Biomimicry for Human Computer Interaction
Uppsala University – February 2023

Organizers: Catharina (Karin) van den Driesche and Åsa Cajander

Workshop Report
On January 26th 2023, a workshop was held at Upsala University on the possibilities of the method biomimicry for Human Computer Interaction. The growing complexity of human interactions dealing with large amounts of data and the shift away from screen-based interactions is pushing the boundaries of Human Computer Interaction. Biomimicry could be one approach to tackle these challenges. Biomimicry, or biometrics, is the imitation of the models, systems, and elements of nature in solving complex problems (Vincent et. al., 2006) that might support HCI projects. In this workshop report insights are shared on how the method of biomimicry could support ongoing changes in the area of human computer interaction.

SUMMARY

The workshop at Uppsala University explored the potential of the method biomimicry for human interaction design. Through a series of reflective activities, the participants explored how biomimicry can be applied to the design of interactive products, services, and environments. Nine participants from the department of Information Technology engaged in a reflection process that consisted of three interactive activities. The activities began with an individual part and then transitioned into a reflective part in pairs or trio, followed by discussions.

The overall setup consisted of:
1. An introduction of biomimicry
2. Activity 1: 'Researcher Identity Memo' on biomimicry
3. Activity 2: Experiencing biomimicry by brainstorming using shape changes in nature
4. Activity 3: Brainwriting on options and ideas for 'Biomimicry for HCI?'
5. Wrap-up and follow-up.

The workshop's overall finding is that there is potential for creative methods (i.e., explorative, imaginative, progressive) based on nature's systems to design (human) interaction. Particularly, working with nature could be an important part of sustainable and responsible development of immersive and interactive experiences being implemented into daily life. The findings also suggest that biomimicry can help create intuitive and natural experiences as HCI moves away from screens into scenes design (e.g., augmented reality, virtual reality). Furthermore, it was found that biomimicry could be a successful creative method for human interaction design because it encourages interdisciplinary exchange between different research fields in HCI.

The outcomes will be of interest to participants who work, or plan to work with systems found in nature for interaction design or are curious about new methodologies for HCI in general. The specific outcome of the workshop includes this workshop report summarizing the outcomes of the activities and discussions. The workshop also foresees the establishment of a reading and/or working group that will continue collaboration on the theme of Biomimicry for HCI.

INTRODUCTION

As technology continues to evolve, so do the ways people interact with it. From wearables to voice-based interactions, virtual reality (VR) to augmented reality (AR), sensors to artificial intelligence (AI), the manner in which humans interact with computers, systems, and applications has been drastically transformed. For instance, designers can use AR and VR to create immersive experiences that make users feel as if they are in a "digital world". Through the design of imaginative scenes, users can be provided with a realistic and interactive experience that allows them to explore a virtual environment as if they were present in a physical space. This has pushed the boundaries of the domain of HCI, as it necessitates the integration of the many different ways people engage with technology. In other words, the field of HCI needs to integrate its capabilities to accommodate the complexities of new human-computer interactions. Augmented and virtual reality are driving this shift, as they allow designers to explore new methods of interactivity that move beyond the traditional screen-based models. Additionally, the complexity of human interaction with large amounts of data presents a challenge, as users must be able to make sense of such data in order to make informed decisions.

Prompted by new technologies, the increasing prevalence of screens in our lives, and growing amount of data, designers are turning to new methods of interactivity that move away from screens and towards more immersive experiences. Moreover, designers are now looking at the way in which nature interacts with its environment and how this can be replicated in our own interactions with technology. The method of biomimicry is an innovative and creative approach to problem-solving that uses nature's strategies and systems as an inspiration. It seeks to understand and emulate the

strategies and systems used by nature and ecosystems to create sustainable solutions (Vincent, Julian FV, et al. 2006). By observing the systems and functions of natural systems, biomimicry is able to borrow concepts that have been perfected over millions of years of evolution (Benyus, 1997). Biomimicry is currently applied in domains such as, engineering, art, aviation, urban design, product design, and architecture. Although biomimicry and interaction design are not often seen as being closely related, biomimicry may hold promising potential to address the challenges and changes for HCI. Hence, the relationship between biomimicry and interaction design is becoming more apparent as technology advances.

