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NEW SILK: Studying Experimental Touchpoints between Material Science, Synthetic Biology, Design and Art

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INTRODUCTION

Most new materials for designers’ use are developed through a science-driven approach, meaning that scientific (mostly technical) innovation is commercialised (Ashby and Johnson 2002). In contrast, designers can bring in their design knowledge into a dialogue on material development by proposing material attributes needed in a certain product or production (e.g. Niinimäki et al. 2017). Moreover, designers can contribute their understanding of aesthetic or sensorial material qualities (Ashby and Johnson 2002). Karana (2009), in particular, has studied material experiences and how designers may include experiential aspects of materials in the product design phase. Designers can even play with and apply different production techniques to enhance material properties and characteristics, achieved through new production techniques in combination with new materials (e.g. Härkäsalmi et al. 2017). This more creative and even experimental knowledge adds to the technical qualities of the materials or attempts to grow new materials. These materials are either new combinations of existing materials or attempts to grow new materials.

Recently, artists and designers have increasingly started to explore and experiment with creating their own materials. Designers may include experiential aspects of materials in the product design phase. Designers can even play with and apply different production techniques to enhance material properties and characteristics, achieved through new production techniques in combination with new materials (e.g. Härkäsalmi et al. 2017). This more creative and even experimental knowledge adds to the technical qualities of new materials.

Materials research is attracting new attention from many corners, especially from a design point of view. Recently, artists and designers have increasingly started to explore and experiment with creating their own materials. These materials are either new combinations of existing materials or attempts to grow new materials that in one way or another create themselves (e.g. Thompson and Ling 2014, 203). The Eksig 2017 ‘Alive, Active and Adaptive’ conference featured many such endeavours (Karana, Giaccardi, Nimkulrat, Niedderer and Camere 2017). Designers and design researchers are invited to help materials researchers to develop attributes for materials or to find suitable application sectors for new materials. Through these endeavours, more experimental collaboration between disciplines is emerging. The biological production of materials is expected to be one of the key enablers of the future bio-economy, and designers have the possibility of playing a key role with this. Protein materials relying on recombinant DNA technology offer distinct advantages: when designing molecular structures for protein polymeric materials, the properties can be tailored to the final applications. Even fibre requirements ‘can be established in advance, and fibre created specifically to fulfill them. Thus, a fibre can be created to respond to changes in heat or light, to carry electronic information, to resist or retain moisture, to destroy odour-causing bacteria or exude a perfumed aroma, or to change surface colour in response to temperature changes in heat or light, to carry electronic information, to resist or retain moisture, to destroy odour-causing bacteria or exude a perfumed aroma’ (ibid., 54). This article presents a study in which new materials are developed through experimental knowledge construction and knowledge exchange between different disciplines. The New Silk research project (2017-2020) is the building block for the research. New Silk aims to produce new types of silk-like materials in the context of synthetic biology. In this article we discuss the initial experimental touchpoints between material science, synthetic biology, design and art encountered during the project’s first year. Firstly, the study shows that shared material experiences in the setting of workshops build foundational understanding of perceived material agency leading to discussion on material activity and research ethics. Secondly, our research identified that all of these disciplines, material science, synthetic biology, design and art, approach materials research through experimental methods, even if the goal of the research differs in each discipline.
The project is inspired by Jane Bennett’s (2010) proposal that materials are vibrant agents, and her account of ‘vital materiality’. Bennett (2010) argues that this agentic force of the material is our (human) perceived materials do not have intentionality or will in themselves, and rather than a utilisation, and Bennett (2010, 31) describes it as a complicated dance that humanity and non-humanity participate in, rather than a utilisation, and Bennett (2010) describes human-material interaction as a collaboration of concepts and material experimentation (Koskinen et al. 2014). Designers as well as artists are thus used to uncertainty and the exploration of materials in a process of development and building knowledge, reaching more developed and sophisticated results. Although scientists have another epistemology and other traditions for their research processes on something that is often something that is to be unconsciously learnt or developed in a process of experimentation on new materials they too are confronted with the unknown, with unexpected behaviour from the materials. We can only make predictions about new materials through our past experiences with them or with similar materials and experiences. Therefore, intensive material interaction and material exploration is the route by which we can construct knowledge in this context. In our interaction with materials, our understanding of the processes may be developed based on the background knowledge of material research in other similar materials and chemistry, biology, or even physics. Such a position forces the intersection of disciplines that have the potential to construct knowledge together, knowledge that would not be possible to achieve within the separate disciplines alone (Hennessy and Murphy 1999).

