Design Guidelines for Human-Agent Collaboration in a Painting Context

Authority, Autonomy, and Delegation

Master Thesis

Lenny Martinez Dominguez

Design Guidelines for Human-Agent
Collaboration in a Painting Context:
Authority, Autonomy, and Delegation

Author
Lenny Martinez Dominguez

Master Thesis
Delft University of Technology
MSc. Design for Interaction
Faculty of Industrial Design Engineering

Supervisory team
Dr. Nazlı Cila, Chair
Dr. Ing. Marco Rozendaal, Mentor

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Chapter 1
Introduction

This chapter introduces the project context and assignment, in addition to explaining the structure of the report.

Project Context

The Stichting Uitvoeringsregelingen voor het Schilders-, Afwerkings-, Vastgoedonderhouden Glaszetbedrijf, the SUSAG Foundation, in the Netherlands, focuses on ensuring that employees in trades characterized by repetitive and physically demanding work like Painting, Finishing, and Glazing can be sustainably employed. SUSAG (https://susag.nl/vragen) defines a sustainably employed individual as someone who:

> **"Works productively, motivated, and healthy within an organization, both now and in the future. [They perform] the work with energy (is vital), can handle the work physically and mentally well (is healthy) and [can] maintain the work now and in the future (is employable)."**

To support this mission, the foundation provides services like periodic health checkups, career and lifestyle coaching, and annual performance reviews to companies and their employees.

The SUSAG foundation approached the Expressive Intelligence Lab to understand how developments in sensor technology, robotics, and related fields can improve their members' sustainable employability. Focusing on painters, one of the trades the SUSAG foundation serves, is handy because the public understanding of what they do makes it easier to explore how newer technologies like agents could be involved in improving sustainable employability. Professional painters work at different scales, from residential spaces to commercial and industrial sites, with different paint types and surfaces. Their work tools vary wildly depending on the site and complexity. They may involve ladders, cleaning materials, drop cloths, paint sprayers, pressure washers, chemicals, and aerial lifts at larger scales (Shetty, 2023). Injuries due to falling or prolonged exposure to chemicals primarily affect painters. Repetitive motions in moving heavy materials and uncomfortable reaching and working postures stress the torso and neck, leading to injuries over time (WRSMH LLP, 2023).

Assignment

Considering the variety in working conditions and commonly experienced injuries of painters, agentic technology is a promising avenue to contribute towards sustainable employment. An agent is any product or service enhanced through integrated computational power and networked connectivity to sense and act autonomously on some level (Cila et al., 2017). Some commercial examples include the self-adjusting Nest thermostat that learns from user input and the wearable tracker Fitbit that collects heart rate and step data and displays it for a user. Siri and Alexa are popular conversational agents that can respond to user input, make recommendations and act independently. More specialized examples of agents include robots and exoskeletons that can support humans beyond the body's physical limitations.

When considering sustainable employment, the focus is on supporting painters' physical and mental well-being by making the work faster, healthier, and better quality. Agents in the form of tools, robots, or exoskeletons could promote physical well-being. Digital or conversational agents could assist in promoting mental well-being.

Project Outcomes and Approach

This project explores how agents can contribute to sustainable employment within the painting context. The main outcomes of this project are:

A. A speculative vision for how painters could collaborate with agents in their practice 10 to 20 years into the future, and
B. A series of design guidelines for human-agent collaboration in the painting context, based on the opportunities of incorporating different types of agents into painters' practice.

The first part of the report focuses on developing the speculative vision that is the first outcome. The latter part of the report focuses on using the speculative vision, a Design Fiction, to achieve the second outcome.

Speculative design methods play a large role in this project because they enable us to prototype and evaluate interactions without focusing on technological feasibility. This is especially useful within human-agent collaboration because we can prototype agents with higher levels of agency than what is possible with today's technology and use them to explore and understand where and how agents fit into existing ecologies and practices.

Reading Guide

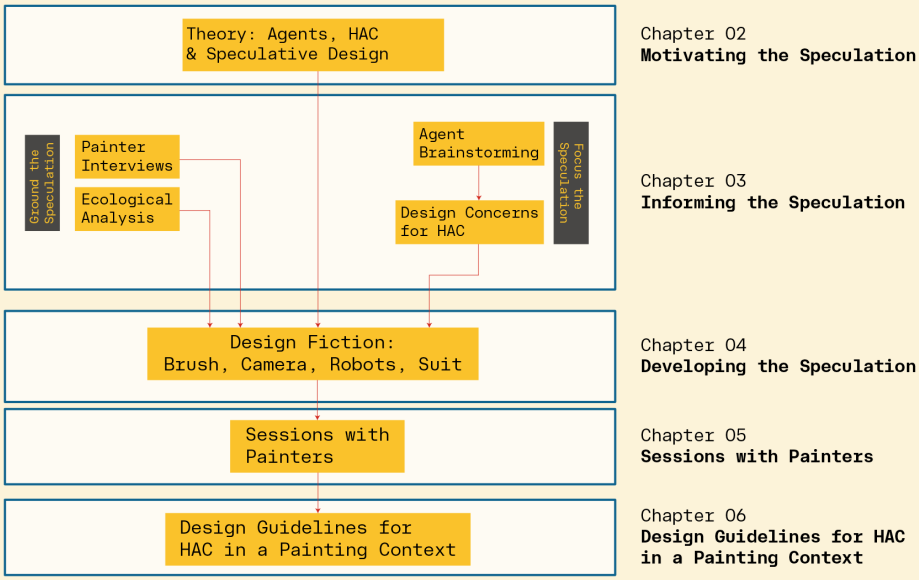

Figure 0. Diagram of chapters in the report, showing how activities and concepts connect to end at the Design Guidelines.

The rest of the report is split into six main chapters (see Figure 0). Chapter 2, Motivating the Speculation, introduces the topics of Agents, Human-Agent Collaboration, and Speculative Design, which are a foundation for the report. In Chapter 3, Informing the Speculation, I describe and highlight the research activities I used to ground the speculation in painterly practice and focus the speculation on Human-Agent Collaboration (HAC). This chapter ends with the planned direction for the Design Fiction. Chapter 4, Developing the Speculation, covers the iterative process of creating the Design Fiction I used in my discussion sessions. Chapter 5, Sessions with Painters, details the structure and insights from semi-structured interview sessions with painters facilitated by the Design Fiction developed in the previous chapter. Insights from the discussion sessions with painters serve as the backbone for the design guidelines presented in Chapter 6. In the final chapter, Conclusions, I reflect on the overall process.

Chapter 2

Motivating the Speculation

This chapter provides a basic understanding of Agents, Human-Agent Collaboration (HAC), and Speculative Design practice.

Agents

Agents are products and services enhanced through integrated computational power and networked connectivity to sense and act autonomously on some level (Cila et al., 2017). Through these added sensing and acting capabilities, agents can transform and adapt themselves to the lives of their users after they have left the factory or studio space, providing room for personalized and tailored interactions. Some popular commercial examples include the Nest thermostat (Figure 1), which learns from user input, and the Roomba, a vacuuming robot that navigates your home space to clean while dodging obstacles.

Figure 1. The Nest Thermostat is a popular commercial example of an agent. It optimizes heating and cooling based on usage patterns to save energy and create a comfortable environment. Photo courtesy of Houzz.co

This practical definition aligns with the "weak notion of agency" proposed by Wooldridge & Jennings (1995) to define an agent as a hardware or software-based artifact that exhibits some form of autonomy, social ability, reactivity, and pro-activeness (see Table 1).

Agents are a broad category of products and services with varied capabilities to sense and act. These definitions are closed enough to ensure we focus on products and services that can dynamically interact with their environment but open enough to encompass different applications and abilities. In the following sections, we will dive into two ways of

assessing and understanding agents: first, by looking at agent metaphors that describe the level of agency an agent exhibits, and then by looking at agent morphologies.

Table 1. Agent characteristics according to the "weak notion of agency" (Wooldridge & Jennings, 1995).