While biomimicry aims to replicate the natural world's design principles to create more efficient and sustainable technologies, interaction design focuses on the way in which people interact with technology. By drawing inspiration from nature, considering the way in which nature interacts with its environment, designers are able to create more natural (i.e., short learning curve, familiar behaviour) and lifelike experiences that can help us better connect with the technology around us. Through this workshop, we want to gain an understanding of biomimicry and its potential to create more interactive experiences that are immersive and sustainable.

ACTIVITY 1: BIOMIMICRY, WHAT IS IT?
After being introduced to biomimicry, the participants created a Researcher Identity Memo in the form of a mind map. This mind map helps to identify questions, biases, assumptions, and other elements of their thinking. It also allows them to visualize any changes in their thinking over time.
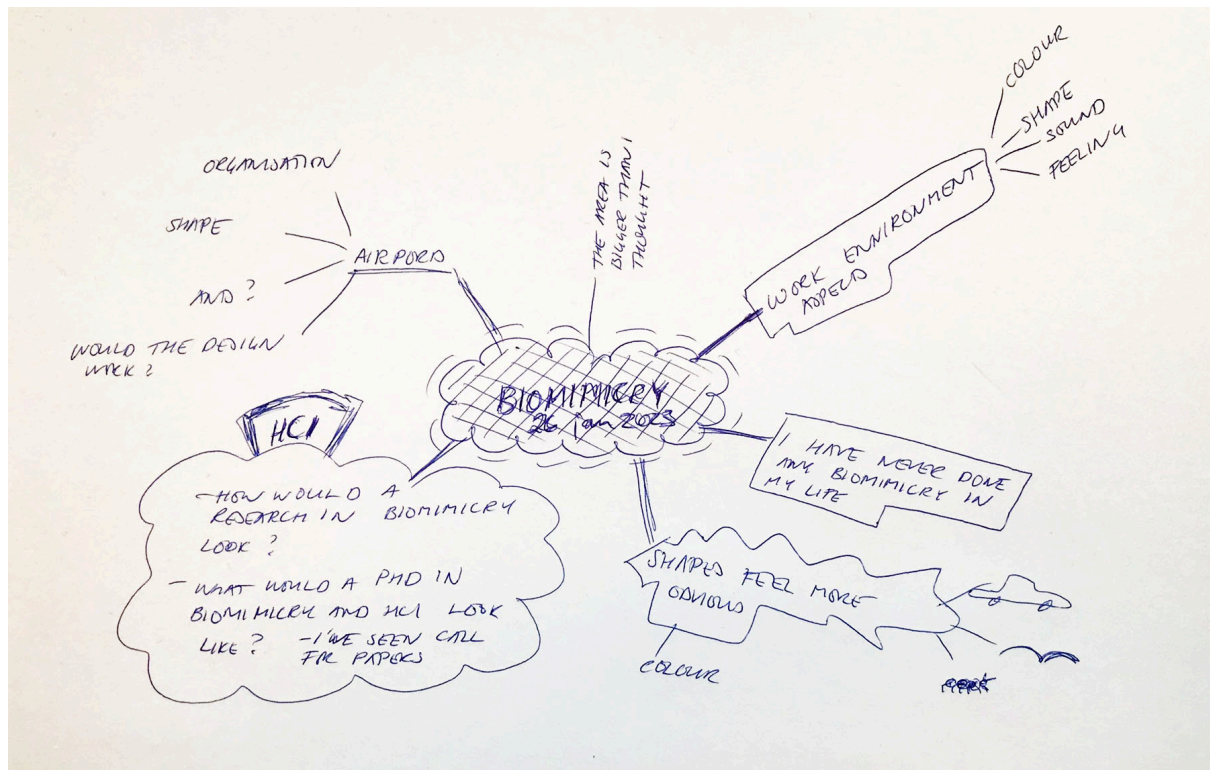

Fig.1: Example of a Research Identity Memo: mind map on current thoughts and ideas on biomimicry.