In this study, we explore how an experimental approach to collaboration and creative practices can lead to the construction of knowledge disciplines. In the studied case, the focus is on interdisciplinary moments where different disciplines work together and share their own disciplinary practice and knowledge (constructed beforehand in a multidisciplinary manner) in an experimental workshop setting. In this way, dialogue between disciplines can take place. As Grix (2003, 9) points out, the aim is not the knitting together of disciplines in a seamless mass of interpretations and explanations, but rather the sharing of insights, best practice and methods with other disciplines. Grix argues that the need for an open mind is essential in interdisciplinarity, and that collaboration can even lead to cross-fertilisation in which a real overlapping of different perspectives can happen. In our study, participants from material science, synthetic biology, design and art collaborated and shared their experiences of the properties of a new material, a material yet to exist.

### 1.2. Experimental interdisciplinary approach

Designerly processes are experimental in nature, as the main goal is usually to create something new, something that did not exist previously. Designers’ processes are constructive, as knowledge is literally created through a fusion of concepts and material experimentation (Koskinen et al. 2014). Designers as well as artists are thus used to uncertainty and tie the solution or answer to a research problem, as this often involves a process of discovery. In our case, we used a sense-making process (Harrison 2000) that can be difficult to put into words, but it is to be taken as a knowledge-building process equal to the more explicit process of the scientist (Tin 2013).

In this material sense-making process, the artefact embodies part of the knowledge and displays this in concrete form (Makelä 2007; Niedereiter 2012, 2013; Niedereiter and Roworth-Stokes 2007). Art and design researchers typically work with and through material, exploring the material through its physical properties, its affordances and limitations (Gibson 1980, 1986). These are bodily, felt experiences that lead to new questions and propose new pathways for further experiments (Groth and Makelä 2016).

### 2. TOWARDS FUTURE MATERIALS THROUGH THE NEW SILK PROJECT

#### 2.1. Research design

This exploratory case study is based on two interdisciplinary design interventions, during which participatory observation took place, that have been analysed through descriptive data analysis. Yin (1984, 1984) defines a case study as an empirical inquiry that focuses on a contemporary phenomenon in its real context. We expand this definition and bring the case into a design research context where a design intervention is made through an interdisciplinary workshop. In our case, the phenomenon under study is the dialogue between disciplines. To set up the framework for the research of these interdisciplinary touchpoints, we organised two creative and exploratory workshops during the project’s first year. These two workshops provided the empirical material for this study. The data consists of notes, video recordings and photographs from the workshops and feedback from the participants. Data were interpreted through descriptive analysis. A qualitative approach guided our inquiry in this study. The following research questions guided our analysis of the data:

- What are the interdisciplinary touchpoints in this context?
- What is the experienced material agency in this context?

#### 2.2. Workshop 1

The first workshop with material researchers and design students took place in June 2017. There were 26 participants: twelve design students, two chemistry students, eight researchers from material sciences and one design researcher. The main aims of the workshop were to familiarise the scientists with the designers’ mindset, and vice versa, and to observe how designers embrace synthetic biology without previous knowledge. The secondary aim was to gain understanding of what kind of collaborative activities would make sense in this context.

The one-day workshop was divided into two sessions: in the morning four material scientists gave 20-minute presentations on their field of expertise (Biomimetics, Short introduction to polypeptides, Spider silk as a polymer, Xenobionic protein production). The afternoon consisted of two one-hour
The artificial material seems to have a special characteristic: filaments formed by pulling can fuse to each other permanently. We asked: How do these molecules work, and how does this behaviour happen? What could future applications be, e.g. adhesives, fibres? To conclude, the project leader pointed out the need for a new dimension of communicating between programmes and disciplines to get inspiration, stating that research is all about inspiration and how to look at things from new angles.

In the first task, introduced by the workshop facilitator (designer), participants were asked to explore the new material by playing with modelling clay (see Figure 1), which in its properties behaved similar to the original material. Participants were encouraged to start working hands-on and use bodily exploration with the material. After a 15-minute hands-on session, participants wrote down their personal observations and reflections regarding the material, its properties and general insights. The most popular ways of working with the modelling clay were rolling bars, stretching thin filaments, pulling and flattening the material, twisting, ripping, braiding, layering and testing the stickiness of the material. The participants were active and attentive and continued discussing what they felt when touching, testing and playing with the material. While playing with the materials, they especially noted the effects of pulling, fusing, and stretching behaviour and how the material breaks.

For the second task, the participants were grouped into six teams. Each team consisted of 1 or 2 material scientists or chemistry students and several design students. Each team was handed an empty notebook containing one question. Three notebooks included question 1: What kind of shared actions would support the New Silk Collaboration? (or find another question) and the three other notebooks included question 2: Where could New Silk concepts be applied? (or find another question). The teams were asked by the facilitator (designer) to discuss and reflect on the proposed questions freely. They were also encouraged to make other comments and propose other questions based on their conversations. Finally, the teams were asked to document their discussion results and observations and reflections regarding the material, its properties, and the three other notebooks included questions.