Characteristic	Definition provided by Wooldridge & Jennings
Autonomy	Agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state (Castelfranchi, 1995)
Social ability	Agents interact with other agents (and possibly humans) via some kind of agent-communication language (Genesereth and Ketchpel, 1994)
Reactivity	Agents perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, the INTERNET, or perhaps all of these combined), and respond in a timely fashion to changes that occur in it
Pro-activeness	Agents do not simply act in response to their environment, they are able to exhibit goal-directed behaviour by taking the initiative.

Agent Metaphors

Cila et al. (2017) provide a taxonomy of agent metaphors that offers a perspective on understanding agents based on how much agency they exert on their surroundings. These metaphors, the Collector, Actor, and Creator, exist on a spectrum from less to more agency.

The **Collector** metaphor describes agents that are data readers focused on sensing, processing, and displaying information. They have the capacity to aggregate data from local sensors or online sources and will share it with users or other products. This agent requires the user's effort and knowledge to make sense of the data and act on it (if they wish). Smart wristbands that track health and sleep data, like the Fitbit or the Xiaomi Mi Smart Band 6 (Figure 2), are popular examples of Collector agents.

Figure 2. The Xiaomi Mi Smart Band 6 tracks sleep, exercise, and heart rate data and displays it across different screens along with time and temperature data.

In the middle category for agent metaphors, we have **Actors**. These types of agents go beyond reading and can react to data. They can respond to input from users and other agents to act. One example of an Actor agent is Bjørn Karmann's Paragraphica camera (Figure 3) which combines user input, GPS, and weather data to generate a unique image. Other examples of Actor agents are the Nest thermostat and the Roomba vacuum cleaner.

Figure 3. The Paragraphica camera. Photo courtesy of Bjørn Karmann

At the high end of the spectrum, we have the **Creator** metaphor. Creator agents are "everyday products with robotic qualities" that can make a tangible change in their form and environments (Cila et al., 2017). Drawn from near-future scenarios, Creator agents are the most elusive and futuristic. These agents go beyond reacting to input and can deeply change practices and ecologies they find themselves in, creating new roles and systems. While Creator agents cannot be realized with current technology, they can still

be explored through designerly interventions and prototyping techniques to learn how these agents should be developed.

These three metaphors provide a useful way of categorizing agents based on how much they can affect their environments. They are not meant to be hard boundaries for understanding agency and instead are a starting point for ideation and design. Within the painting context, Collector, Actor, and Creator agents can potentially improve sustainable employment by raising self-awareness of health or providing a better understanding of quality (Collector), assisting in tasks like sanding or painting (Actor), or even creating new roles for the painters (Creators).

Agent Morphologies

In addition to considering the agent's ability to affect their environment, it's important to consider the agent's form. This section will focus on four morphologies: Product/Tool, Wearable, Robot, and Digital. Each morphology carries challenges and opportunities for how an agent may function and how people perceive it.

Digital Agent Morphology

This is the easiest morphology of the four to define and differentiate. Digital agents are software-based agents embedded in different contexts and roles as stand-alone systems (like Siri, Alexa, or Microsoft's Bing) or as part of a larger system of agents. Interactions with these agents are mediated through an input device like a touchscreen, keyboard, or microphone, as the agent is not physically embodied. Some agents are tied to a physical device like Siri (Figure 4) or Alexa, a browser or webpage like ChatGPT (Figure 5) or Bing, or a phone number (such as with Airline booking services).

Figure 4. Apple's Siri is a virtual assistant that answers user queries and requests. It is available across all Apple products and is visually represented by this orb.

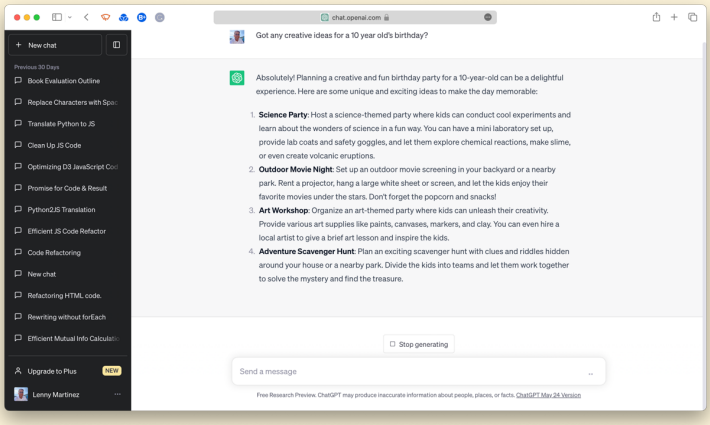

Figure 5. The ChatGPT interface.

Robot Morphology

Robots have various forms and functions based on the tasks they're designed to perform and the environments they operate in. They have been deployed in different contexts and industries, such as hospitals (Beane & Orlikowski, 2015; Pelika et al., 2018) and manufacturing (Welfare et al., 2019; Simões et al., 2020), as well as public spaces (Fincannon et al., 2004; The Wijkbot Kit – Cities of Things, 2023), other planets (Mars.Nasa.Gov, n.d.), restaurants (Kawaba, 2021; Barr, 2018), and the home.

Interaction with robot agents can be mediated through a control system, such as an app, computer program, or controller, and by interacting with the physical robot. In some instances, robots can be interacted with multimodally. One such example is the DLR's Rollin' Justin (Figure 6), designed to be teleoperated from the International Space Station but can also complete tasks autonomously (Filthaut, 2023).

Figure 6. Rollin' Justin is a humanoid robot designed for work on Mars as part of a broader team of robots. It can work autonomously to complete tasks and be teleoperated by astronauts on the International Space Station. (wikipedia.org/wiki/Justin_(robot))

Other examples of Robot agents include iRobot's Roomba vacuum cleaner (Figure 7), which can clean space at pre-programmed times and return to its charging spot as needed, as well as the robotic arms used in high-paced and automated industries like automotive manufacturing, pharmaceuticals and food processing and packaging (Figure 8).

Figure 7. iRobot's Roomba vacuum cleaners build a map of the space they are moving through to learn what obstacles to avoid and clean more effectively. (irobot.com/en_US/roomba.html)

Figure 8. The ABB IRB140 robotic arm is an example of robots being used in industry. This arm can be used in food processing, packaging, automotive manufacturing, and pharmaceutical industries. In 2017, this robot arm was discovered to have many security flaws (wired.com/2017/05/watch-hackers-sabotage-factory-robot-arm-afar/)

Product/Tool Morphology

Almost as expansive as the robot morphology, the product/tool morphology covers all "smart products," objects enhanced through sensors and actuators to have new functionalities. This category encompasses everything from the Nest thermostat (Figure 1) to the Withings Body Smart scale (Figure 9) to trashcans that sense your presence and open themselves to accept garbage (Figure 10).

Interactions with these agents are usually mediated by the agent, occasionally with additional support through an app. Interactions with these product agents also result in a hybrid perception of such agents as either agents or tools. In one example from Rozendaal et al. (2019), children in hospital environments interacted with an agent in the form of a ball (a product). They shifted between treating it as a regular ball (tool perspective) and a creature or play partner (agent perspective).

This shifting perspective is clarified through the lens of the tool-agent spectrum that highlights how a computationally enhanced artifact (i.e., an agent as we have defined it earlier; for this segment, we'll refer to it as agent-as-object) can be perceived as a thing, a tool, an agent, or a partner based on the extent that people perceive the artifact both as having intentions of its own and being conducive to the intentions of others (Rozendaal et al., 2020). An agent-as-object is a tool if it is perceived to be conducive to the users'

intentions, and the same agent-as-object is an agent when it is perceived as having intentions of its own. If an agent-as-object is perceived as conducive to the user's intentions and having intentions of its own, it is a partner. This hybrid perception phenomenon is most strongly perceived in product/tool agents and wearable agents, as their design is typically based on existing physical products such as trashcans, bathroom scales, kitchen appliances, etc.

Figure 9. The Honey-Can-Do trashcan opens its lid to receive trash based on a sensor. Image courtesy of Best Buy.