Creating a Researcher Identity Memo was a useful tool to help the participants better understand their own thoughts on biomimicry.

Outcome of Activity 1: Researcher Identity Memo on Biomimicry

Participants	Thoughts, questions, and ideas on biomimicry	Analysis inductive 02-23
1		
	Build on experience developed over millennia	Evolution
	New inspiration	Inspiration
	Example of interdisciplinary collaboration	Working with nature (WWN)
	Positive	Feeling
	Learning about nature	
	How important is the 'function' aspect?	Question/ Applicability
	Abstraction level: Spirals: Abstract becomes fundamental at a higher abstract level	Abstraction
	Thought provoking	Inspiration
	Getting an edge	Feeling
2		
	Nature: Colour: Green: Can change: Under various influences	Idea/ WWN
	Time?: Dry fish skin: Piranha fish: Sparkling: In dynamics: How sparkle: Under water: Will it work if take her away?	Idea/ WWN
3		
	Biomimicry of humans?	Question/ Human and nature

	Interbeing of living things: reproducing parts of ourselves in new ways: mind=body=environment: mimicry of entire ecosystems: the means is the ends	Human and nature/ WWN / Ecosystems
	Teleonomy 2.0; cybernetics perspectives erase artificial distinctions between natural kinds	Evolution based
	Beneficial relationship of humans and non-humans: structure society in the way of the other ecosystems: to save our planet become our planet, and then saving ourselves is not separate from saving the planet.	Human and nature/WWN / Ecosystems/ Sustainability - Conservation
4	(+) Tried and tested: Beautiful: Organic and embodied = beauty for beauty's sake?	Question/ Evolution
	(-) Survival of the 'fittest': Sexual selection and genetics focus = no space for …[unreadable]	Evolution based
	Assumptions: Biology/Nature has the best 'solution'?: Idealising of nature and natural processes	Question/ Evolution
	When is it (not) appropriate?	Question/ Applicability
	How can it (not) inform interactions w/v natural media?	Question/ Applicability
5		
	So much potential vs. exploitation	WWN/ Sustainability - Conservation
	Interaction with nature = Interaction without voice = Interacting with animals and plants	WWN
	My examples were limited: So many examples	Evolution
	How can I yield nature's power to serve humanity?	Question/ Human and nature
	How nature learns/communicate; Improve pedagogical methods and communications	Idea/ WWN
6		
	Lucid dreaming	Idea
	Steiner points soul bubbles	Idea
	Artificial vs. Nature	Human and nature
	Hive intelligence	Idea
	Color changes tattoos	Idea
	More code	Human and nature
7	Airport: organization and shape and would the design work?	Question/ Applicability
	HCI: How would a research in biomimicry look?: How would a PhD on biomimicry and HCI look like?	Question/ Applicability
	I have never done any biomimicry in my life.	Applicability
	Shapes feel more obvious: colour	Idea
8		
	Would love to [not readable] bio-inspired	Applicability
	Important to stay in touch with nature	Feeling/ WWN
	Design process must be fun	Applicability
	Useful solutions	Applicability
	Lot to be done still in its infancy	Applicability
	Great interdisciplinary [not readable]	WWN
	Expensive to do?	Question/ Applicability
	When is it taken scientific, when is it considered as a hobby?	Question/ Applicability
	Why we do it? Is it just for the sake of doing it? Or is it a return to frontier?	Question/ Applicability
	Military is the most beneficiary for this.	Applicability
	Sometimes ugly translations of the 'real' thing	Applicability
9		
	Connect the clues	WWN/ Applicability
	Nature: imperfect perfections: harmony, patterns	WWN/ Evolution

