their position in an image of a circular economy. The project management team also looked into innovative waste, reuse and recycle projects, failed systems, and other sources of inspiration.

The designers wanted to understand the stakeholders' different visions and where they considered themselves to be today. The interviews with stakeholders concerned; their business idea, how household waste related to that idea, current challenges with waste system that creates obstacles for their business, what is needed in order to create more recycling, successful or unsuccessful projects they heard of, other related questions that they found critical.

Two different project partners were holding the interviews, and one person also did an initial analysis. This person suggested that one of the difficulties was everyday logistics for households, conflicts concerning responsibilities of collecting activities, that some actors made revenue on unsorted waste, and suggested that some kind of gamification concept could work. This person also commented that no reuse actors was currently part of the project. Identifying that one actor is missing concerns to have identified some negative space. Still, at this point, negative space in the collected data was more or less unidentified.

Interpretation

Two designers did their own analysis in order to decide on a set up for the first workshop. The designers approach for

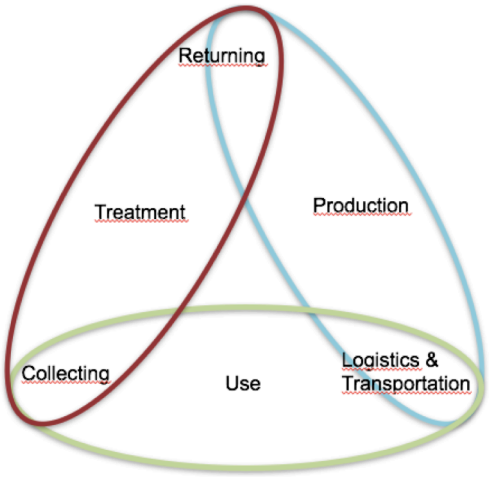

Figure 2. The designers refined their initial sketch of a circular system of products and waste management, to clarify the bigger picture of a circular flow of products and materials.

the analysis was to map out the waste system on a very general level. They made three circles of stakeholders: "production", "use" and "treatment" (See Figure 1). The circles were placed next to each other with some overlap. In the overlap concerned "logistics" and "collection"

The designers approach was to cut out all the interview answers and post them on the drawn map. Each excerpt belonged somewhere or outside the map, for example addressing a treater or user perspective. Some excerpts on laws or regulations were put outside the map. This revealed how the answers were addressing specific areas of the waste system. It also revealed that some areas of the waste system were not addressed at all based on the answers. This way, the designers could identify negative space in the collected data.

The analysis shed light on that the stakeholders primarily considered that the households was the reason why the overall management system did not work fully satisfactory.

Households were not considered to be active enough in sorting and making sure that waste was recycled.

One important consideration for the planning of the next step: an idea generation workshop, was how to make stakeholders share their expertise and contribute.

When planning for the workshop, a senior designer suggested that the participants would need to "think away from users in the workshop. Make people move away from their downpipe perspectives. (…) Maybe it is because it is more easy or more comfortable to think about it." She expressed that there was a "need to create larger perspectives (…) part of flow." The designers also refined their sketch of the circular system (See Figure 2), to communicate a holistic perspective of a sustainable system to the stakeholders.

Idea generation

The idea generation workshop was the first out of two workshops that were held with stakeholders. The first workshop focused on what and which parts that affects the waste chain – such as manufacturing, distribution, sales, use, storing, and collecting, treating, and finally new products of reused material. This workshop focused on finding possibilities for changes in the overall system in order to reduce, reuse and recycle. The second workshop would instead focus on changed roles. For example, the producer as a collector and treater, sales as collectors. In this paper, we will focus on the first workshop, to illuminate how the designers actively work with negative space, and to reframe the stakeholders understanding of the current system and its challenges.

The designers made a brainstorming exercise where the participants were divided into diverse groups and asked to "Imagine a scenario where the human or the collection system is not a factor that affects how good the material is when it should be recycled. What is the requirement on producers and treaters to minimize waste?" The participants were also asked to focus on potential collaboration opportunities for producers and treaters. Thus, the designers focused on moving the users from being positive space, into becoming as negative space or background. This was done to hinder the stakeholder from their current fixations on users which could prevent them from taking a more holistic perspective of waste management challenges.

