Spatial Robotic Experiences as a Ground for Future HRI Speculations

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ABSTRACT
This work illustrates how artistic robotic systems can provide a reservoir of unfamiliarity and a basis for speculation, to open the field toward new ways of thinking about HRI. We reflect on a collaborative project between design students, a media art studio, and design researchers working with the baggage handling department of the Schiphol airport. Engaging with the industrial context, we developed 'meta-behaviours' - abstracted ideas of processes carried out on the worksite–and passed these over to the students who translated them into robotic enactions using a pre-defined hardware developed by the media art studio. The resulting visit experience challenges the audience to decode the installation in terms of metabehaviours and their possible relations to industrial HRI. We used this to reflect on the value of conducting artistic and speculative work in HRI and to distil actionable recommendations for future research.

Authors Keywords
Human-Robot Interaction; Interaction Design; Art; Speculative design; Industrial Robotics.

CCS Concepts
•Computer systems organization ~ Embedded and cyber-physical systems~Robotics •Applied computing ~ Arts and humanities ~ Media arts

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INTRODUCTION
There are many connections between work in robotics and artistic practice: the possibility of animate, reactive, skilled and agential collections of matter is a compelling proposition for creating work that engages and questions, and offers a rich terrain to explore. The default proposition here is that robotics has a lot of possibilities to offer creative practitioners, as seen through a profusion of works where robotic potential is enlisted to achieve artistic goals, or where robotics is the subject of artistic inquiry. We are interested in a less explored proposition: that arts and creative practice supports advances in robotics. Early explorations of robotic potential blended creative and pragmatic ways of working, and were enmeshed in the conceptual and technological development of what robots could be - see for example, the posthumous account of Ihnatowicz's work on kinetic art which pushed the envelope through creating autonomously reactive sculptures [38]. As the technologies mature, however, the industrial imaginaries take over, and it is more challenging to import ideas from creative practice into robotic research.

The current turn in robotics from industrial automation to social and cognitive robots means that there is a need

to rethink the ways that people and robots co-exist [21]. Emerging investigations of 'worker robot relations' asks questions of what the relationship between people, jobs and robots should be [27]. This prompts a focus not restricted to functionality, but covering the enacted lived experiences, constellations of interaction and shifting value systems that are central to an embedding of technology in everyday life. Engaging with these questions requires – in addition to technological fluency – a way to open up the landscape of future possibilities, and to uncover and shift the underlying imaginaires of what robots are and critically explore [21] how we might relate to them.

This is a space where creative practice can intervene. Technology related art requires active interpretation and engagement on the part of the viewer, while engaging deeply with questions of what the technology means as well as what it can do. Work can be experiential, giving a space for engaging with possibilities in visceral, liminal, poetic ways as well as a rational interrogation. Ambiguity and open works provide space for feeling into what alternate futures and worlds might be, circumventing default assumptions and future relations. This connects to speculative design and design fiction: careful and critical creation of alternate futures, raising questions around technology such as spookiness [4], the uncanny [17, 35], enchantment [28] and so on. However, in the translation to HRI there is also a need to engage to some extent with the actual: having working robotic elements to create the sense of agency and autonomy that is central to meaningful robotic experiences. Bringing the threads together, this potential for deep engagement, along with a sense of open possibilities creates a reservoir of unfamiliarity: it is a pool of estrangement and provocation that can be drawn on to scaffold exploration of the possibilities of different futures.

In this pictorial, we map out a project that works in this space. We take a Research through Design [24] approach to work with three distinct groups: artistic practitioners with a history of creating large scale robotic installations; educators supporting students in learning to work with interactive technology; and transdisciplinary robotics researchers looking at hard industrial HRI questions. Through the engagement, we develop a process where key features of the worksite are abstracted into intermediate level knowledge [22] so that they can be re-interpreted by students into creative robotic behaviours, leading to an experience that recasts the industrial setting into experiential engagement. Through visual documentation and the researchers' reflections, this works contributes with:

• A reflective description of a process where artistic practitioners were engaged around HRI concerns to support speculation.

• Development of the concept of meta-behaviours that translate practices found on-site into interaction design material.

• Methodological reflections that can support future HRI researchers to engage with artistic practice.

RELATED WORKS

Robots have long been explored within artistic settings to achieve unprecedented modes of expression and audience enchantment. Popular examples of robot musicians can be found from the 18th century, see the Vaucanson *Flute Player* [2], up to today, e.g., the robot for Chinese bamboo flute performance [20]. Artists have used robots to produce artworks in various ways: Tresset's *X robots Named Paul* [34] create portraits of visitors; Murray-Rust and Jungenfeld's *Lichtsuchende* [26] is a piece composed of robots interacting; Yuan and Yu's [37] I can't help myself invites visitors in to their critique of automation, with a large industrial robotic arm unsuccessfully sweeping up its own leaking hydraulic fluid; Sougwen Chung's *Drawing Operations* [5] works as a performance about human-robot collaboration through paintings. These are just few examples of the growing body of projects being developed at the intersection between art and robotics, which is also gaining increasing attention from the HRI community [10, 15, 16, 28]. As illustrated by Cubero and colleagues [10], artistic settings not only provide venues for robotics that are alternative and substantially different from its traditional application domains (e.g., industrial applications, education, healthcare etc.), but also often require dedicated control interfaces and distinct modus operandi. It is becoming increasingly evident that not only can robotics provide opportunities for artistic expression, but also that art practices can offer unconventional sites for investigation and knowledge production within HRI.

Art practices informing HRI design

Acknowledging the potential value of artistic practices for informing HRI design, researchers have started to leverage diverse art forms as ways of generating knowledge, drawing on theatrical formats, dance techniques, and installations. Levillaine et al. [19], for instance, used installations involving non-anthropomorphic robotic artifacts, to observe how people interpret and react to robots' behaviour characteristics and personalities. Jochum et al. [18] explored the use of theatrical performances for staging believable HRI scenarios and understanding their perception and potential acceptability from the audience. Alcubilla Troughton et al. [36] focused on dancers' expertise and explored the potental of improvisational techniques as basis for designing rules to shape robot motion choices.

As Baraka [1] argues, through improvisation, dance, role-play and more, the lab can turn into a theatre that can mirror, poke, and question our reality to understand matters of relationality around human-robot coexistence. The way artistic practices afford knowledge production is distinct from the ones dominant in the HRI, as for other technological fields. Related work at the intersection of artificial intelligence and arts, for example, informs us about how the latter opens the *epistemological* space of a technology, and *spectacularises* its possibilities as well as its socio-cultural relations and political implications [12]. Similarly, hen artistic practice is substituted for mechanistic explanation the possibilities of new technology are understood more viscerally and vibrantly [13, 14].

Hence, art practices can provide the field with a fertile ground, especially for the critical end of robotics research, which is increasingly necessary for dealing with the complexity and intricacies of robots operating in social contexts [31]. However, apart from few virtuous examples, the practical ways to engage with art in HRI remain under-discussed, methodological recommendations are lacking, and the adoption of artistic techniques remains mostly appanage of specific researchers who can leverage a personal background on artistic disciplines.