	Evolution: Industrialism	Evolution/ Human and nature
	It's hard	Applicability
	Comprehension	Applicability
	Understanding before mimicry: Mimicry without understanding for understanding	Applicability
	Relax the spirit	Feeling
	Stress relievedly	Feeling

Analysis of the Researcher Identity Memos revealed nine themes on biomimicry in the context of researchers working for the Information Technology department, in alphabetic order:

Biomimicry in general (Activity 1)
Applicability
Ecosystems
Evolution
Feeling
Human and nature
Idea (specific ideas from nature)
Inspiration
Sustainability - Conservation
Working with nature (WWN)

The results of this study offer a glimpse into how the nine participants perceive biomimicry in relation to HCI, as well as possible ways of implementing biomimicry for HCI in a practical way. Before we go into the inventory results it should be mentioned that (almost) none of the researchers had actually used biomimicry in previous projects.

The possibility of incorporating natural elements into the design and research of human interaction (with computers or digital information) provides us with an abundance of resources. However, this abundance poses a challenge, as it can be difficult to find the right system in nature to solve design or technological problems (i.e., applicability). Another important element of using biomimicry is ways of understanding how our designs can affect the environment (i.e., ecosystems). By studying how different species interact with each other and their environment, we can gain insight into how to design a balance between humans, technology, and nature, preserving diversity of the planet. By understanding how nature as a whole has evolved in their respective environments, we can learn more about inclusivity while interacting with our environments. Abandoning the concept of 'survival of the fittest', and instead embracing a philosophy of cooperation and collaboration among all living things.

Sustainability and conservation are two of the most important concepts for protecting the environment. By understanding the importance of preserving natural resources and protecting the planet, we can ensure that future generations will be able to enjoy the beauty of the world around us. Working with nature is an important part of sustainable and responsible development of technologies. Additionally, being in nature is a great way to relax and rejuvenate. This ability evokes a wide range of emotions in people that inspires strategies for 'emotional design'.

ACTIVITY 2: BRAINTSTORMING INTERACTIONS USING NATURE'S SHAPE CHANGES

During the next activity, participants experienced biomimicry by 'thinking like nature operates' when designing a new interactive experience, discussing alternative possibilities for existing screen interactions (e.g., instructing, conversing, manipulating, and exploring) and translating systems found in nature into new ways of interaction in public space.

The design challenge of this activity was to integrate 'shape change' to create future scenarios for new ways of interacting as if having a conversation. The shape changes in nature are Elastomers, Auxetics, Rollable, Foldable, Inflatable, Anisotropic, Multi-stable, and Shape memory (Qamar, Isabel PS, et al. 2020).

The context of a real-world settings was the environment of a train station where the person waiting for the train to arrive has a conversation explaining that they are late to someone who is not present at the station. Every participant could choose the shape change they wanted to integrate into the design of an intuitive and natural conversation using any kind of (imagined) technology (Figure 2).
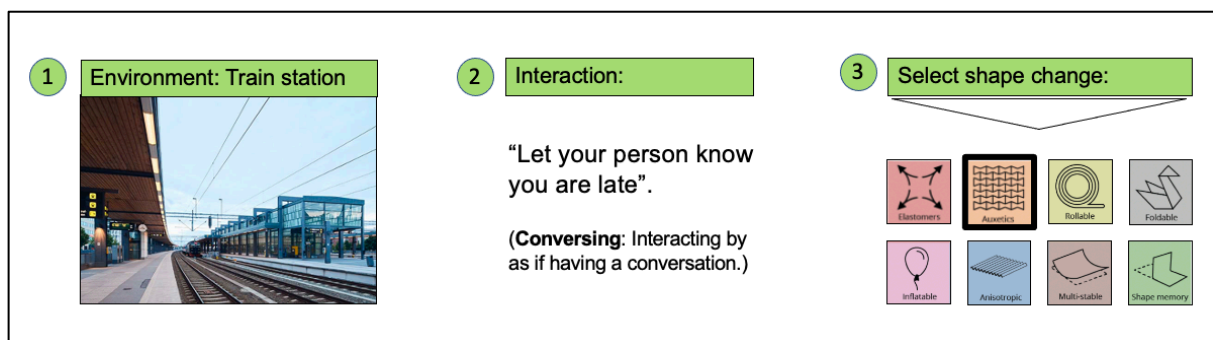