Figure 10. The Withings Body Smart tracks health metrics like weight and body composition and passes them on to an app. Image courtesy of The Verge.

Wearable Morphology

Related to the Product/Tool morphology, Wearable agents set themselves apart by their proximity and connection to the human body. They may be worn as an accessory like the Fitbit or Oura Ring, an article of clothing like a jacket that encourages you to calm down when feeling anxious or stressed (Li et al., 2020), or a smart insulin pump. Exoskeletons like the ones designed by Festool (Figure 11) also fit within this agent morphology. While they are not as close to the body as a jacket or insulin pump, they act very close to the body, a core quality of this type of agent. As with Product/Tool agents, interactions with Wearable agents are mediated by the agent and display perceived hybridity as both a tool and an agent.

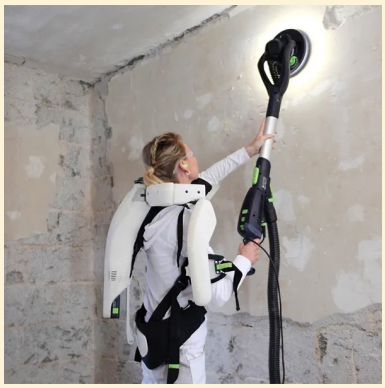

Figure 11. Festool's ExoActive exoskeleton (in white here) actively provides support when working overhead, minimizing stress on the shoulder, back, and neck muscles. Photo courtesy of Festool.

Opportunities and Challenges of Working with Agents

Considering the variety of embodiments and capabilities, agentic technology is a promising avenue to contribute towards sustainable employment. As mentioned earlier, tool/product agents, robots, and wearables can support the physical well-being of painters, making their work faster, healthier, and better quality; digital agents could assist in supporting mental well-being.

For agentic products and services to be successful, they must be designed as objects considering their varying abilities to work and sense autonomously to optimize the ability to collaborate in different contexts and under potentially unknown conditions. Each agent morphology is its area of research, with various difficulties, but it is helpful to consider a few:

- Due to the proximity to the body with which wearable agents act, breakdowns can lead to harmful, confusing, or dangerous situations for the user. Through autoethnographic notes, Forlano (2023) highlights instances where a smart insulin pump malfunctions, leaving her unsupported or dangerously weak.
- While the quality of digital agents has improved, people still struggle with having a mental model of conversational agents (Luger & Sellen, 2016). This creates a difference in expectations when interacting with digital agents.

- There is a track record, as documented by the blog "We put a chip in it" (weputachipinit.tumblr.com/), of non-discriminately adding sensors and actuators to everyday objects and creating meaningless Product/Tool or Wearable agents.

To successfully design and deploy agentic technology, we must look at agents as enhanced objects in a vacuum and actors in activities in specific contexts with humans and other actors. Farooq & Grudin (2016) refer to this more holistic perspective as "human-computer integration." Through integration, the agent and human become partners that "construct meaning around each other's activities" (Farooq & Grudin, 2016). To consider this symbiotic relationship holistically, we must consider the qualities needed for successful collaboration.

Human-Agent Collaboration

Cila (2022) adapts Michael Bratman's Shared Cooperative Activity (SCA) framework, identifying and highlighting qualities and agent abilities necessary for more robust and pleasant human-agent collaborations.

Bratman (1992) identifies three characteristics necessary for human-human collaboration: mutual responsiveness, commitment to the joint activity, and commitment to mutual support. Mutual responsiveness entails that the involved parties in collaboration will act while paying attention to the intention and actions of the other parties, knowing the other parties are doing the same. Commitment to the joint activity entails that the parties involved in a collaboration may have different intentions but are committed to the activity and avoid conflicts between their intention and commitment. They agree on an approach for the activity and division of labor that matches their capabilities and the needs of the task. The last characteristic, commitment to mutual support, entails that parties involved in the collaboration are committed to supporting other parties to ensure each party can fulfill its role.

Using these characteristics as a base, Cila identifies collaboration qualities and design considerations that can enable more robust human-agent collaboration (see Table 2). Cila's framework of collaboration qualities and design considerations provide opportunities to consider the design of agents from a collaboration/behavior-first approach, aligning with Farooq & Grudin's concept of "human-computer integration" (2016). By considering collaboration first, new agents can be designed more closely and robustly to match their context. A collaboration-first approach also opens a way to evaluate existing agents within a context to assess their fit within a collaboration, opening room to redesign or tune agents.

For this project, Cila's framework has been useful as a starting point for agent ideation and evaluation.

Table 2. Collaboration Qualities for Human-Agent Collaboration.

Collaboration Qualities	Description of Collaboration Quality
Code of conduct	A code of conduct outlines expected behavior and principles for collaborative activities. It ensures transparency and emphasizes agent responsiveness.
Task delegation	Task delegation involves assigning tasks to agents or artificial entities in a collaborative setting. It's important to identify which tasks the agent will perform to augment human skills. Understanding user needs and context is crucial for effective delegation and maintaining creativity and fun in the interaction between humans and agents.
Autonomy and Control	Autonomy refers to an agent's ability to make decisions independently, while control is the user's ability to influence those decisions. The level of autonomy should be appropriate for the specific task, with flexibility to adjust and user input to improve performance. Flagging exceptions and opting out of decisions are also important considerations.
Intelligibility	Intelligibility refers to explaining how an AI works and why it behaves in certain ways, to improve transparency and help users understand its capabilities and limitations.
Common ground	Collaborators' shared knowledge, beliefs, and assumptions about a joint activity are called common ground. It is essential for effective communication and collaboration, not only among people but also in Human-Computer Interaction (HCI) and Human-Robot Interaction (HRI).
Agent offering help	Designing a helpful agent involves addressing when and how it offers assistance. Proactive robots that aid when required to improve collaboration and team fluency metrics. Help preferences vary across situations, with users desiring reactive, information-providing, or recommendation-offering agents.
Agent requesting help	Agents can effectively request human assistance when encountering tasks beyond their capabilities. Studies have shown that robots can augment their sensory or physical capabilities by proactively asking for help, and that people are willing to help agents when needed. Designers should explore effective means for agents to request help, consider factors that influence compliance, and respond to uncertainty in the context.

Speculative Design

Speculative Design practice uses models, prototypes, and fiction to present alternative worlds and realities (present or future) to challenge current relationships, political, social, natural, or economic (Mitrović et al., 2021). These models and prototypes are mirrors "reflecting the role a specific technology plays or may play in each of our lives," providing an opportunity for discussion and reflection (Auger, 2012). Without the constraints of commercial and technical feasibility, the prototypes and models that result from speculative design practice offer an opportunity to explore and reflect on potential human-agent collaborations within the context of painters. When considering speculative approaches for exploring potential human-agent collaborations, the three areas of interest were Material Speculation, Speculative Enactments, and Design Fiction.

Design Fiction

Bruce Sterling defines Design Fiction as "the deliberate use of diegetic prototypes to suspend disbelief about change" (Bosch, 2012). In this context, a diegetic prototype is a fictional depiction of technology, and it is used to tell a story about the world in which the technology is situated. By situating technology within a narrative structure, we can grapple with bigger questions related to ethics, values, social perspectives, etc. (Tanenbaum, 2014).

Design Fiction is an interesting speculative approach because it is not limited to working with a specific media or tool. Design Fiction can take the form of video (broosdoc.nl/werk/keep-your-shirt-on), scenarios (Lupetti et al., 2018), web novels (Dalton et al., 2016), fictional research papers and abstracts (Blythe, 2014; Baumer et al., 2020) or product (Søndergaard and Hansen, 2016). For design fiction to be successful, regardless of the media used, it must "incorporate the elements of good storytelling alongside an understanding of how readers interpret and understand narratives to create compelling (and believable) fictional worlds around an imagined technology" (Tanenbaum, 2014). A compelling and believable fictional world, in turn, enables a more open discursive space to discuss future technologies within their context.