After the brainstorm activity, the workshop took a different turn and the user was made into positive space again. This time, the negative space was the rest of the system. It was still there, but as an unproblematic space, out of focus, that made the overall system work great for the user. "If we have reached the goal with as little waste as possible, and where as much as possible is reused, how does material/product/packaging look for the user?" Each group got personas to work with, such as "Greta 83 years, living alone, having home care" and "a family of two men with children living in the city without a car", "student living alone" and "an office with 10 people, older facilities".

Overall, the result from the workshop revealed the importance of making producers be responsible for the product when is becomes waste. Overall, the producer should expect that product comes back. There was also a need for taxes based on how recyclable products are. Overall products would need to have simple and clean rather than complex materials, and stay clean throughout the entire life cycle. For example, it was prominent that digital id and QR codes could support tracking and to tax the producer according to climate impact, such as if the packaging is bigger than needed. New rental and other services such as recycling could potentially be part of home care.

Interviews with the designers

The idea generation workshop was considered successful in generating ideas related to a vision for waste management. After the workshop, two designers (one senior and one young) were interviewed about their understanding of the activities and their role.

The senior designer expressed that they were trying to make the participants see the situation differently, by understanding spaces: "It's like when you paint a picture, the picture is not complete without the spacing. This is exactly what we are doing today. That's actually the thing that is interesting. The wholeness."

This designer also pointed out the risk of not being able to take a more holistic perspective. She argued that to "improve on the things that are already there, then you will not get as far." She also expressed that the reason to "think away" the users in the workshop was to make people move away from their pipeline perspective, and to create a bigger perspective part of a flow. She said that" what already exists today often get dominating. [People] don't see what it is really about. This is what you always need to do in design. What do you put as the central question? Reduce waste. Make waste a resource. That is our starting point."

The young designer argued that people might find it uncomfortable to think long-term and to really dig into needs with a more holistic perspective "It is experienced as uncomfortable – What should it be? What is the use of this?" According to the designer, people may prefer to dive directly into a solution, and think short-term, without truly looking into needs. The designer argued that for some, it could be a relief to reduce the problem from the beginning, as it then would become a different kind of responsibility.

Thus, the designers described how they understood fixations among the stakeholders, and how they worked on removing those fixations by arranging workshop activities that concerned switching negative and positive space.

Reframing Sewing

This case concerns design process of a sewing machine at a design firm and is more directly related to designing user experience, than the previous case.

Brief

A producer of sewing machines had observed an increased interest among its customers in an easily transportable sewing machine that they could bring with them to sewing classes, on holiday or when meeting friends for a sewing evening. This led to collaboration with a design firm for developing a new sewing machine as well as laying the foundation for future product development.

Research and investigation

Before the ideation phase, the design team carried out a research phase to gain a deeper understanding of the brand, the users, and the current trends. The results highlighted a do-it-yourself trend and an increased interest in contemplative craftwork and artistic entrepreneurship well as a sharing culture manifested in the use of social media, blogs and other platforms. These insights guided the idea generation phase.

Interpretation

Based on the analyses and the interpretations of the pre-studies, the designers coined the expression "*Imaginary room"*. This conveyed creating a fictive space between the user and the machine where the creative and contemplative activity of sewing takes place. One of the designers reflected: "*the sewing machine is a personal tool, I interact with it and do something creative together with it, I and the sewing machine in a creative collaboration. We wanted to express this and create something that we call imaginary room*". Coming up with and considering the idea of imaginary room involved exploring for new ways seeing the sewing activity. In other words, the designers identified the negative space between the user and the machine instead of looking at the positive spaces e.g. the sewing machine, or the user.