Fig.2: The design challenge using shape change (Qamar, Isabel PS, et al. 2020)

The first step in this activity was an individual brainstorm using the technique of the 'Crazy Eight', however we used a 'Crazy Four' for 4 ideas in 4 minutes (Figure 3).
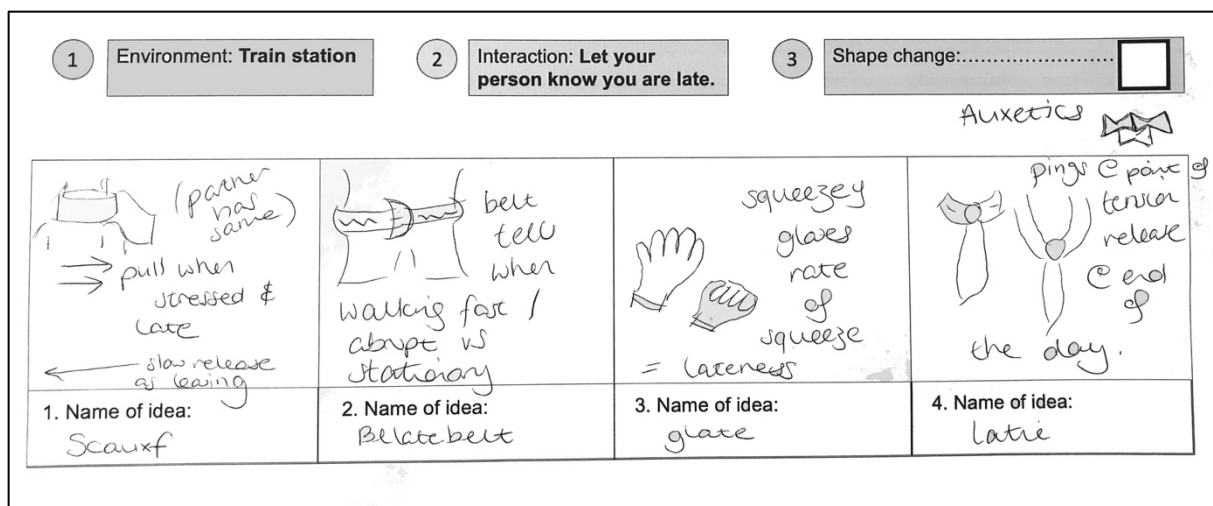

Fig.3: Example of the crazy four brainstorm.