Material Speculation

Conceived as a complement to Design Fiction, Material Speculation (Wakkary et al., 2015; Wakkary et al. 2016; Wakkary et al., 2018; Wakkary et al., 2022) focuses on physical and realized design artifacts in everyday life as the basis for speculation and inquiry. Central to material speculation is the concept of a counterfactual artifact, a component of the theory of possible worlds. Counterfactual artifacts are realized products or objects designed and envisioned as belonging to another possible world but existing in our own, occupying the boundary between actual and possible worlds. One example of a counterfactual artifact is the Tilting Bowl (see Figure 12) which appears to be a mundane bowl but will arbitrarily tilt at a random time. By interacting with the counterfactual artifact over a long time, participants in the speculation can reflect on the artifact itself and the conditions for its existence: systemic, infrastructural, political, economic, and moral (Wakkary et al., 2015).

Figure 12. The Tilting Bowl is an example of a material speculation artifact.

Speculative Enactments

Elsden et al. (2017) propose Speculative enactment (SE) as an approach that focuses on "meaningfully enacting elements of a possible future with participants" by building scenarios that are consequential to the participant and letting the participant act out freely within that scene. The consequentiality of the scenario is the main defining quality of a SE. It is a useful quality because it serves to ground the speculation by connecting it to the participants using counterfactual materials (the data profiles in Metadating, for

example) and demanding a social performance (attending a speed-dating event) and shown in Figure 13 (Elsden et al., 2017).

Furthermore, Speculative Enactments prioritize the participant's experience, using speculative materials in a real context or scenario and ensuring the participants are in on the speculation. This empowers participants in a SE to react to the parts they identify with and improvise where possible. Such deviations from a scripted interaction are helpful because they allow the participants to feel at ease and explore their behavior more deeply.

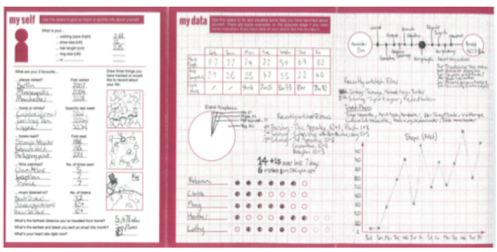

Figure 2: Completed Metadating data profile. The left hand side 'my self' includes quantified twists to common dating profile questions. Right hand side – 'my data' – represents hand-drawn data they tracked or chose to represent about themselves using the common infographic outlines provided.

Figure 3: A genuine speed-date from the Metadating event.

Figure 13. Examples from Elsden's Metadating project. The data profile (left) was a speculative material designed to be used by participants in a real speed-dating session (right).

Choosing a Speculative Approach

Comparing the three approaches, Speculative Enactments focus on participatory and consequential interactions. A Speculative Enactment requires a deep understanding of the participants to craft a scenario that is grounded and meaningful to them. In the case of working with Dutch painters, this is more difficult due to the lack of continual access and the ability to converse fluently with them.

If Speculative Enactments focus on participatory and social dimensions of interaction, Material Speculation focuses on interaction's embodied and physical dimensions. To properly engage in Material Speculation, the counterfactual artifact must be designed to be a high-fidelity object that can live in the world. Participants in this kind of speculation

would also have to engage with this artifact over a long period. This makes Material Speculation difficult to enact successfully during the limited period of a master's thesis.

This leaves Design Fiction as the last contender. As a speculative approach, Design fiction uses narrative to build a world around an interaction. Compared to the previously explored speculative approaches, Design Fiction is indeed more open-ended and malleable to be usable during the limited time of the thesis and with the limited availability of painter participants. To successfully enact a Design Fiction, careful attention must be paid to the story's logic and its maintenance throughout the narrative. Without consistent logic, design fiction has no power and becomes general speculation (Tanenbaum, 2014). Moreover, attention must also be paid to the tone and medium of the narrative to align with the perceptions and tastes of the people who will engage with the Design Fiction.

Chapter 3

Informing the Speculation

This chapter highlights the design activities used to inform the speculation. In the first part, interviews and an ecological analysis ground the speculation in painterly practice. In the second part, a brainstorming activity is followed by an annotation activity to focus the speculation on concerns related to human-agent collaborations. Insights from both sets of activities inform the design of agents to be used in the speculation.

Painter Interviews

While the public understanding of what painters do makes it easier to explore and envision how agentic technology can be incorporated into their practice and be involved in improving sustainable employment, more is needed to inform the design of agents or successfully ground a Design Fiction. With the help of Muzus and my supervisors, who provided the interview structure (see Appendix B1) and contacts and facilitated the interviews in Dutch, respectively, I conducted a series of semi-structured interviews to understand painters' work practices and processes as well as their understanding and perspectives on smart products and sustainable employment. The interviews took place in person at three different working sites with painters from Willems (willemsvastgoedonderhoud.nl) and Elk (elk.nl). We interviewed seven painters and one Quality, Health, Safety, and Environment (QHSE) Manager, who overall had experience in painting ranging from 9 months to 45 years.

Session Summaries

Session 1: Elk

In this session, we interviewed four painters with at least 20 years of experience each, and one was the foreman for the project. This interview gave us an initial understanding of painting practice and processes, such as working in duos and using agile methods to organize daily work activities. They value the aesthetic aspect of their work and find joy in making things look beautiful, emphasizing the importance of multiple layers of paint. A recurring theme was the physically demanding nature of their work compared to more tech-driven trades like carpentry and bricklaying; they consider the manual painting process less intellectually engaging. The session shed light on the division of labor, highlighting a growing trend towards specialization. The painters noted a transition from being involved in multiple aspects of a job to focusing primarily on painting tasks.

Session 2: Willems 1

For this session, we interviewed one painter with seven years of experience at Willems and a role as a mentor and coach for junior painters, and a QHSE Manager. We discussed the generational differences in the painting industry, with younger painters being more open to innovations than the more conservative older generation. The interviewees expressed concern that excessive reliance on automation might strip the work of its human touch, highlighting the importance of empathy and social interaction. Painters require a synergy between artistry and precision, encapsulated by the phrase "Iedereen kan verven maar niet iederen kan schilderen."[1]

Session 3: Willems 2

In this third session, the focus shifted toward exploring the personal perspectives and preferences of the painters. We interviewed a young painter with nine months of experience and his mentor for this session. Both painters shared their affection for maintenance and restoration work and the satisfaction of seeing the transformation. The affection both painters shared in their work is in tension with the increasing time constraints and the simplistic construction of new buildings, making restoration work less appealing and difficult to accomplish to their desired quality. They discussed the challenges of motivating the new generation of painters, agreeing that a combination of offering variety, hands-on experience, and better compensation would make the profession more attractive. Both agreed that learning from experienced painters was essential for improvement and growth.

[1] The phrase translates to "Anyone can paint, but not everyone can paint." In Dutch, both "verven" and "schilderen" translate as "to paint" in English; the former focuses solely on the mechanical motion of painting, while the latter implies a deeper understanding of the artistry and precision involved.

Analysis and Interview Insights

Notes from each session, in the form of observations and direct quotes, were transcribed, and insights were identified through a thematic analysis (Braun and Clark, 2006) of the transcripts. Thematic analysis is useful for these interviews with small sample sizes because it emphasizes the participants' voices and perspectives, facilitating a grounded and nuanced understanding of the data.

Through the initial coding of the notes (see Appendix B2), we identified seven broad clusters:

- **Work Process:** notes describing the work practices and processes, from a high-level description of how painters work to details about different sanding techniques.
- **New Generation:** notes referring to the new generation of painters and generational differences.
- **Agent ideas:** notes describing different functions agents could have that would be useful to painters.
- **Agent aspects:** notes describing the painter's perception of agents.
- **Work-related issues:** notes describing current issues and concerns while working.
- **Before + Now:** notes describing how the practice has changed.

Working with these clusters as a base and through rounds of iteration, several themes surfaced (see Appendix B3) and were refined into insights, shown below. These insights increase our understanding of the painter's practice and inform later activities like the Ecological Analysis.

Interview Insights from Thematic Analysis

Process & Practice

- Price, Quality, and Time are agreed on before the job without consulting painters.
- Uniform choices are weather dependent, with extra warmth and comfort in winter and more breathability in summer.
- Have everyday tools and a box of whatever tools and materials they need for the day.
- Use agile methodologies to manage day-to-day activities and planning. The Foreman coordinates the project.