Idea generation

The design team set out to generate ideas for creating this imaginary and easily transportable room that could respond to the on-going societal trends. The idea generation process was explained as several brainstorming sessions where the team was brought together to sketch ideas using different representations: "*several of us sit together and sketch. It can aim at e.g. how to improve the ergonomy in this. We give it several minutes and sketch some ideas and then show them to each other*". This led to mapping a solution space where each new idea occupies a space that was formerly negative. The idea generation in the early phases of the design process involved coming up with a large variety of ideas i.e. radical moves and thereby expanding the negative space: "*this phase is quite intensive, in this case we had different ideas and several parallel tracks*".

The idea generation phase also involved coming up with new design expressions as a foundation for idea generation e.g. *360 degree design*, meaning that the product should be aesthetically appealing from every angle. Exploring a three dimensional form from every angle gave the designers an opportunity to understand and address the negative spaces around an object and not just from one view. One of the designers mentioned that "*you can somehow think of having a back side. Sometimes you don't even talk about it as the backside, because it is the front side. If you want such a machine to be seen by others, this side becomes quite important*". This highlights how the designer reframed the traditional way that sewing machines are designed.

The imaginary room expression was translated to a curved white surface on one side that embraces the machine and the user space and contrasts with a black surface on the other side of the machine to emphasize the creative interplay between the sewing enthusiast and the sewing machine.

The designers used different tools to drive their ideas forward through sketching and making physical and digital models. "*The imaginary room is something that you should see, you should feel the size in front of you*". The tools involved exploring the negative space and making both negative and positive spaces more precise. This was done in an iterative process that required visual and spatial thinking.

The media used in the process can facilitate exploring different aspects or areas in the negative space, e.g. the physical modeling media facilitate exploring negative spaces that concern the experience of interacting with the product: "you can have a good idea and sketch it both 2D and 3D. You get a little further in CAD. I feel that you need to have a physical experience and feel it. It is difficult to understand this in CAD and even in sketches. You discover something else when you work with a foam model."

When involving users and clients or any other stakeholders in the idea generation process, sketching can facilitate user's engagement and involvement in the process. This enables the designers to further explore the negative space with the help of other actors in the process and find otherwise unidentified negative spaces. One of the designers reflected on the use of sketches in collaboration with other stakeholders: "you don't need anything. You only need pen and paper. When they talk about their ideas, you can draw and see how they mean. In this way, they get involved in the process in an open and free way."

Evaluation

After having generated a large variety of ideas, the designers evaluated their ideas. This process involved shrinking the negative space to the margins of a preferred solution space. One designers said that: "we chose some favorite solutions by numbering the ideas on a white board and evaluating them". Overall, the solution space that is evaluated can vary from visual and properties of an artifact, a production or material choice to a use situation. Later phases of the design process, such as evaluation, concerns

to have a good understanding of what is identified negative space and what is the most promising positive space.

HOW TO ADDRESS NEGATIVE SPACE IN HCI

We argue that negative space is always present, but not necessarily understood or taken advantage of in design processes in HCI research. We argue that not addressing negative space leads to design fixations, and less successful solutions. This perspective is related to other critical questions raised about how design knowledge is articulated and practiced in HCI and how this affects the design outcomes e.g. [5, 35, 37]. Fixations can occur on different levels and areas ranging from fixation on a smaller specific design problem, such as a specific artefact, function or activity [23, 26]. Fixations limit a more holistic understanding of an overall system or solution When developing certain artistic skills, this may also involve training the brain to be flexible about foreground and background, and using methods to address such issues. Being able to explore a wider negative space, early in the design process, brings about more solution opportunities and a greater understanding of a design challenge.

When aiming to understand negative space, we have found that taking a *problem solving perspective* of designers' expertise, was less suitable for understanding and articulating negative space. The problem solving perspective involves a more linear process and activities such as decomposing, which does not necessarily support understanding and articulating negative space. However, both *re-framing* and *co-creation* perspectives of design expertise supports the articulation of negative space.

We have presented two cases of identifying and making use of negative space in design challenges. These exemplify the designers' ability to make use of negative space - to reframe a situation and avoid design fixations. For example, the waste management case illustrates how designers identified negative space, in order to reframe the design situation. They also supported stakeholders to reframe their understanding of the design challenge, and to identify and remove fixations on a specific way of understanding the situation in order to co-create a solution.