The second step was to discuss the ideas in pairs or trio to get inspired and pick the best idea to create a future scenario together (Figure 4).
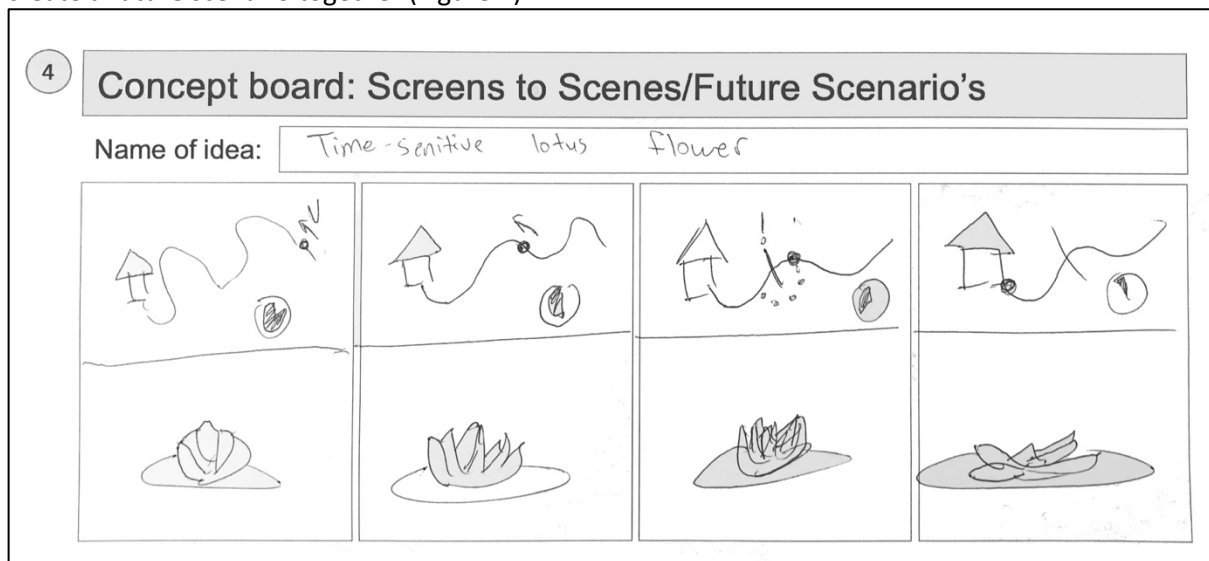

Fig.4: Example of a Future Scenario moving from screens to scenes.

Outcome of Activity 2: 'Moving from screens to scenes using biomimicry.'
The outcome of this creative activity was an engaging and thought-provoking experience of biomimicry. After a short time (30 min.) of creative exploration, the participants experienced the potential for applying natural systems to develop new ways of interacting in public space. Using the shape changes in nature as a starting point, participants discussed new possibilities for existing screen interactions, such as smart clothes, time sensitive materials, colour as information, tree and clouds communication, changing of shared objects (e.g., balls), and shape memory. It was inspiring to witness how, through the lens of biomimicry, participants were able to create and discuss alternative possibilities for existing screen interactions. This activity was a success in the sense that participants expanded possibilities for advancing and innovating technologies and the ways people interact with it using nature as inspiration.

ACTIVITY 3: BIOMOMICYR FOR HCI?

The last activity existed of a brainstorm session and a discussion on what components of HCI could benefit from the method of biomimicry. The brainstorm technique existed of two parts: individual creation of three How Might We' s, followed by the Round Robin or Brainwriting technique. Round Robin or Brainwriting is a brainstorming technique that encourages people to reflect on each other's ideas and generate new ideas collaboratively. By discussing various components of HCI and exploring the potential for utilizing biomimicry, the participants could identify potential pitfalls and risks associated with a proposed HMW.
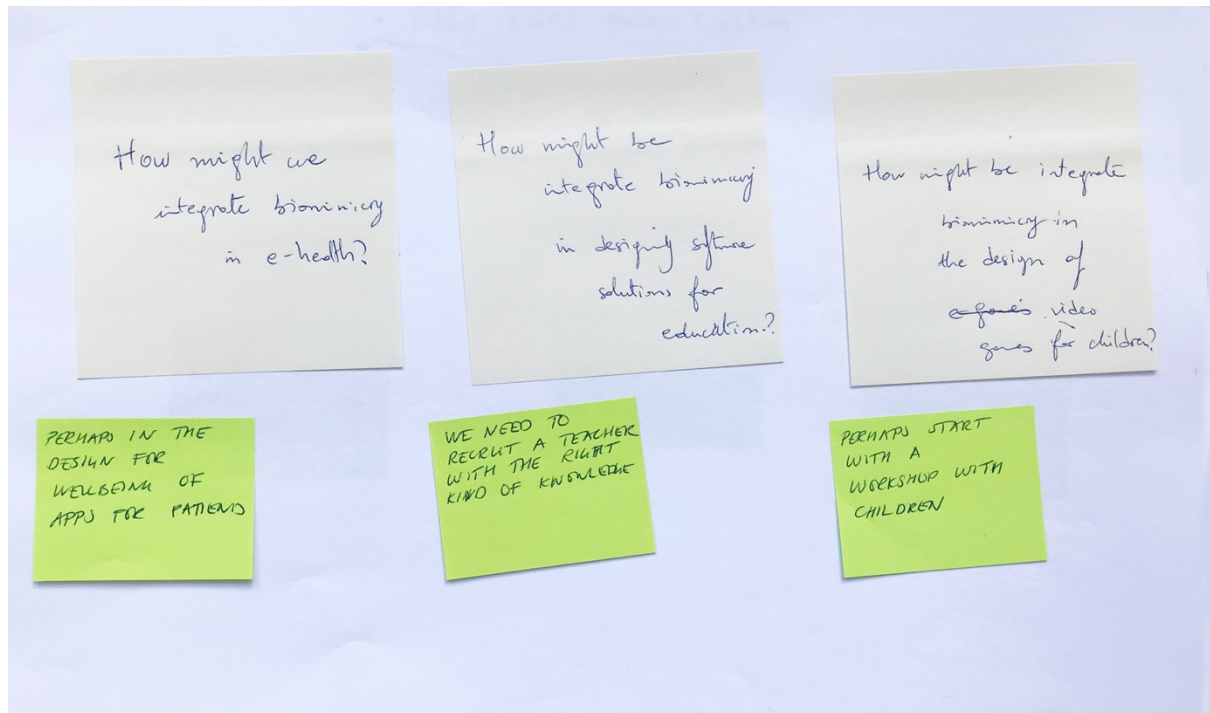