SPATIAL ROBOTIC EXPERIENCES FOR INDUSTRIAL SPECULATION

This project sets out to investigate how artistic practice, in particular spatial experiences can be brought to bear on rethinking worker-robot relations. It mixes a heavy industrial setting with exploratory, playful methods that create space for discussion and re-imagination. It also connects to education - students work as collaborators to re-interpret and implement ideas from the industrial context using the robotic infrastructure provided. Sitting within larger projects, the work in this paper was somewhat opportunistic, making use of the conjunction of elements. To speculate about the future uses of robots in Schiphol baggage handling system, students used a poetic physical form language to re-interpret practices from the work site into robot behaviours that visitors could then experience. The spatial robotic experience was than used as a way to support an open discussion of future HRI possibilities with stakeholders. In this paper, we do not detail our findings from discussion with stakeholders and visitors, but rather articulate what it takes to engage with artistic practices in HRI research.

Artistic Robotic Infrastructures

The underlying robotic architecture, both physical and digital, has its roots in artistic practice. It is a longstanding project of the Living Architecture System Group (LASG) to create artworks that connect robotics and architectural thinking to ideas from complexity theory and parametric design. These projects take the form of immersive environments at architectural scale where visitors can experience interactions with an interactive assemblage. The components of these projects have a distributed topology composed of multiple nodes that contain microprocessors, sensors and mechanical actuators that allow for movement, vibrations, light and other responses. Individual nodes work both autonomously and in coherent groups, employing networked communications that support collective coordinated behaviours of various kinds. There is a coherent and evolving form language behind the works: organic shapes and movements connected with geometrically derived ligatures, where nothing is hidden - the microprocessors and cables are visible, part of the body - and physical materials are carefully chosen to be simple and clean yet reflective, vibrant and vibratory. This all happens within a ‘spatialized digital milieu’ [R6, 11], where devices are given a location, and react to global ‘weather’ as well as shared events.

For the artistic practitioners, there were two particular investigations at play: a chance to exercise the technical infrastructure, to see how the concepts and the hardware responded to the needs of a diverse group of students; secondly, to try out the form language developed by [R7] as a ‘kit of parts’ approach - a flexible and open approach to physicalizing large scale robotic architectures.

Interactive Education Environments

The Over the course of several years, a site of collaboration has been formed between artistic practice and education, around the Interactive Environments Minor course run by [R1], where students explore and prototype possibilities for creating immersive spatial installations using digital technologies. They work full time for 20 weeks, designing, prototyping and learning, and since 2018 the course team has collaborated with LASG. This will ultimately lead to a permanent installation of the robotic components as an experiential testbed to further develop the potential of these robotic infrastructures. The course works in two halves, an initial exploration of technology through creating simple robotic creatures that interact with each other and their environments, followed by a deeper self-guided exploration of interaction possibilities.

We planned this engagement in the middle week, to create space between the two halves. The students would build up a collection of simple robotic modules and collectively create a large scale shared experience. This set the possibility for collaboration - by giving the outline of what the students would build, it provided an impetus for their thinking about robot behaviours, and also provided a point of engagement with external ideas. For the educational practitioners, the main need was to have an engaging structure for the students - it needed sufficient complexity to be interesting, but enough space that the students could exercise creativity and come up with something they were proud of. It also needed to be rapidly constructed, and equally rapidly broken down after the fact.

Researching Schiphol baggage handling system

Completely separate from these efforts, the third story begins in industry, with teams exploring the future of worker robot relations. The ‘Transdisciplinary Taskforce’ (TDT) [R2] - was set up in collaboration with Schiphol to investigate how baggage handling could be transformed with the introduction of robots . They were engaged with understanding the site and the current processes, through site visits, interviews, context and system mapping, with an eye to exploring possible future robotic interventions and supports. The goal of the TDT is to shared visions of the future of work for Schiphol baggage handling system, and more broadly to develop the techniques and methodologies that support this kind of practice. The project here provided a way for the TDT to synthesise and reflect on their findings so far, which had been primarily observational. It also functioned as an exploration of how to bring speculative approaches back to the industrial stakeholders, and meaningfully use them in the process of investigation and transformation. The TDT also has a project goal to socialise the methods used among the stakeholders and demonstrate how transdisciplinary approaches can be used, while also maintaining buy-in from the workforce and the wider organisation.

RESEARCHERS' POSITIONALITY

R1 "I'm a senior interaction designer and educator with a technical inclination. I develop and teach courses on human computer interaction and prototyping where I bridge between the design of small interactive things and interactive architecture, inclusive of HRI explorations"

R2 "I'm a junior design researcher, currently investigating the challenges faced by baggage handlers in airports and explore how to integrate robotics to alleviate their physical strain. My experience spans from communication for industry, to gamification and visualization of science in education, to teleoperation and error handling for robots operating in space"

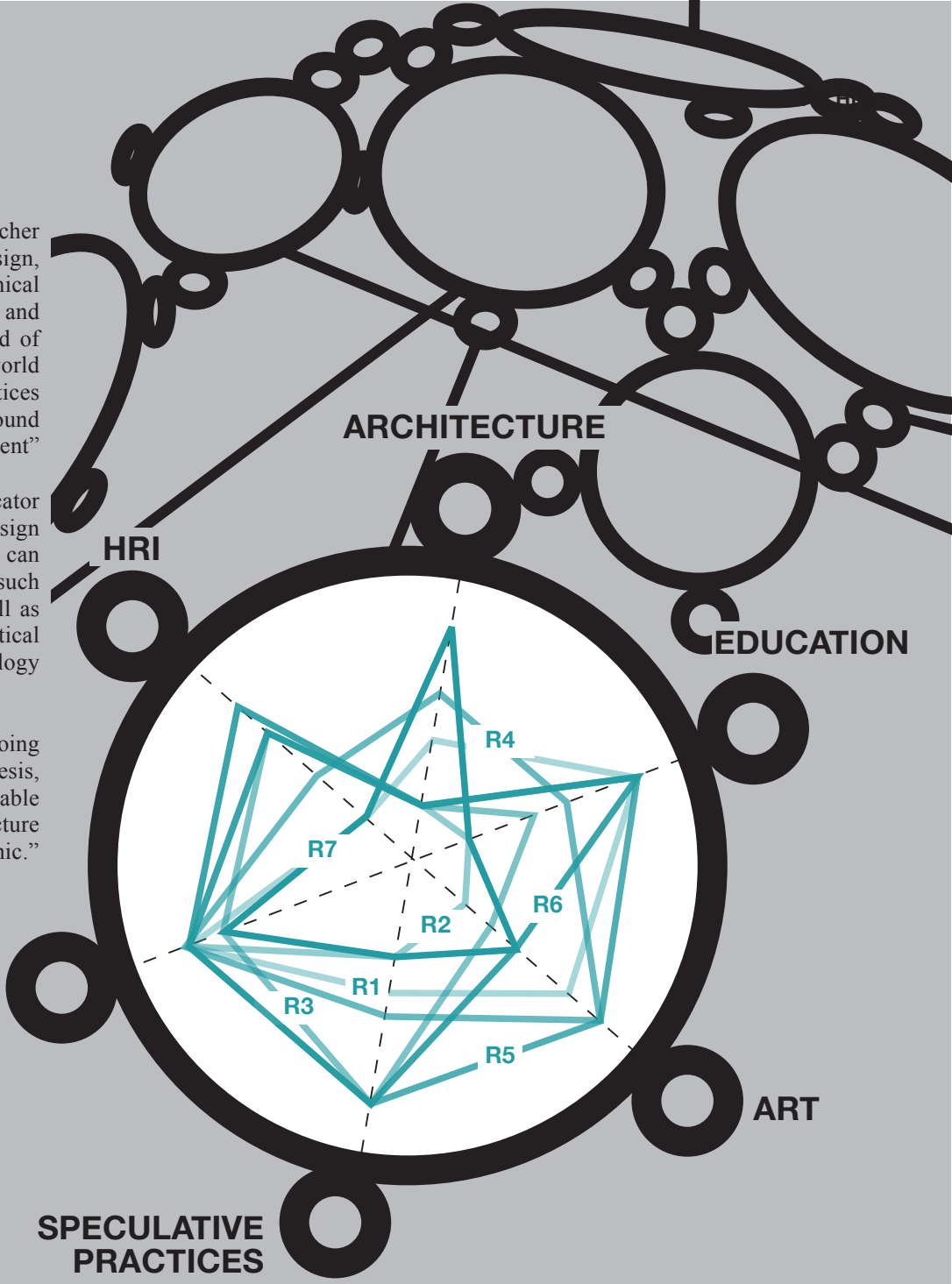
R3 "I'm a postdoctoral design researcher, strongly interested in critical and speculative design practices. I'm currently exploring possible relations between humans and robots in an airport context. This is my first experience in HRI but I see this as one of the most interesting and promising terrains to apply critical and future-oriented design practices."