The other case revealed designers reframing ability in an entirely different type of design situation. This case concerned sewing and related activities, and showed alternative perspectives instead of focusing merely on the activities done with the sewing machine. This lead to a new solution that enabled socializing, sharing practices and communication relevant for sewing.

We find that there is a value to describe negative space as either *unidentified* or *identified*. We argue that only identified negative space supports keeping a holistic view on the design challenge. Both cases show how involvement of stakeholders with diverse expertise can support the designers to identify, understand and address negative space. Unidentified negative space is instead a space that is hidden or concealed, for example due to lack of specific knowledge areas, or due to a certain fixation. When such a space is not understood it is not possible to act on.

Identifying negative space in a design process

Below we will give some suggestions for how to approach negative space in different activities during a design process in HCI research.

Briefing: What if the initial research or design question was turned into negative space? For example, when trying to understand what a specific activity is about (such as sewing) it can be valuable to consider that this activity could primarily concern something else – such as socializing. What are the activities happening in the periphery, could we turn this to become the focus and what happens then to our understanding of the situation? What could the question be about then? How would that affect the initial question?

Research and investigation: When conducting interviews to understand use and design possibilities of for example a specific system there is a risk of focusing too much on understanding something that appears to be distinctive instead of taking a bigger perspective, and stepping back, and look at underlying or hidden aspects. Moreover, the answers that participants give may be influenced of their current imagined perspective of what is important for the interviewer, rather than being based on a holistic understanding. What if the interaction with the system becomes negative space and the workflow and other routines and activities surrounding it becomes the foreground? How does that change one's perspective of the situation, and which questions that are asked? Making the interaction with a system as a background, opens up to make other issues like workflow, social relations, to become foreground.

Interpretation. The activities done during research and investigation can either open up - or limit the design and innovation space, which then will affect the interpretation of the data. Interpretation activities can involve to actively visualize both negative and positive spaces, moving outside the collected data, in order to get a more holistic understanding.

Idea generation. Participants in an idea generation workshop can be supported to explore negative space of suggested solutions or problems. This concerns to help participants to become more flexible and less fixated on stereotype perspectives that affects their idea generation. There are various design methods that involve supporting designers to open up for addressing negative space. Methods such as combining, substituting, eliminating, reversing, and putting to another use can support to avoid fixations and open up different perspectives of what is positive and negative space.

Evaluation. Evaluation of a system or a prototype does not necessarily open up to addressing a radical re-framing or

understanding of negative space. Especially in the later phases of the design process, the possibility to make use of negative space on a large scale is limited and not desirable due to costs and time issues. The process is usually more linear then and addressing negative space rather involves more incremental and smaller improvements rather than entirely re-framing a situation.

Communication. In both research and design, project results are communicated through different media. Storytelling can involve creating scenarios and considering different perspectives of people and devices. What is foreground and background? Is a system in the background or foreground of the story or is it the users and their activities and desires that are in focus? We argue that the ability to convey solutions as both foreground and background is related to the ability make use of negative space.

Identifying negative space in HCI research

This paper leads to more philosophical or meta questions that concern: What is currently negative space of Human Computer Interaction (HCI) research and what is positive space? What is accepted as research and what is not? Are we missing out on specific topics or design challenges - because those are outside what is understood to be primary interesting HCI research? How could such unidentified negative or identified spaces affect our understanding and articulation of design? We find that these are important questions for future work to address.

CONCLUSIONS

This paper describes design as a process, and critically reflects on design knowledge in HCI and its articulation, where for some "anyone" can be a designer. Through theory and two empirical design cases, we contribute with an understanding of negative space as a crucial design skill in a design oriented research field such as HCI. We exemplify how negative space skills are about re-framing, and can be used to open up design fixations, also with stakeholders. Moreover, we contribute with a differentiation between two types of negative space – unidentified and identified negative space. We argue that making unidentified into identified negative space is both possible and necessary in HCI research in order to take a holistic perspective in various design situations and to avoid design fixations.

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