Fig.5: Example of the Round Robin/Brainwriting

The HMW activity was supported by two supporting options for integrating the biomimicry method for HCI; 'preparing human interaction for biomimicry' and 'what components of human interaction would be an interesting start for using the biomimicry method'? During the Round Robin or Brainwriting activity participants reflected on possible ethical implications (Figure 5).

Outcome of Activity 3: 'How Biomimicry for HCI?'

Participants	Ideas	Reaction	Analysis inductive 02-23
1			
	VR headset for blind people to describe the environment.	Ethical issue what if VR gives 'wrong' advice leading to an accident.	Ethical issues
	Sleep.	Connect to improving 'performance'	Improvement
	Programming exercises about modelling biomimicry.	Connect to efficiency: Good for use in education.	Improvement
2			
	For alternate non-verbal/written communication between people.	How? With help of what? Special devices or well-known things around us.	Alternative solutions

	To inspire ways of using HCI to generate calming /soothing experiences.	Like protective layers.	Alternative solutions
	To identify (more) efficient ways of human-machine collaboration and teaming.	With …[not readable].	Improvement
3			
	Sorting information.	[no reaction]	
	Conveying information.	Is there a better more intuitive way for us to get office news that isn't an email newsletter?	Improvement
	Conveying information.	Is there a better more intuitive way for us to get office news that isn't an email newsletter?	Improvement
	Adaption to environment.	I want my bicycle lock to react when its cold outside so it doesn't freeze shut!	Nature as partner
4			
	Symbioses between human and machine – human body provides energy needed for a device that adds value to the human.	I like this in carbon aware and healthy office context aware. Cycling at the desk?	Symbioses between human and machine
	Lifecycle of a computer mimics natural lifecycle of a living being- birth, youth, old age, death.	I wonder if one would become emotional at the end of computer life or is it 1:1?	Symbioses between human and machine
	Carbon cycle.	I think the other two align to this very well.	Improvement
5			
	…integrate biomimicry in our HCI courses?	Maybe something accessibility	Nature as partner
	…integrate biomimicry in our research projects?	Probably depends on the project	Nature as partner
	…how would biomimicry be a part of collaborations between HCI and occupational health researchers?	Maybe something around sleep exercise.	Nature as partner
6			
	Design of small devices for home.	Devices communicating with nature with minimal intervention e.g., trees tell apps temp and pollution level. Water bill is high; the app lowers heat to reduce bills.	Nature as partner
	Public transport.	Ants tell apps most efficient route.	Improvement
	Interactive clothes.	If cold thick else: become thinner. Clothes have protective shield spikes like hedgehog when attack.	Alternative solutions
7			