R4 "I'm a researcher with long experience in art+technology and HCI research. I have developed software infrastructures for responsive environments, and extensively engaged in education to explore and build possible forms and interaction ideas emerging from this. The installations we create incorporate classical aspects of robotics, e.g. sensing, communication and actuation, but introduce possibilities for expressive poetic applications of robotics in an architectural context."

R5 "I'm an interdisciplinary researcher and educator working between design, AI and HRI. I connect philosophical ideas to concrete design practices, and explore how the more speculative end of design can effect change in real world contexts. I leverage artistic practices to explore uncharted territories around robots, sound, light and movement"

R6 "I'm a design researcher and educator working at the intersection of design and HRI/AI. I investigate how we can leverage traditional design practices, such as graphic and product design, as well as prototyping techniques, to promote critical and responsible approaches to technology development"

R7 "I'm an architecture student doing research with the LASG for my thesis, looking at ways to create an approachable kit-of-parts for interactive architecture with a distributed and compliant tectonic."



INDUSTRIAL CONTEXT

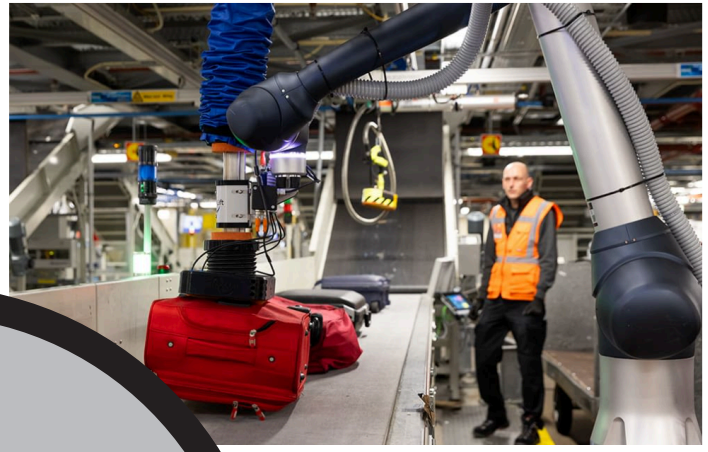
The modern baggage handling system is a complex socio-technical infrastructure. This work looks at Schiphol handling baggage system [29], a major international hub, that processes tens of millions of suitcases per year, with six different handling companies and over a hundred different airlines. This is hard work for the handlers, and there is a push to make the work less physically demanding. One of the responses to this is to look at increasing the level of automation in the process. Due to the heterogeneous nature of baggage to be dealt with, this is not an easy task. Despite this, the Dutch Labour Inspectorate to fully mechanise the handling of baggage within two years [7]. Schiphol responded accordingly:

"Every workplace in the baggage handling hall will have a properly functioning lifting aid by April 2024, which must be used by all employees. At the same time, we are also working on the next step for the period after this: automation of physical work."

The airport is investigating the possibility of cobots to support workers [29] - see image of announcement. These are generally planned to aid in lifting tasks, to remove the physical strain from workers. As well as the physical difficulties in moving suitcases around, there are questions about what the role of employees should be. As part of this project [https://shorturl.at/FIKLQ] the Transdisciplinary Task force has been brought together to investigate what the future of worker robot relations might be here - in particular, to support Schiphol's goal that:

Baggage robot takes over the heavy lifting

How do we make the work of our colleagues in the baggage hall less physically demanding? By taking the heavy lifting off their hands. This is why we recently purchased nineteen baggage robots, one of which is already in use. That's how we're working towards a lighter workload.



"Even in an automated baggage handling hall, employees will still have an important role. We are shaping the future of work and how the role of people will change in it".

https://shorturl.at/FIKLQ

ARTISTIC GROUP

Material kit design

EDUCATORS

Workshop planning

Infrastructure design

On day 1 students were divided into 7 groups, each assigned with a metabehaviour to be used as a prompt for designing.

Groups forming

The groups conceptualised and explored ways to enact their metabehaviours in a spatial and experiential manner, relying on the given technologies, and exploiting the digital milieu and the reference physical form of language.

Implementation

EXPERIENCE

To guide the visitors, a pamphlet was created to explain the process, the concept of metabehaviour, and to provide with instructions to match each robotic creature with the correspondent metabehaviour.

STUDENTS

Understanding context and metabehaviours

Some members of the team held steering sessions with the groups to understand their ideas, needs and potential criticalities, and to create moments of collective sharing.

TD TEAM

Metabehaviours creation

TD taskforce + researchers brainstormed to define a set of seven metabehaviours

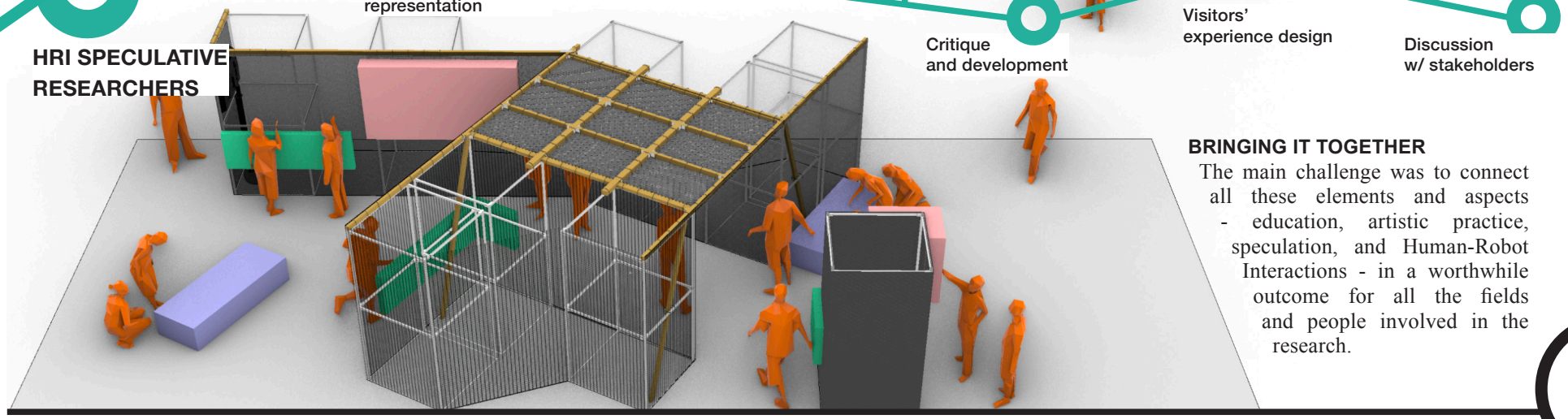
Metabehaviours ideation and context representation