Work Quality and Satisfaction

- Painters take pride in the quality of their work.
- To achieve quality in the result, they focus on quality at each step of the painting process (cleaning, sanding, priming, finishing).
- Painters find pleasure in seeing a good result.
- Brushes are the best tool for achieving quality but are also slower than rollers.

Difficulties and Dislikes

- Project hours and expectations do not always align. This creates stressful situations where they must have good results with short turnarounds.
- Changing weather conditions (like rain, temperature) can lead to project delays within tight timelines. The painters are also not always equipped for the changing weather.
- Painting work puts strain on the back, wrist, and knees. This comes from carrying materials, reaching high areas, and having strange postures. Pain accumulates over time

On Changes in the Profession

- Safety has improved. Scaffolding is safer than ladders, and other equipment (masks, kneepads) are available and used.
- Some tools have become more efficient. Battery-powered tools like sanders have greatly improved the quality of the work.
- Core tools, brushes, and rollers have not improved as much. The materials they're made from are less reusable.
- Newer paints dry faster, making quality work more difficult.

The Next Generation of Painters

- It is hard to get painters to stick with the profession. From 20 newcomers, around 1 will stay.
- Older painters train newer painters for at least a month after they do their schooling. Mentorship is about teaching values and motivation, as well as technique.
- The newer painters are more social/holistic than the older generation.

Painting is both a craft and physical labor.

- See work as being physical & repetitive with little room for cleverness. "Carpenters have the complex machines, but we don't. Ours is a very physical job."
- Painting is a craft, and painting by hand is the dumbest part of the job. The brush remains a brush.
- Radio/Music provides moral support and makes repetition bearable

Conditions for accepting robots.

- It can explain "why" it makes a particular decision or judgment.
- It can work on sanding or painting – tasks the painter does not like.
- It can work independently of the painter; the painter becomes a delegator and does other tasks.
- Agents that correct without a "why" are not valuable. "Somebody with experience should correct me."
- Painters could take suggestions but will need the ability to override.

What robots miss

- People are social, robots are not. Robots would lack a human touch.
- Empathy is necessary for painters to teach/train others and work.

Perceptions of technology

- Robots and Agents are seen negatively because they might replace the job or be in the way of their work.
- Painters are concerned with practical aspects of tools: How to maintain the tool? What does it cost in time to wear? How safe is it? Will it have an emergency exit? Can it be overridden?
- Framed as superpowers, newer generations see agents as useful additions to their work

Ecological Analysis

Considering the symbiotic relationship between humans and agents, it is not enough to consider the agent as a static entity with varying levels of agency and behavior or the agent as a collaborative partner. We must also consider the agent as an actor within a series of everyday practices in a specific context.

Everyday practices are social, cultural, and deeply interconnected with objects (Rozendaal et al., 2021). When considering an agent as an actor in everyday practices, we must look more broadly than the individual human-agent interaction and consider the wider ecosystem that consists of smart objects coexisting and interacting with different actors (human and non-human) and both digital and analog infrastructures — also known as the ecology (Rozendaal et al., 2021). An ecological analysis is an opportunity to map out the actors, environmental and infrastructural factors, and the relationships between them to solidify an understanding of the context, surface new insights, and identify opportunities for agents to be introduced. Entanglement theories like Postphenomenology, Actor-Network Theory, Activity Theory, and Agential Realism have been used as lenses for analyzing ecologies because they generally agree that artifacts have politics and that agency is fluid (Verbeek, 2015; Frauenberger, 2021; Rozendaal et al., 2019; van Dijk and van Beek, 2021; Winner, 1980).

For this project, I have conducted an ecological analysis of the painter's current practice using notes and media from previous interviews with painters. While the entanglement theories mentioned previously were not used directly, the analysis is informed by a basic understanding of them. The ecological analysis is separated into four layers: Environment, Human actor, Technology, and Time. The Time layer provides an opportunity to show how the other layers connect.

Environmental Layer

The painters involved in this project primarily work on restoring and maintaining social housing. The projects are noticeable due to the large presence of scaffolds and tarps to minimize the rain and wind, as shown in Figure 14. The scaffolding is set up in parts, and as sections of the building are renovated, the infrastructure is moved until the project is done.

Figure 14. Images of a project site being renovated.

When working on external restoration on multi-story buildings, painters move up and down scaffolds to complete their tasks (see Figure 15). The walking space can be narrow and not perfectly aligned with window locations, forcing painters to coordinate how they complete their tasks and often getting in odd poses to reach the right places. While they can get very high, four or more stories, Painters take advantage of existing building infrastructure like elevators to transport materials. Without such infrastructure, painters manually carry their paint and tools up and down the stairs built into the scaffold platforms.

Figure 15. Painters at different sites use scaffolding to work on exteriors more safely and comfortably than ladders.

At every project site, painters have a dedicated storage space for their tools and materials (see Figure 16 and Figure 17). In some cases, the storage space is a full-sized container as seen in Figure 17, and in others, it's a portion of a smaller trailer (Figure 16, left) that also includes their break room, as seen in Figure 16 (center). When not part of the trailer, painters also have access to a break room and office space that is its own container. The break room and storage containers are brought to the site before the restoration work begins and are taken away once the project is completed.

Figure 16. Example of painter's small trailer featuring break room and storage (left, center), and a big storage container (right).

Figure 17. Before heading to the part of the building site they are working on, painters stop by their storage depot to grab the materials and tools they'll need for their work that day.

Human Actor Layer

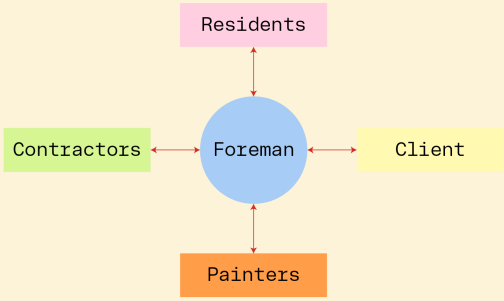

Figure 18. The foreman is the human actor that connects all other actors involved on a project site.

There are several human actors involved in a restoration project, that interact with each other at different points in time. The main ones have been identified in Figure 18.

Foreman

The foreman is at the center of the human actors on a painting site. It is the foreman's job to coordinate the project timeline to ensure that work is completed in a timely fashion. They are also in charge of coordinating with contractors for all the non-painting

tasks, from pressure cleaners, to setting up scaffolding, to glaziers and even the portable toilets. They also oversee the daily work of painters and sometimes employ lean/agile methods like stand-up meetings. Finally, they are the point of contact if residents have questions, concerns or want to complain; it is the foreman's job to manage resident expectations.

Painters

The focus of this project, painters work to restore the building. They work in pairs, usually without fixed combinations, to complete their tasks. When one painter starts a task, the other painter starts the following task behind them so they can work faster. Some painters have mentorship duties and give feedback and lessons to the new painters. Painters often have specializations or tasks that they are more interested in completing like sanding or varnishing.

Client

Prior to arriving on the project site, the client has set and paid for specific quality expectations. While they are not present during the process, they do show up again at the end to review the quality and make sure it is as they have paid for.

Contractors

Contractors are non-painting workers involved in the restoration project. They take care of the tasks involved before and after the painting work, such as installing and uninstalling the scaffolding, carpentry, and glass work, as well pressure cleaning the surfaces.

Residents

The residents of the buildings being restored affect the restoration process. They are directly affected by the work of the painters, in terms of noise and job quality. Certain tools such as paint sprayers can only be used when no residents are around.

Technology Layer

Everyday carry & tools

Painters work with small boxes daily where they have their tools for the day (Figure 19, left and center). They also carry tools on their body that are useful in different situations (Figure 19, right). Painters work with both electric and non-electric tools. In their everyday carry box, you may find caulk and a caulk gun for sealing tasks, a duster brush, some sandpaper or electric sander, a caulk knife, and brushes.