	Me in lecture room, front of class, I want to know if they understand a concept. Tables change colour from green to red.	Nice ideas by may silence [not readable] voices.	Alternative solutions
	Me in lecture room, front of class, I want to know if one student in a class of 200+ is struggling. Their name changes colour in my rota.	Much better! More anonymous.	Ethical issues
	Student + Computer + COVID. Keyboard changes colour if there is a particular virus.	Ethical consideration: respect of privacy.	Ethical issues
8			
	How might we integrate biomimicry in e-health?	Perhaps in the design for wellbeing of apps for patients.	Nature as partner
	How might we integrate biomimicry in designing software solutions for educations?	We need to recruit a teacher with the right kind of knowledge.	Nature as partner
	How might we integrate biomimicry in the design of video games for children?	Perhaps start with a workshop with children	Nature as partner
9			
	Redesign of the interface between user and computer to be more natural o more keyboard and mouse?	User brain computer interface.	Alternative solutions
	The flow of activity in HCI is chaotic and confusing let built something that favours the natural flow of ideas.	Mimic seasons or stream of water.	Nature as partner
	[no third option]		

Analysis of the Round Robin/Brainwriting activity revealed five themes on biomimicry for HCI in the context of researchers working for the Information Technology department, in alphabetic order:

Biomimicry for HCI (Activity 3)
Alternative solutions
Ethical issues
Improvement
Nature as partner
Symbioses between human and machine

Through our exploration of biomimicry for HCI, we discovered five themes: Alternative Solutions, Ethical Issues, Improvement of Existing Solutions, Nature as Partner, and Symbioses between Human and Machine. These themes provide a first step for understanding the potential applications of biomimicry for HCI. By starting to explore these themes, we can gain insights into how to effectively use biomimicry for HCI, to create more responsible and sustainable technology, and to improve existing solutions. The outcome of the brainstorm session suggested how nature can be used as a partner in the development of new technologies supporting the symbiosis between human and

technology. We also discussed the importance of understanding the ethical implications of using biomimicry for HCI. In conclusion, this explorative workshop has indicated the potential of biomimicry for HCI and how it can be used to create more effective and ethical solutions for our increasingly technological world.

4. CONCLUDING REMARKS

Through this workshop, participants gained a first glance of how biomimicry can be used to create meaningful and sustainable user experience. They have been able to explore how nature can be seen as a source of inspiration for design. Additionally, they have been able to learn how to use biomimicry to move from screens to scenes and create future scenarios based on natures principle of shape change. This allows them to further explore the idea of working with nature, as a partner, to create solutions that could be beneficial to humans, technology, and the environment.

Additionally, through the activities we have been able to discuss the implications and possibilities of biomimicry for HCI. The outcomes of the workshop create a great opportunity to further research on this potential. To continue this journey, we will set up activities such as a reading and working group to deepen our understanding of biomimicry for HCI. This will allow us to broaden our knowledge, explore further ideas and collaborate in new research projects.

The workshop ended with participants feeling inspired by the potential of biomimicry and its ability to create innovative solutions to existing challenges for HCI. Hence, Biomimicry for HCI has the potential to transform the way we interact with technology, and the future possibilities of this methodology are truly promising.

References
- Benyus, J. M. (1997). Biomimicry: Innovation inspired by nature.
- Vincent, J. F., Bogatyreva, O. A., Bogatyrev, N. R., Bowyer, A., & Pahl, A. K. (2006). Biomimetics: its practice and theory. *Journal of the Royal Society Interface*, *3*(9), 471-482.
- Qamar, I. P., Stawarz, K., Robinson, S., Goguey, A., Coutrix, C., & Roudaut, A. (2020, July). Morphino: A nature-inspired tool for the design of shape-changing interfaces. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (pp. 1943-1958).