HRI SPECULATIVE RESEARCHERS

Critique and development

Visitors' experience design

Discussion w/ stakeholders



BRINGING IT TOGETHER

The main challenge was to connect all these elements and aspects - education, artistic practice, speculation, and Human-Robot Interactions - in a worthwhile outcome for all the fields and people involved in the research.

ANATOMY OF A META-BEHAVIOUR

Meta-behaviours is a concept in flux: we were defining them through the doing as part of a Research through Design (RtD) approach [9, 24, 32] to create intermediate level knowledge [22] that bridges specific practices on the worksite with broader concepts. Therefore, we conceptualised them as abstractions of physical, cognitive, interactive, and inter relational performances or repeating patterns, that happen within a working space, and we crafted them as having concise and comprehensible names or short sentence descriptions.

They were not intended to be objective and universal, but rather they should be seen as boundary objects: concepts that can be used in different places, with a loose shared meaning but specific local meanings [33], that promote shared transform, mobilise and legitimise design knowledge [3]. Meta-behaviours were created by leveraging the TDT direct observations of the baggage handling sites and a transdisciplinary [25] interpretation and systematisation of the workers' actions, tasks and engagement, to ideate short and simple stories of practices capturing moments of change, crisis or reconfiguration within the baggage handling system.

These stories centre on baggage loading and unloading, using long lateral conveyor belts, carts and containers. There are moment of crisis when the baggage stops flowing properly, which is communicated to the workers through light indications and information on screens. In this case, they have to regain control over the flow by altering it and moving other workers to different work stations. This whole process engages the workers with several sub-tasks, actions or performances, and seven of these performances were transformed into the meta-behaviours that have been then provided to students.

The **meta-behaviours** looked for **enacted** practices in the **context**, abstracted them for students as design possibilities to create an **artistic implementation**. This framed the encounter that visitors had, leading in to their **speculation** about how the **meta-behaviour** - and the process it embodied - could be rethought in the future.

7 META-BEHAVIOURS

Making space
Workers must be provided with the proper working space to avoid hindering each other or bumping into machinery.

Loading and fitting
Workers must load the carts/ containers with baggage, while fitting them in a precise way.

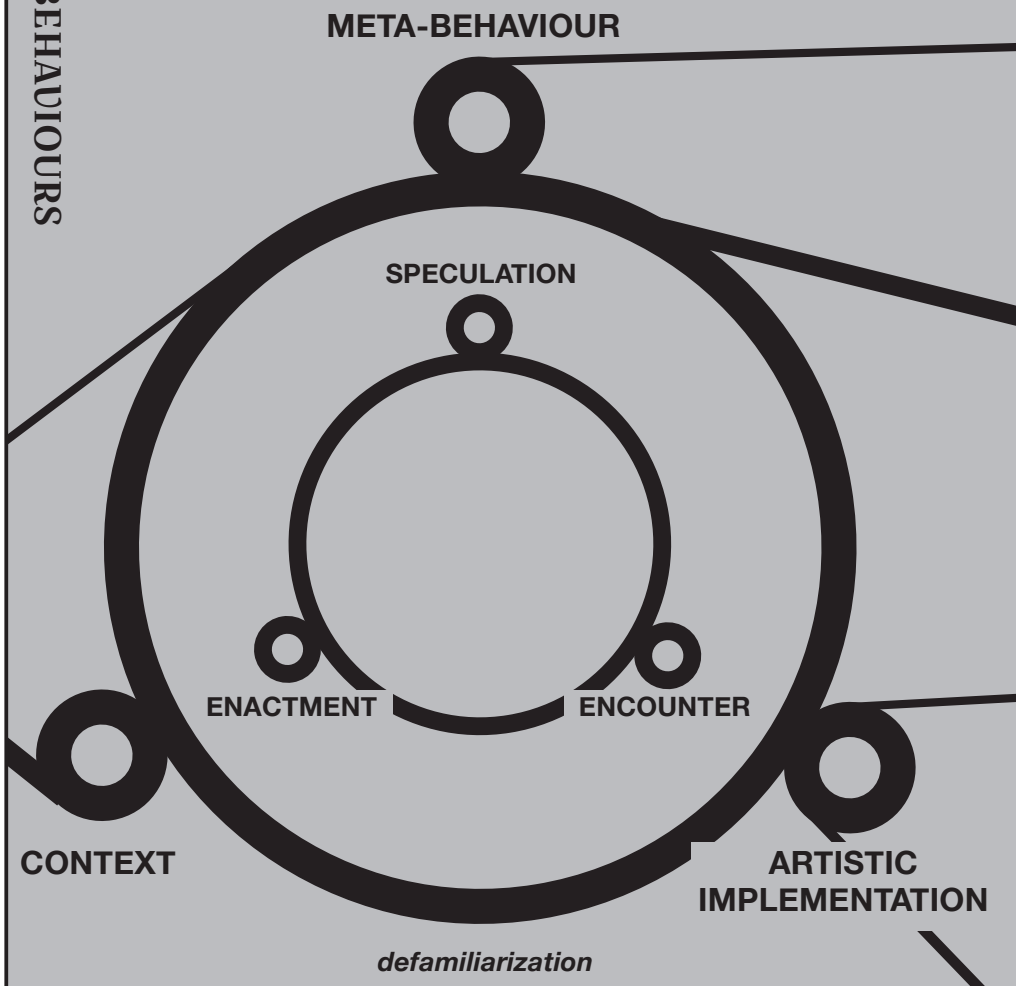
Communicating the role
Within the reference working environment, the responsibilities are displayed through soft and "playful" communication (e.g. color of vests).

Getting attention
(experienced) workers can understand the correct functioning of machineries/ technologies relying not only on sight.

Protecting
Workers are at risk of injury and must therefore take safety precautions while performing certain tasks.

Lifting and dropping
To lift the baggage workers may rely on technological aids, which prevent fatigue and injuries.

Asserting control
When the flow of baggage stops its correct flow, some workers must regain control over it.



PARTICIPANTS' EXPERIENCE

During the visit, participants were given a pamphlet that provided some information about the context and the overall investigation. It asked them to go through the exhibition in pairs, to explore and experience the artificial creatures and the designed interactions. Inside the pamphlets, participants found the metabehaviours cards deck which they used to note down where they thought they had seen a correspondence with each metabehaviour.

"Are you ready to take the first step into a speculative future?