Figure 19. A painter's everyday carry box (left, center), and some of the tools they carry in their pockets that are useful in different situations (right).

Brushes

Painters work with different-sized brushes (Figure 20). They provide the best quality finish because you can add thicker layers of paint than with a roller.

Figure 20. Collection of brushes showcasing the different sizes and quantities. Today's brushes are made of synthetic materials and don't last as long as older brushes. They still provide the best painting quality compared to a roller or a paint spray.

Power tools

Painters do not work with many power tools. Battery-powered sanders (Figure 21, right) have been a big innovation because their portability increases the sanding efficiency. Other tools like the freehand milling machine (Figure 21, left) and the vacuum cleaner are present on sites, but used only in specific instances (removing wood rot, and cleaning sanding dust respectively).

Figure 21. A freehand milling machine (left) and a battery-powered sander (right) are some of the few examples of power tools painters work with.

Kneepads

Kneepads (Figure 22) are one of the few support items painters use. They are soft and durable and fit seamlessly into the painter's uniform.

Figure 22. Painter's kneepads.

Project Organization

Organization is handled by the foreman. Apps like AFAS and paper schedules in the break room for everyone to see help them organize work activities and keep track of budget and project progress (Figure 23).

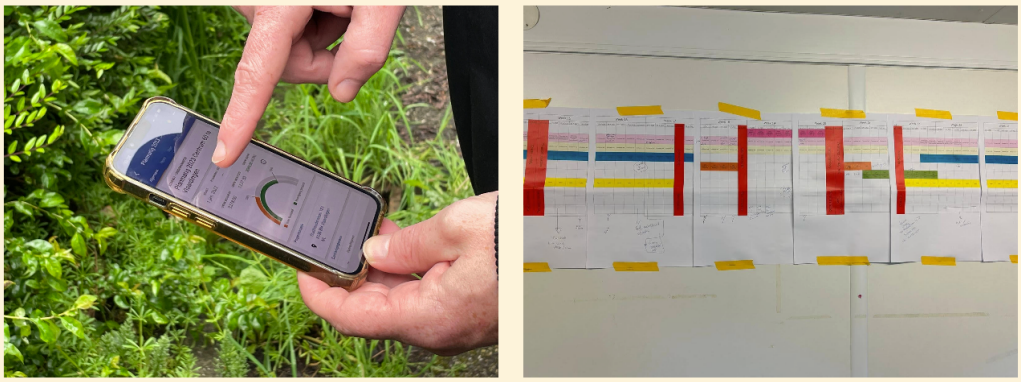

Figure 23. Some foremen use the AFAS app (left) and paper schedules (right) to keep track of project work and budget.

Time Layer

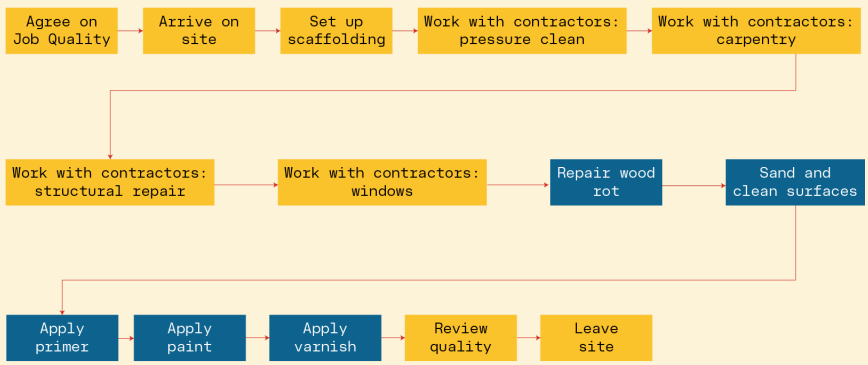

Figure 24. A timeline of activities in a restoration project. Activities in blue are the exclusive work of painters.

The timeline for a restoration project begins when the client and the company agree on a quality expectation for the site. After this, the company arrives on the site with their

break room and storage containers. The foreman organizes the project so that scaffolding is set up and the work begins with contractors pressure cleaning, doing structural repairs, and glass work. Then the painters come in renovate the windows and doors and other exterior surfaces. As the painting work is completed, the scaffolding is moved around to cover the next working area. Once all work is completed, the client passes by the site to ensure the quality they paid for is delivered, and then the painting company leaves the site.

Agent Brainstorming

To start focusing the speculation on human-agent collaboration concerns, I facilitated a brainstorming session with seven other designers. The goal of this session was to identify initial design directions for collaborative agents for painters across the morphologies described in the previous chapter in a way that supported sustainable employment. For the session, I provided an introduction and more details about the painting practice, as well as brainstorming questions related to autonomy and control, and intelligibility based on Cila (2022). These questions were included because an initial focus for the project was around these two collaboration qualities. The instructions provided to the painters can be seen in Figure 25.

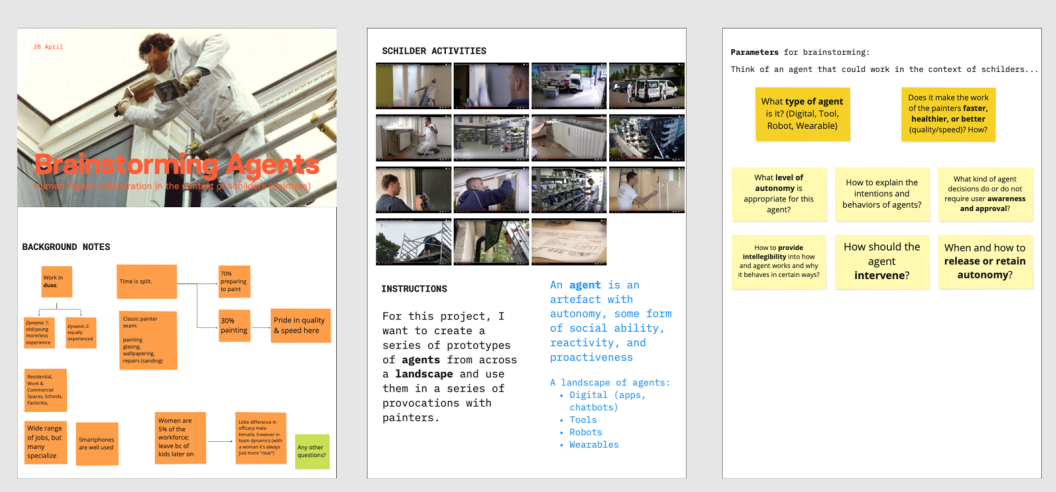

Figure 25. Material shown during the session to introduce the topic of painters and agents.

Brainstorming Results Clustered

During the brainstorming session we generated and discussed 45 different agent ideas (see Appendix C1 for the full results). I analyzed the results of brainstorming by clustering the ideated agents based on their morphologies. As part of this exercise, I created a fifth

morphology, ambiguous agents, to classify the ideas that didn't fit easily into the other morphologies of Product/Tool, Wearable, Robot, Digital (Tables 3–7).