Figure 4: Second day results: the miracle of growth. Photo by the researchers.

Critical feedback was mainly related to the lack of time and the difficulty of absorbing and understanding so much new information in a very short time. The fact that the real, tangible material samples were missing, as these were still under development, and the experiment with modelling clay were found to be both inspiring and confusing. One participant said, ‘The modelling clay experimenting made me more confused... I understand the material as sticky threads...’ Another said, ‘It would have been nice to see a new silk material sample.’

2.3. Workshop 2

The second experimental workshop was organised internally for the research consortium in collaboration with a bio-artist. The second-day workshop took place in Biofilia, a special lab for bio-art at Aalto University. The workshop programme was planned by the bio-artist. The main aims were to familiarise scientists with artists’ working methods and to explore potential touchpoints between art and material science, especially in the New Silk project.

The workshop began with a short introduction of all participants and continued with three lectures: a general project presentation by the project leader (professor in synthetic biology), a presentation on the molecular visualisation of silk proteins (scientist) and a presentation by the workshop leader (artist). The next step was to familiarise the participants with the material itself through the hands-on, bodily experience of touching and feeling microbial cellulose (see Figure 2). Participants were blindfolded when touching the material by playing with modelling clay (see Figure 1), which in its properties behaved similar to the original material. Participants were encouraged to start working hands-on and use bodily exploration with the material. After a 15-minute hands-on session, participants wrote down their personal observations and reflections regarding the material, its properties and general insights. The most popular ways of working with the modelling clay were rolling bars, stretching thin filaments, pulling and flattening the material, twisting, ripping, braiding, layering and testing the stickiness of the material. The participants were active and attentive and continued discussing what they felt when touching, testing and playing with the material. While playing with the materials, they especially noted the effects of pulling, fusing, and stretching behaviour and how the material breaks.

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“Interesting new ideas to develop.”

Critical feedback was mainly related to the lack of time and the difficulty of absorbing and understanding so much new information in a very short time. The fact that the real, tangible material samples were missing, as these were still under development, and the experiment with modelling clay were found to be both inspiring and confusing. One participant said, ‘The modelling clay experimenting made me more confused... I understand the material as sticky threads...’ Another said, ‘It would have been nice to see a new silk material sample.’
Table 1. Participants in workshop 1, their roles and activities, workshop results.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Roles</th>
<th>Activities</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Designers</td>
<td>Workshop participants</td>
<td>Presentations</td>
<td>Imagining how future materials could behave</td>
</tr>
<tr>
<td>2 Chemistry students</td>
<td>Workshop participants</td>
<td>Playing with modelling clay</td>
<td>Possible application sectors for new material yet to exist</td>
</tr>
<tr>
<td>8 Material researchers</td>
<td>Workshop participants</td>
<td>Written individual reflection</td>
<td>Group brainstorming</td>
</tr>
<tr>
<td>1 Designer</td>
<td>Facilitator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Participants in workshop 2, their roles and activities, workshop results.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Role</th>
<th>Activities</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Bio-artist</td>
<td>Presenter</td>
<td>Presentations</td>
<td>Discussions on:</td>
</tr>
<tr>
<td>7 Material researchers</td>
<td>Presenters</td>
<td>Exploring living organisms</td>
<td>1) research ethics while working with &quot;living&quot; materials</td>
</tr>
<tr>
<td>2 Designers</td>
<td>Participants</td>
<td>Microbial cellulose growing experiment</td>
<td>2) disciplinary practices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discussions</td>
<td>3) interdisciplinary touchpoints</td>
</tr>
</tbody>
</table>

Table 3. Experimental approach in new, active materials.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Design</th>
<th>Material science</th>
<th>Art</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus</td>
<td>Material properties</td>
<td>Material activity and technical qualities</td>
<td>Artistic expression</td>
</tr>
<tr>
<td>Interest</td>
<td>What the application areas are</td>
<td>What it can do</td>
<td>What it expresses or what it is</td>
</tr>
<tr>
<td>Perceived material agency</td>
<td>Design ethos</td>
<td>Assembly options</td>
<td>Representations or how it grows</td>
</tr>
</tbody>
</table>