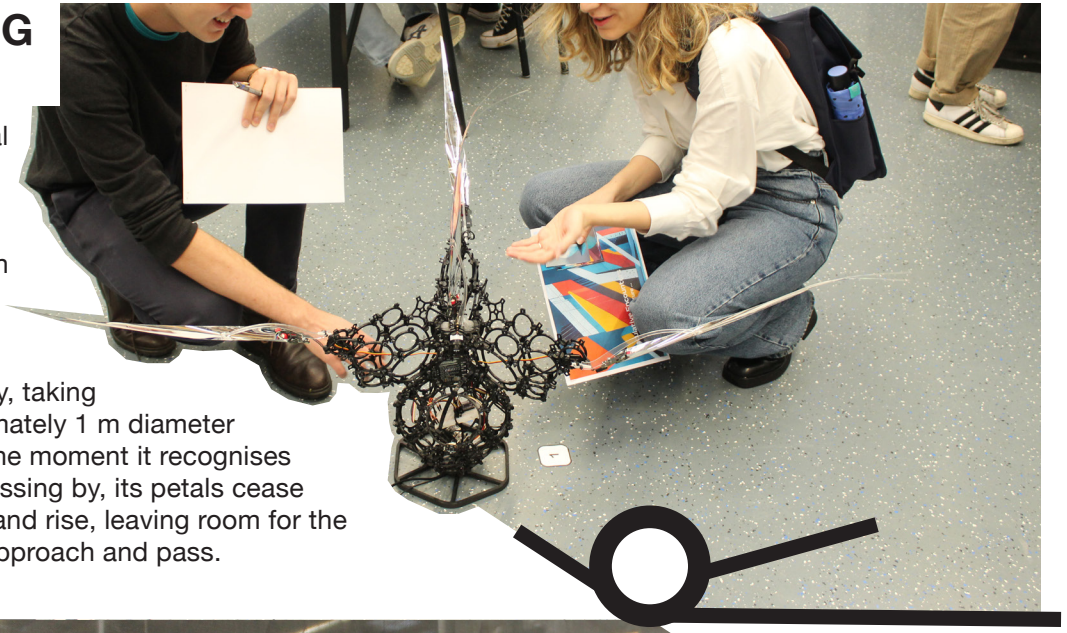
Look for metabehaviours around you.

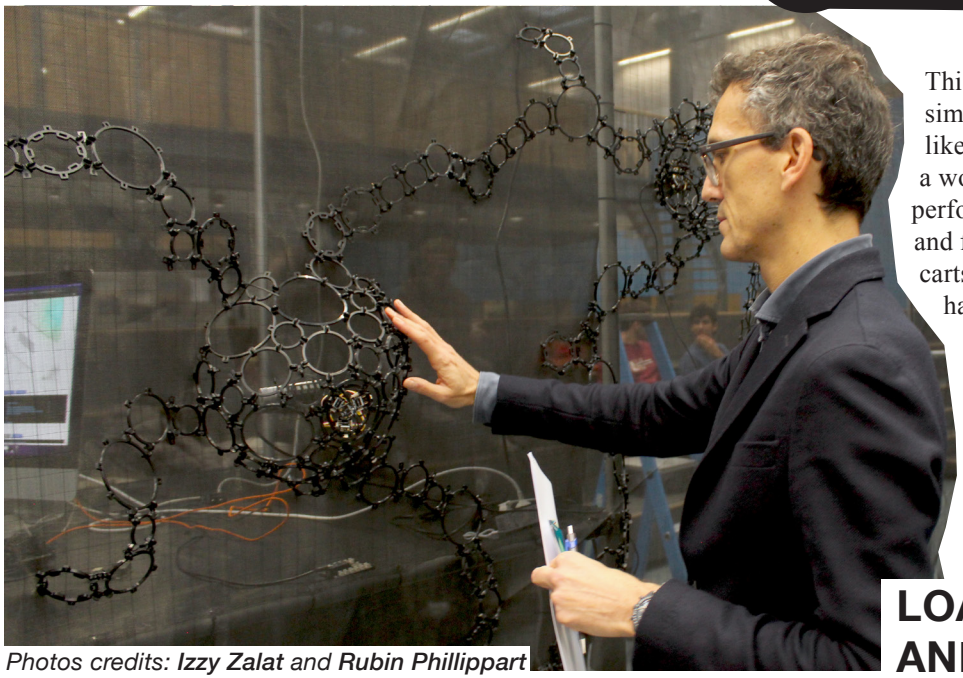
Interact with the artificial creatures you are going to meet. Play with them. Touch them.

Immerse yourself into speculative human-robot relationships."

MAKING SPACE

This artificial creature is composed of three petals which extend radially and move energetically, taking up approximately 1 m diameter of space. The moment it recognises a human passing by, its petals cease movement and rise, leaving room for the person to approach and pass.





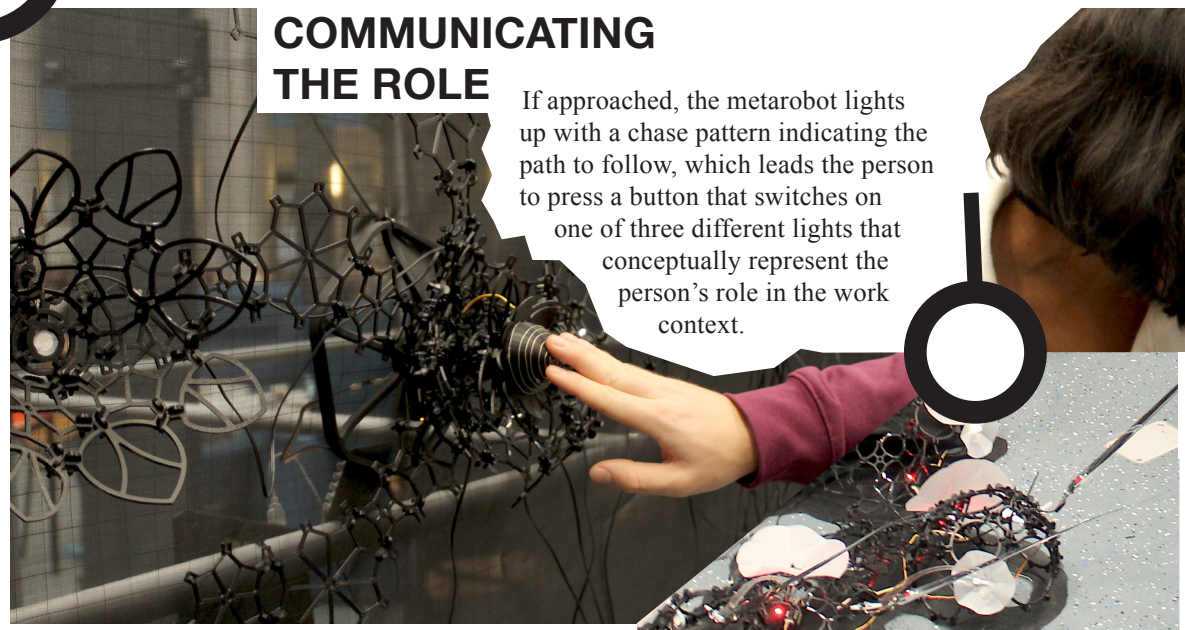
Photos credits: ***Izzy Zalat*** *and* ***Rubin Phillippart***