Table 3. Agents ideated during the session: Product/Tool morphology

paint gun that can limit the edge of the paint spray	Magic spray that replaces taping of areas you don't want to paint	roller with pressure sensors to train how much pressure to add to improve paint finish.	brush or roller that stops functioning when you have worked long enough
A smart chair that can move in every direction. Leans and moves according to what and where you need to paint automatically based on your location + posture.	Smart brush/roller. Recognizes when quality is good or needs more work. Alerts you when your motion/work posture is bad for your wrist.	roller attached directly to paint can continuously get paint to apply. Can sense when it's close to ceiling or obstacle to prevent touching them. Supported by painter	
smart roller	smart brush		

Table 4. Agents ideated during the session: Wearable morphology

Smart clothes. Help you keep a healthy posture & remind you to switch posture when it's getting unhealthy/rigid	Helmet that analyzes the area to highlight what can be handled by agents	Vest or jacket that provides back support. Measures back posture and warns about back posture.	Coverall with sensors that sense body posture & movement to track repetitive motion and posture
Wearable that monitors muscle strain and movement repetition. Encourages painters to take a break or do a different activity.	Jacket that moderated movement and motion, forcing breaks	Ar glasses for training your strokes and speed	

Table 5. Agents ideated during the session: Digital morphology

Digital system that monitors painter movements and posture/muscle health to organize breaks and work schedules	Digital agent matches music to work to maintain rhythm	Chatbot to help organize appointments and coordinate work	App that helps you organize, control & communicate process to others

Table 6. Agents ideated during the session: Robot morphology

Robot that lays tape in perimeter of room	Crawling sander robot that moves in an area, sanding it down to a uniform finish	Robot follows you to hold things for you or act as a seat when you need an extra set of hands.	Remote-controlled robot that paints instead of the painter. Robot has form of a brush
Clamp-able artefact that paints the space it is in front of it between two poles. Can be appropriated for ceilings.	Robot scans your workspace to organize tasks and planning needs.	Drone that helps paint. Tiny swarm that tells you where to do a better job	Robot arm that can be trained to match painter movements and work independently.
Painting robot that is controlled with an app. Moves along wall to paint	Swarm of rollers that can be set up to paint a column or part of a wall while the painter works on the edges or other areas. The rollers draw paint continuously from a central can.	Mobile robot arms that can paint within a QR-code defined space. Painters only focus on painting the edges	Little helper for transporting or communicating along ladders
Robot that is hooked up to human's brain to plan and judge painting work. Treats human as a computing device to augment itself while it paints.	Ecology of robots that help paint, tape, work across diff scales (micro to large). Includes a moderator brain to plan & execute ideas.	Agent rolls down a wall and covers the corner in tape.	Paint bug swarms go and paint the hard-to-reach corners

Table 7. Agents ideated during the session: Ambiguous agents morphology

Agent that purifies air	Wall projection of posture that would be more comfortable for painting	Agent that encourages breaks – has cute, playful vibes.	Slime mold paints for you
Agent that frames spots and tasks to be done, evaluating what will take longer	Agent that makes you feel appreciated. Brings positive feelings at the end of the painting process	Agent uses projection to highlight areas that need to be improved or that are hard to paint	System that identifies falling drops of paint and neutralizes them before they reach the ground.
System that keeps an area of paint wet while working on a different area. Useful when trying to switch between parts of a job to keep posture healthy	Automated warehouse that is aware of the different jobs and provides painters with the necessary tools.		

Analysis

The brainstorming aimed to generate initial starting points for agents that could collaborate with painters. By looking at the morphology clusters, we can get an idea of features designers consider useful from each archetype.

- **Tool agents** focused on improving working efficiency and training the painter. These ideas were confined mainly to the commonly used painter tools: the brush and the roller.
- Wearable agents focused on enhancing the painter's uniform to measure and evaluate body posture to raise self-awareness of posture and provide physical support. Some wearable agents also assisted in planning work tasks and improving the painter's brushwork efficiency.
- Robotic agents had the broadest range of proposed applications, focusing on taking over different tasks. Many agents focused on painting the larger flat areas so the painter could focus on the edges and more complex parts. Additionally, some acted as quality control checkers or assistants for the painters. Interestingly, no ideas outright replaced the painter in their tasks.

- Digital agents focused on organization and coordination for work processes and break and leisure activities for the painters. This is likely because digital agents are perceived as always online and can connect with different documents, schedules, and materials to synthesize information.

Beyond these previously identified morphologies, I created the Ambiguous agent category for the ideas that did not have a specified embodiment or could fit into multiple categories. The ideas in this category focused on indirectly supporting painterly work by keeping a clean environment, organizing working conditions, or ensuring the painter is appreciated and takes breaks.

Other Insights

Through the activity, other comments or thoughts emerged during sharing moments worth mentioning.

- **"Prevent more work for better quality."** Painters already have many things to do. These agents all take over part of the work they are doing now, and that's useful, but maybe having agents that help minimize errors and work tidily would improve the work quality. It wouldn't be great if the agents created too much complexity to use or incorporate. One way of addressing this can be having an agent with varying levels of autonomy based on painter comfort and minimizing workflow hindrances.
- What do agents add to mastery? Many proposed agent ideas focused on teaching painters proper pressure and posture. The applications are valid, but it's also essential to consider the company investment and what value the agent can add when they have mastered the skills. As one participant mentioned, "If it's a tool, make it a tool they can master the use of."
- **Zooming out to see patterns.** Could the agents collect data to build a bigger picture of the practice or other topics? Like how we track infrastructure, such as the National Bridge Inventory in America[2], we could use agents to collect posture, usage, and structural data to understand the current state of the

[2] hub.arcgis.com/maps/a0fa29a39fe444ac97d4337c569b9801/about

profession at a large scale. With posture and usage data, the ergonomics of tools and equipment could be improved to keep painters healthier for longer.

Design Considerations for Human-Agent Collaboration

The initial analysis of the cluster was useful in surfacing designerly thoughts about how each agent morphology could collaborate with painters to improve sustainable employment. To dive deeper into designerly knowledge, I conducted a series of annotation sessions focused on annotating the brainstorming ideas with thoughts, questions, comments, and concerns related to Human-Agent Collaboration. This activity aimed to generate intermediate-level knowledge, in the form of design concerns and considerations, about Human-Agent Collaboration through a thematic analysis of the annotations to inform the design fiction. assistant avatar. Intermediate-level knowledge refers to knowledge that lies between specific instances and generalized theories (Höök & Löwgren, 2012). It is a form of knowledge that is more abstract than particular instances but does not aim to achieve the generality of a theory. Design patterns, guidelines, and annotated portfolios are some forms of intermediate-level knowledge that play a direct role in creating new designs (Höök & Löwgren, 2012).

Session Structure

I conducted three sessions to annotate the brainstorming ideas, focusing on questions, thoughts, impressions, and concerns related to Human-Agent Collaboration. I engaged in one-on-one conversations with a designer for two of the sessions. In these sessions, I guided the conversation using the Miro board and prompted the participants for input and ideas. Each session lasted roughly 90 minutes. For the third session, I created a set of annotations by myself to have a baseline set of notes for the thematic analysis.

Analysis Methodology and Results

The annotations were processed on a person-by-person level in an initial round of tagging before being grouped by the brainstorming idea they were related to (Figure 26). At this

stage, I reviewed the codes before clustering the annotations into themes. After reviewing the created themes and combining some of them (Appendix D1), I arrived at 16 themes (Table 8). For each theme, I reviewed the contained annotations and generated some design considerations in the form of questions, mirroring the format in Cila (2022).

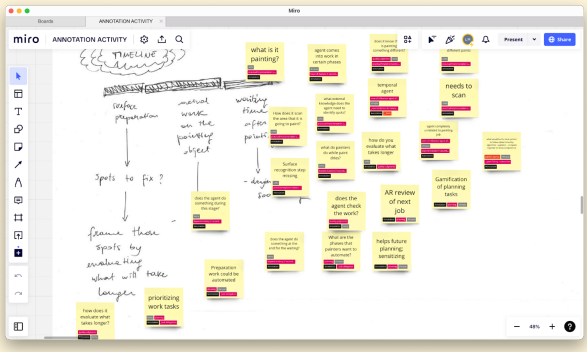

Figure 26. A view of the Miro board after superpositioning the notes from the different participants related to the same brainstorming page.

Table 8. Design Concerns and Considerations from Thematic Analysis

Theme	Design Considerations
Task Complexity	What new steps does the agent add? What level of complexity is acceptable for the painter? How does the agent make the work easier for the painter? What new steps does the agent add?
Interaction Modalities	What are the ways a painter can interact with agents? How should a painter control or interact with the agent?
Painter Wellbeing	how does the agent affect the painter's wellbeing? How can agent passively affect health? How does a painter build self-awareness? How does a painter build awareness of his work? What level of detail is needed to understand painter health? How can an agent increase self-awareness about health in the painter? How can agents actively affect health? How can an agent motivate a painter?
Quality Considerations	How to explain if extra work is needed? How does the agent evaluate quality?
Practical + Implementation Considerations	How is the agent built? What sensors does the agent need? What technologies does the agent require to work? How is the agent maintained? How is the agent repaired? How can the agent be stopped? What new technologies are involved in making the agent? How ergonomic should the agent be? How portable is the agent?