Results and Discussion

Material experimentations through imagination are challenging if the actual material does not yet exist. This could be seen in the reflections from the first workshop. This is especially challenging for designers, who need physical experience and embodied knowledge to deeply understand the material’s properties, affordances and perceived agency. On the other hand, it was interesting to note that by playing with the substitute material, it was possible to understand the actions of this new material, the material to exist. Experiences with materials were led by bodily actions, as our documentation showed. Pulling, flattening, twisting, ripping and layering the materials were led by bodily actions, as our documentation showed. Through embodied interaction, the participants could understand the material actions, the participants could create a mental image of New Silk (the material yet to exist) and transfer this understanding to other scales (from nano to the human scale). This was in fact a knowledge transformation process through which participants could understand the future material through embodied experiences with substitute material and transform this embodied experience into ideas about possible new material actions. As Norman (1993, 49) argues, “representations” are important because they allow us to work with events and things absent in space and time, or for that matter, events and things that never existed - imaginary objects and concepts. He further argues that representations can ground an ‘idea’ through which we can think (we think through representations). Through this knowledge-making action we can discover higher-order relationships, structures, and consistencies, and we can better understand a particular phenomenon.

In the second workshop, the strong tactile experiences created emotional associations of the material being alive. This led to discussions on research ethics and a strong association of the material possessing agency. Does this material have a will of its own, and what are we allowed to do with it? Can we modify it and do we have a right to design it? These associations take the designer closer to generic engineering. The question of material agency in different disciplines, learning about bio-art and bacterial cell lines, and art and science in general. (Material science).
CONCLUSIONS

This study aimed to find new perspectives and interdisciplinary touchpoints between materials research, synthetic biology, design, and art. Interestingly, all these areas use recognized design research, experimental design, and design interventions to conduct to push boundaries and to explore alternatives, which leads to integration of making experimentation and theorising (Redström 2004). We argue that two topics emerged as the most interesting from these collaborations: perceived material agency and an experimental research strategy (see Koskinen, Ilpo, John Zimmerman, Thomas Binder, Johan Redström, and Stephan Wensink, 2017). The importance of learning from mistakes while trying different approaches and error type of research strategy was obvious in all disciplines. The foundations of research and error type of research strategy, was obvious in all disciplines.

Moreover, we might design not only material attributes but perhaps even the morphologies of these first interdisciplinary collaboration encounter advance material science the foundational investment in how the material functions and, especially in the New Silk project, how two different materials (with different DNA) affect each other or even blend together, is the focus of the research. However, materials researchers study how these materials’ interactions evolve and the way they are used. As the leading material scientist pointed out after the workshop, genetic engineering is needed to create material the way they are done in nature. He added, ‘Next to material science we need to know a lot about how the actual materials are formed using the building blocks produced by the microbes. This “assembly process” is actually very demanding, as it requires combining a lot of different fields such as polysaccharide physics, microbiology, and biochemistry, or in general, material science. Moreover, in the future we might design not only material attributes but perhaps even the morphologies of these new engineered materials and their “will or behaviour.

During the coming years, we intend to monitor how these first interdisciplinary collaboration encounter advance in the actual product development stage. While we build new knowledge, knowledge that combines materials research with design knowledge, tangible with verbal knowledge and even ethics with practice. Through combining design-specific and scientific knowledge, it will be possible to utilise physical and chemical attributes that include not only technical attributes, but which also have strong aesthetic and sensorial material qualities. These first workshops were mainly a starting point for a series of shared actions falling under the context of interdisciplinary material development. As one of the participants noted:

“Research is a process that takes a lot of time and the possible uses of the new materials in “real life” can take many more years.”

ACKNOWLEDGMENTS

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REFERENCES

Aho, Michael, and Kara Johnson. 2002. Materials and Design: The Art and Science of Materials. Artistic practices were compared in this manner, and the discussions reflected interdisciplinary sharing. In this knowledge-sharing process, physical experiments with the material helped the discussion to evolve. All participants were aware that there are some touchpoints between these disciplines. Interestingly, the experimental approach, a trial-and-error type of research strategy, was obvious in all disciplines. Therefore, exploratory and imaginal materials will be part of design work even more so in the future. It will also be important to engage more deeply in the understanding of perceived material agency, especially when designing in the context of synthetic biology. In this research context, we can advance our understanding of perceived material agency and explore this issue through imaginary materials. Moreover, in the future we might design not only material attributes but perhaps even the morphologies of these new engineered materials and their “will or behaviour.”

Growing this materials research with design knowledge, tangible with verbal knowledge and even ethics with practice. Through combining design-specific and scientific knowledge, it will be possible to utilise physical and chemical attributes that include not only technical attributes, but which also have strong aesthetic and sensorial material qualities. These first workshops were mainly a starting point for a series of shared actions falling under the context of interdisciplinary material development. As one of the participants noted:

“Research is a process that takes a lot of time and the possible uses of the new materials in real life” can take many more years” (Material science). Therefore, exploratory and experimental collaboration will continue.

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CASE STUDY

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