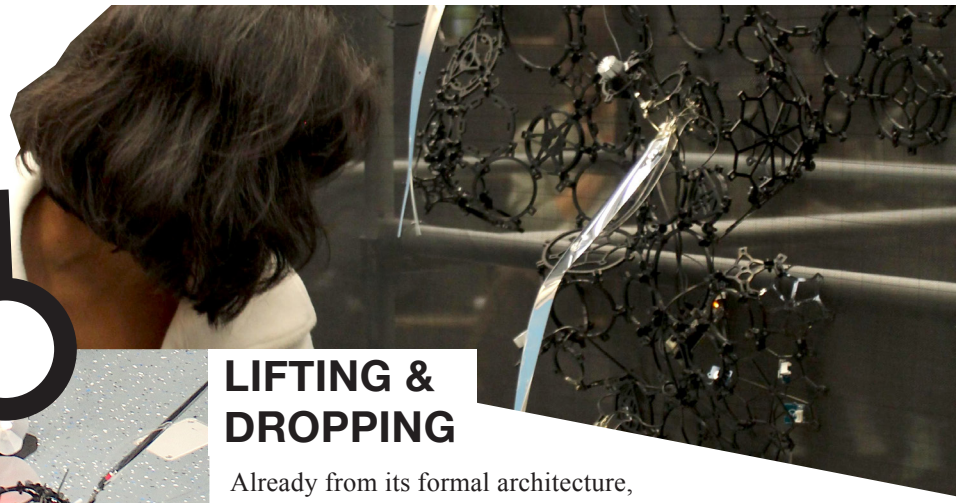
This metarobot simulates the dancer-like movements that a worker generally performs when loading and fitting baggage into carts or containers. It has a number of light points that are randomly activated, inviting the person to touch them, thus switching on to the next one.

LOADING AND FITTING

COMMUNICATING THE ROLE

If approached, the metarobot lights up with a chase pattern indicating the path to follow, which leads the person to press a button that switches on one of three different lights that conceptually represent the person's role in the work context.





LIFTING & DROPPING

Already from its formal architecture, this creature invites people to follow the motion of its petals and lights, which proceed from the bottom upwards to indicate the movement of lifting, and then descend rapidly downwards, like a drop.

This metarobot is instantiated across three different locations throughout the exhibition space and uses spatialized sequenced light patterns to attract conscious focus from people, exploiting also reflective surfaces.

GETTING ATTENTION

PROTECTING

This creature is normally busy carrying out various tasks it promptly interrupts when a human being passes close by, protecting him or her from itself. At this moment, the creature's petals rise allowing passage and its lights change from red to green.

ASSERTING CONTROL

This artificial creature that emits signals that altered the collective behaviour of the other creatures and the digital milieu, when touched in certain spots, representing the same operation a worker does when regaining control over the flow.

Photos credits: ***Izzy Zalat*** *and* ***Rubin Phillippart***

RESEARCHERS' REFLECTIONS

We conducted affinity mapping using the process outlined in Andres et. al [23] to reflect on the process. Each of the seven main practitioners involved – authors of this paper – wrote a short reflective statement about the process and their part in it, answering 6 questions about their role, feelings, analysis of the process. These were then translated onto a Miro board, coloured by question and tagged by participants. From each block of text, we extracted key parts as individual affinity notes. We then iteratively clustered these: R3 and R5 developed an initial configuration. This was then socialised and discussed with R6 and clusters were merged and reformed. These clusters form the basis of our reflection here. (note: researcher IDs do not correspond to the order of authors). When generally positive quotes are presented, they come from researchers who were not responsible for that part of the process, but from someone looking in from another domain.

Feelings and engagement

Within the team, there were many reports of fear, 'apprehension about the success of the activities' (R3), 'initial doubts' (R2) about the process, worries about the awkwardness of joining once the initial conceptual work had been carried out (R3), often simultaneously with excitement, enthusiasm and curiosity (all). R2's initial doubts turned into 'appreciat[ing] the value' of speculative working, and R7 noted the students moving from struggles to dedication and passion. The evening before the exhibition, when the students decided to stay late and went from 'nothing working' at 5pm to 'pizzas with functional robots' at 8pm was particularly resonant (R1). There was sense of responsibility, particularly for the people bridging most between different groups (R3, R5) as there were many expectations to live up to. 'Buy in' was important, as the project needed to legitimise speculative HRI practices for industrial stakeholders. The students 'were invested from day 1' (R4), but there was concern about how this 'slightly silly yet serious' (R5) way of working would land with the project management team who were essential in order to socialise the practice with the worksite. The indeterminacy of the outcomes was challenging for the researchers, but was also a barrier to engaging stakeholders. However the final experience provided a site both for integrating external inputs as well as building shared understanding as a team (R6).

Project complexity

The project was complex
- more so than in many scientific studies,
closer to carrying out action research in the field (R6).

For the students who suddenly encountered both philosophical ideas and industrial settings for their work, it was difficult to get a picture of the whole project (R1), and there was a sense of 'building the plane while flying it' (R4). However, the transdisciplinary framing was also seen to be productive for the students - it gave them a sense of purpose and helped them think across the disciplinary embeddings that they each had (R3). The complex pathway of translation from site to metabehaviours to implementations by students and then to audience interpretations allowed a potential for misinterpretation, and 'disruption of meaning' (R3), intensified by the compressed timeframe (R7). Maintaining all of the various threads - education, research, practice and stakeholder management was a particular challenge (R5). Here, the availability of the team and their openness to unfamiliar ways of working were important, and there was a sense of continual 'alignment micro-interactions' that were needed to maintain connections and navigate disciplinary differences (R6).

Engagement with the experience

The materials provided gave a structure for engagement which sparked new perspectives and curiosity among the participants (R2). The visitors had a sense of purpose in unravelling the links between the meta-behaviours and the robotic interactions. This led to much longer engagements that the research team would have expected (R5) - most visitors working with the materials spent 20-30 minutes exploring the space. There was also cross-fertilisation - attendees observed each other, looking for cues on how to proceed. In response to the exhibit, the attendees who were familiar with the site used the interactive moments as a way to develop their personal reflections on the work site; rather than trying to describe the actual baggage hall, they had conversations about the way it was framed in the interactions (R2).

ATTITUDES

Reflecting on our attitudes around the project showed a mix of approaches. There were background ideas that speculative design can prove useful in a design practice, providing meaningful interpretations and discussion, and that this experiment bore that out (R2). The project was seen as 'a fertile ground for experimenting' with ideas and concepts (R3), to embody possibilities that had been latent. There was a sense of leaving space (R5) for the students to be able to create their own interpretations and directions, coupled with the power and the challenges of working with those uncertain outcomes.

LEARNINGS

These challenges were somewhat mitigated by the structures around the workshops and education. Having critique moments where the students showed work in progress helped explore questions of representation, abstraction and narrative (R4) and led to some of the "strong and eloquent responses some teams gave to the meta-behaviour prompts" (R4). Initial concerns about mismatches in technique turned out to be unfounded, as the focus on the experience allowed enough flexibility around concepts that people could find common ground. The meta-behaviours were part of this, forming the glue between concept and experience. Discussions around the experience were lively and stimulated, rich with reflections (R3). Visitors understood the intent of the work, and the concepts embedded in it (R4). The blend between education, art practice and speculation seemed to be stimulating (R3), creating positive feedbacks amidst the 'slight sense of chaos' (R4). The multi-disciplinary nature of the work supported the students in their investigations and they made an extremely strong showing of interpreting the context and creating dynamic responses to it (R4).

FUTURE DESIRES

The largest sense of missed opportunity around the experience was to have been more bold in recruiting stakeholders for the event. It takes work and sensitivity to build the relationships that help people to engage with this kind of practice, and this limited reach for engaging with the workforce. On the day, those stakeholders who attended were enthusiastic, would have brought more people if they had known what to expect (R2). This indicates a need for better description from the research team about what will happen and how to engage with it.

Process reflections

Meta-behaviours

The meta-behaviours were a central part of the work, as they provided 'a fantastic bridge between the rigour and practicality of an industrial robot context and the open-ended exploration required to push experience design and technology in new directions' (R4). They provided structure for visitors (R2); purpose to the experience as a whole (R5); stimulated students to create interesting and high quality interactions with the infrastructure provided (R3); gave something to 'work with and re-interpret, while not being overly constrictive'; and acted as a focusing function (R4). They were 'a way to bring soft speculations within a proto-industrial context' (R3) connecting future possibilities for HRI within the intended setting. Openness and abstraction helped - if they had been too obvious, too closely related to the practices on site, this would have reduced the potential for discussion and engagement.

The question of how far to abstract was balanced with desire to keep tangibility and contextual connections to the worksite. Since the concept of meta-behaviours was developed through the process as a way to connect the various conceptual threads of the project, the initial formulation was quite open - the TD Taskforce was asked to find meta-behaviours without fully specifying what they were. They were happy to work in a relatively exploratory manner, even though it was not clear how all of the concepts would be translated by the students (R5). Each group of students was able to implement their designated behaviour with minimal conceptual difficulty - most challenges were how to make the technology function correctly. After the meta-behaviours were handed over, there was still space for surprise - one group unconsciously developed a new meta-behaviour, while another naturally came up with a surprising interpretation that matched the researchers internal imagery (R3).

DISCUSSION

Evaluating what worked

This was a RtD inspired approach: the process of designing the speculative encounter was as much the subject of research as the outcomes that came from it. It is a prototype that argues [8] for a particular position, that is: artistic practice can be a useful resource for HRI, in particular through supporting speculation about the future possibilities of human robot interactions. In this pictorial, we do not dive into analysing the data and reactions of the visiting stakeholders. Rather, from the practitioner's reflections, we start to build up a situated sense of what worked here and what didn't, and we draw out some of the key points:

• The process was exploratory, risky and uncertain, which made it hard to represent to the wider project team what the outcomes would be. Even within the core team, the belief in the possibility of the work to connect to industrial stakeholders changed dramatically as the experience came together. This is an issue for experiential work: even good documentation is less convincing than actual experiences.

• Building trust through collaboration was beneficial. Each engagement helped to develop confidence that something could be unpacked. We needed to develop a practice of micro-interactions, noticing anxieties and the continual process of building bridges between disciplines.

• Exploratory, opportunistic projects such as this serve a dual role: they function as a site of research, but beyond this they are vehicles to socialise the ideas of criticality and experience beyond the laboratory. Stakeholders who had not previously been champions of speculative design for HRI left the experience looking for ways to bring more of these practices into their sites.

• Having a purpose to the engagement through the pamphlet and meta-behaviour cards gave participants a frame for engaging with the experience, creating a deeper kind of investigation than simply presenting the work, or an open ended 'explore' instruction.

• The meta-behaviours functioned as a connecting material between the various parts of the projects. The students had overview of the context, but they did not have to dig into the complexities as these were distilled and simplified into the short descriptions. They had space for creative interpretation about the ideas behind the activity, that did not fall into brute physical mimicry on one side or over-narrating on the other.

• Having a strong form language meant visitors needed to work with what was actually there - there was no space to create icons or characters, to name things or otherwise engage in design semiotics. For the visitors, it meant they could discuss in terms of what was in front of them, leaving space relative to their understandings of the context where they work - while still offering the potential for familiar connections.

Methodological takeaways

From this, we distil some takeaways about our method and practice as short provocative statements:

• Indulge into counterintuitive material choices - the robots here do not match the default expectations of industrial robots: they are fragile, low power, 'useless'. But this creates more conceptual space than bringing in a 'real' robot, as well as making prototyping safer and easier.

• Dismantle hierarchies to make space for 'naive' views - giving the students the materials, when they do not have deep context or long term experience is surprisingly powerful. The knowledge of embedded stakeholders creates limits; unfamiliarity and translation provided a resource of surprise and creativity and imagination.

• Stay with the trouble of value disconnects - before seeing the piece, some stakeholders were unconvinced; after the experience, there was a strong support for bringing this work into the industrial context. This is not a surprise, nor a reflection on the quality of the stakeholders: it's the necessary practice of negotiating understandings across diverse groups.

• Abstract to create safe spaces for collaboration - visitors projected their feelings and imagination onto the speculative experience, not the real thing. This makes it much easier to have challenging discussion around it - it creates a safe, polysemic way to interact [6].

• Play deeply - we provided a playful frame for exploring the context, but on its own, this would not have been enough. The combination of structure, an open script to engage with was central to the thoughtful engagement of participants.

• Building on and harnessing the artistic technological infrastructure that had been developed over several years – while modifying it for open creative input – meant that we could create a robotic experience in 4 days that would have otherwise been extremely difficult to conceive and execute.

CONCLUSION

This pictorial documents a process where artistic practice is brought into HRI, to create grounds for speculation. We illustrate the way that a multidisciplinary project can connect artistic practice to important HRI questions of how people and robots should relate. Through an intensive, rapid collaboration, we translated practices that are in the process of being redesigned as sites of worker robot engagement into an interactive robotic experience. This drew on the practices of an internationally renowned group of artists as well as the curiosity and dedication of a cohort of bachelors students. One outcome of the process is the concept of meta-behaviours, which function as translations of knowledge between different parties, acting as boundary objects, containers of intermediate level knowledge that help to structure and deepen engagements between creative practice and HRI concerns. Alongside this, we offer methodological considerations that can help future HRI researchers to draw on the reservoirs of unfamiliarity provided by artistic practice, bringing creative approaches to co-speculating about future interactions with robots.

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REFERENCES

[1] Baraka, K. 2023. Why Robotics Labs Should Look More Like Theatres. Connected World. I. Vermeulen, ed. VU University Press.

[2] Bedini, S.A. 1964. The Role of Automata in the History of Technology. Technology and Culture. 5, 1 (1964), 24–42. DOI:https://doi.org/10.2307/3101120.

[3] Bergman, M., Lyytinen, K. and Mark, G. 2007. Boundary Objects in Design: An Ecological View of Design Artifacts. Journal of the Association for Information Systems. 8, 11 (Nov. 2007), 546–568. DOI:https://doi.org/10.17705/1jais.00144.

[4] Byrne, D. and Lockton, D. 2021. Spooky technology: a reflection on the invisible and otherworldly qualities in everyday technologies. Imaginaries Lab ; School of Design, School of Architecture, and Frank-Ratchye STUDIO for Creative Inquiry, Carnegie Mellon University.

[5] Chung, S. 2015. Drawing Operations.

[6] Cross, I. 2003. Music as a Biocultural Phenomenon. Annals of the New York Academy of Sciences. 999, 1 (2003), 106–111. DOI:https://doi.org/10.1196/annals.1284.010.

[7] Dutch Labour Inspectorate. 2023. Notification document:European Commission notification Balanced Approach procedure for Schiphol. Retrieved January 15, 2024 from https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2023/09/01/bijlage-3-notification-document-balanced-approach-procedure-schiphol/bijlage-3-notification-document-balanced-approach-procedure-schiphol.pdf

[8] Galey, A. and Ruecker, S. 2010. How a prototype argues. Literary and Linguistic Computing. 25, 4 (Dec. 2010), 405–424. DOI:https://doi.org/10.1093/llc/fqq021.

[9] Giaccardi, E. 2019. Histories and Futures of Research through Design: From Prototypes to Connected Things. International Journal of Design. 13, 3 (2019), 139–155.

[10] Gomez Cubero, C., Pekarik, M., Rizzo, V. and Jochum, E. 2021. The Robot is Present: Creative Approaches for Artistic Expression With Robots. Frontiers in Robotics and AI. 8, (2021).

[11] Gorbet, M.G. 2023. The Spatialized Digital Milieu: An Infrastructure Approach to the Design of Responsive Environments. DDes. Florida International University, Miami Beach.

[12] Grba, D. 2022. Deep Else: A Critical Framework for AI Art. Digital. 2, 1 (Mar. 2022), 1–32. DOI:https://doi.org/10.3390/digital2010001.

[13] Hemment, D., Murray-Rust, D., Belle, V., Aylett, R., Vidmar, M. and Broz, F. 2022. Experiential AI: Enhancing explainability in artificial intelligence through artistic practice. (Mar. 2022).

[14] Hemment, D., Zeilinger, M., Vidmar, M., Elwes, J., Warner, H., Sarmiento, D. and Hill, R. 2022. Towards a heuristic model for experiential AI: Analysing the Zizi show in the new real. DRS Biennial Conference Series (Jun. 2022).

[15] Herath, D., Jochum, E. and St-Onge, D. 2022. Editorial: The Art of Human-Robot Interaction: Creative Perspectives From Design and the Arts. Frontiers in Robotics and AI. 9, (2022).

[16] Herath, D., Kroos, C., and Stelarc eds. 2016. Robots and Art. Springer Singapore.

[17] Jochum, E. and Goldberg, K. 2016. Cultivating the Uncanny: The Telegarden and Other Oddities. Robots and Art: Exploring an Unlikely Symbiosis. D. Herath, C. Kroos, and Stelarc, eds. Springer. 149–175.

[18] Jochum, E., Vlachos, E., Christoffersen, A., Nielsen, S., Hameed, I. and Tan, Z.-H. 2016. Using Theatre to Study Interaction with Care Robots. International Journal of Social Robotics. 8, (Aug. 2016). DOI:https://doi.org/10.1007/s12369-016-0370-y.

[19] Levillain, F., Zibetti, E. and Lefort, S. 2017. Interacting with Non-anthropomorphic Robotic Artworks and Interpreting Their Behaviour. International Journal of Social Robotics. 9, 1 (Jan. 2017), 141–161. DOI:https://doi.org/10.1007/s12369-016-0381-8.

[20] Li, J., Hu, T., Zhang, S. and Mi, H. 2019. Designing a musical robot for Chinese bamboo flute performance. Proceedings of the Seventh International Symposium of Chinese CHI (New York, NY, USA, Jun. 2019), 117–120.

[21] Ljungblad, S., Serholt, S., Milosevic, T., Bhroin, N.N., Nørgård, R.T., Lindgren, P., Ess, C., Barendregt, W. and Obaid, M. 2018. Critical robotics: exploring a new paradigm. Proceedings of the 10th Nordic Conference on Human-Computer Interaction (New York, NY, USA, Sep. 2018), 972–975.

[22] Löwgren, J. 2013. Annotated portfolios and other forms of intermediate-level knowledge. Interactions. 20, 1 (Jan. 2013), 30–34. DOI:https://doi.org/10.1145/2405716.2405725.

[23] Lucero, A. 2015. Using Affinity Diagrams to Evaluate Interactive Prototypes. Human-Computer Interaction – INTERACT 2015 (Cham, 2015), 231–248.

[24] Luria, M., Hoggenmüller, M., Lee, W.-Y., Hespanhol, L., Jung, M. and Forlizzi, J. 2021 Research through Design Approaches in Human-Robot Interaction. Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction (New York, NY, USA, Mar. 2021),

685–687.

[25] Max-Neef, M.A. 2005. Foundations of transdisciplinarity. Ecological Economics. 53, 1 (Apr. 2005), 5–16. DOI:https://doi.org/10.1016/j.ecolecon.2005.01.014.

[26] Murray-Rust, D. and von Jungenfeld, R. 2017. Thinking through robotic imaginaries. (Mar. 2017).

[27] Zaga, C, Lupetti, M.L, Forster, D., Murray-Rust, D., Prendergast, J.M., and Abbink, D. 2024. First International Workshop on Workers-Robot Relationships. HRI2024 (2024).

[28] Rose, D. 2014. Enchanted objects: design, human desire, and the Internet of things. Scribner.

[29] Schiphol. 2023. Baggage robot takes over the heavy lifting. Retrieved January 15, 2024 from https://www.schiphol.nl/en/blog/cobot-at-schiphol/

[30] Seifert, U. and Kim, J.H. 2008. Towards a conceptual framework and an empirical methodology in research on artistic human-computer and human-robot interaction. Human Computer Interaction. I. Pavlidis, ed. Citeseer.

[31] Serholt, S., Ljungblad, S. and Ní Bhroin, N. 2022. Introduction: special issue—critical robotics research. AI & SOCIETY. 37, 2 (Jun. 2022), 417–423. DOI:https://doi.org/10.1007/s00146-021-01224-x.

[32] Stappers, P.J. and Giaccardi, E. 2017. Research through Design. The Encyclopedia of Human-Computer Interaction. Interaction Design Foundation.

[33] Star, S.L. and Griesemer, J.R. 1989. Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. Social Studies of Science. 19, 3 (Aug. 1989), 387–420. DOI:https://doi.org/10.1177/030631289019003001.

[34] Tresset, P. and Fol Leymarie, F. 2013. Portrait drawing by Paul the robot. Computers & Graphics. 37, 5 (Aug. 2013), 348–363. DOI:https://doi.org/10.1016/j.cag.2013.01.012.

[35] Troiano, G.M., Wood, M. and Harteveld, C. 2020. "And This, Kids, Is How I Met Your Mother": Consumerist, Mundane, and Uncanny Futures with Sex Robots. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (New York, NY, USA, Apr. 2020), 1–17.

[36] Troughton, I.A., Baraka, K., Hindriks, K. and Bleeker, M. 2022. Robotic Improvisers: Rule-Based Improvisation and Emergent Behaviour in HRI. 2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (Mar. 2022), 561–569.

[37] Yuan, S. and Yu, P. 2016. Can't Help Myself.

[38] Zivanovic, A. and Ihnatowicz, E. 2018. Sound Activated Mobile (SAM) at Cybernetic Serendipity. Symposium on Cybernetic Serendipity Reimagined (Liverpool, 2018), 7.