Task Planning + Delegation	How does an agent plan for work tasks? What does the agent prioritize when planning actions? What level of control over planning does the painter want to keep?
Painter Agency	How does the agent affect the painter's agency? Can the painter work on their favorite tasks? When does the painter have to follow the agent or system? Is the painter still connected to the tasks and work? Does the painter still have control of the result? When can an agent be overridden?
Emerging Practices + Job Variety	How does an agent change the practice? How can an agent change the routine of the painter? What opportunities for variety does the agent provide? What new patterns/techniques can the agent create? How does the agent motivate painters?
Remote Working	How present does the painter need to be to agent? How in touch to the materials do the painters remain?
Multi-Painter Interactions	How can an agent bring together the painters?
Agent Failures + Corrections	What can be done when the agent fails? How can an agent be trained? How forgiving are the agents to error? How can an agent be corrected?
Agentic Systems (Swarms)	How can an agent be part of a swarm? How independent should an agent be from other agents? How to manage resources with multiple agents? How do agents in a system communicate with each other? How is conflict managed between agents?
Form Considerations	What morphology should the agent be?
Business Considerations	How to adjust the business model of painting?
Agent Effectiveness	What conditions does the agent need to be effective?
Data + Privacy Concerns	What data does the agent need to function? How is the data collected by an agent managed? Who can access the data used by agents?

Direction for the Speculation

The research and design activities discussed in the chapter provide different perspectives to inform the speculation: the first two serve to ground the speculation in the painter's practice, while the latter two can focus the speculation on Human-Agent Collaboration.

Grounding the Speculation

The interviews with painters provide a grounded introduction into the practice and work processes of painters, and highlights tensions such as the intergenerational differences between painters and the increasing tension between painters wanting to produce quality work and not having enough time to do their work. The ecological analysis makes concrete the different actors, activities, and environments painter work in and provides ideas for objects and activities that could be inspiration for agents. Both activities rely primarily on knowledge about the painter's practice.

Focusing the Speculation

The agent brainstorming session provides an initial set of ideas, but more importantly a better understanding of how each agent morphology could support painters. The design concerns (themes) and considerations generated from the annotation sessions serve as a list of topics that could be explored in the speculation. These activities rely almost exclusively on designerly knowledge.

To identify a direction and space for the Design Fiction, we must find connections between the two kinds of knowledge, and more practically between the outputs from the grounding and focusing activities.

Painters as Generalists

Based on insights from the interviews, I decided to focus the speculation narrative on the idea of painters having to become more independent generalists. If the recruitment rate of painters remains low, painters will be forced to not work in human duos. In such a future, agentic technology can offer better support to the painters by collaborating across different tasks to get the work done.

This narrative provides an opportunity to explore the support of agents whose design is informed by painterly and designerly knowledge. Reflection and iterations on the output led to the creation of three agents for the Design Fiction. The rest of this section delves into each of the agents: their design and value proposition, connection to painterly practice and designerly concerns, and their role in the speculation.

Paint and tool-carrying robots

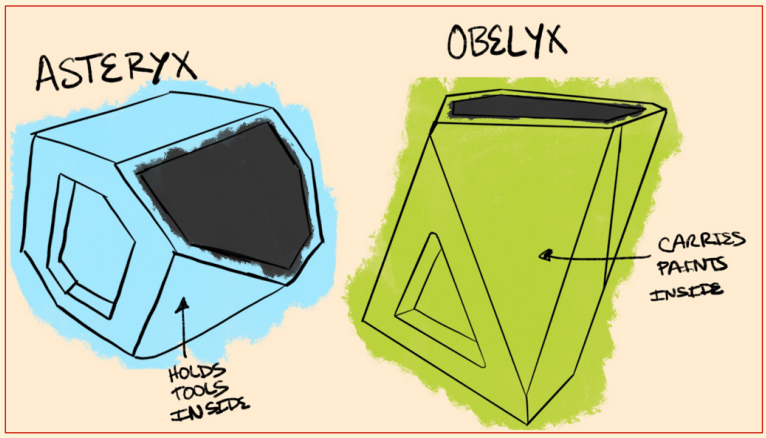

Figure 27. Asteryx and Obelyx are a pair of robots that carry the painter's tools and work materials.

This pair of agents (Figure 27) is inspired by the tension painters feel between their job being a craft that creates beauty and physical labor. Asteryx and Obelyx were designed as paint and tool-carrying robots to minimize the carrying aspects of physical work and allow the painter to focus more on the craft side of their tasks. They float to move around the scaffolding quickly and stay out of the painter's way until called.

These agents provide an opportunity to explore the theme of Delegation identified in both the annotation activity and as a collaboration quality identified in Cila (2022). The annotation activity theme of Task Delegation focused on understanding how the agent plans and prioritizes tasks when assisting and what level of control over such planning the painter wants to keep. In the case of Asteryx and Obelyx, the agents exhibit only basic abilities to plan and prioritize tasks. All control is in the hands of the painter, who calls the robots when needed. As mentioned in Table 2, task delegation involves assigning tasks to agents or artificial entities in a collaborative setting while understanding user needs and context. By conceiving Asteryx and Obelyx as obedient agents, I want to develop a more nuanced understanding of the painter's craft work and related frustrations and see what tasks painters would delegate to agents if the agents were not painting.

Camera that keeps track of the work quality and progress

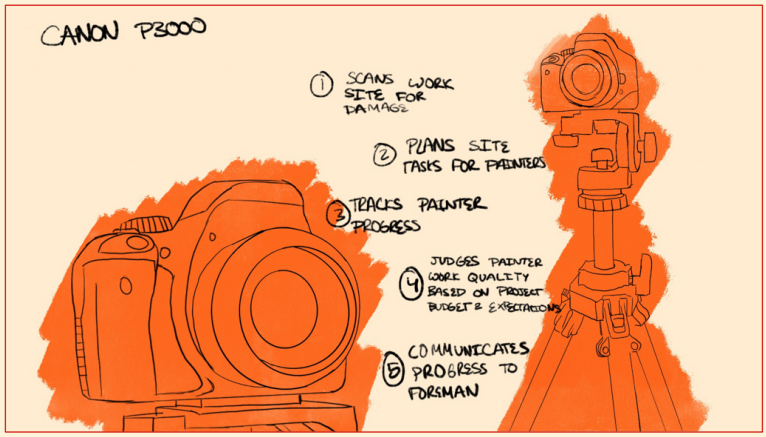

Figure 28. The Canon P3000 camera tracks and evaluates work tasks to ensure quality and smooth progress.

This agent is inspired initially by the desire to explore the social roles agents may have in the future. The Canon P3000 camera (Figure 28) combines sensor analysis with painter quality standards to judge work activities and track progress on a project site. It is designed to stand in for the foreman and provide progress reports and feedback to the painter through the work activities. The camera evaluates work quality and time to complete a task against time expectations and budget to ensure work progresses successfully. Additionally, it can scan for structural issues, such as wood rot, that could delay the project.

This agent provides an opportunity to explore the theme of Authority in Human-Agent Collaboration. The concept of Authority is not explicitly included in the themes of the annotation activity or Cila's collaboration qualities. However, it can be inferred through the other themes and qualities of collaboration. In this context, Authority refers to agents acting on you on behalf of someone else (such as the foreman). From the themes of the annotation activity, Authority relates to Quality Considerations, with questions of how an agent can explain if extra work is needed or how an agent evaluates quality. The specific details of how the agent evaluates quality are not the focus of the speculation, but the agent will be used to explore if, how, and when an agent can express opinions about work quality to painters and act as a manager.

Looking at Cila's collaboration qualities, the theme of Authority connects to the qualities, code of conduct (outlines of expected behavior and principles for collaborative activities to ensure transparency and emphasize agent responsiveness), autonomy (the agent's ability to make decisions independently), and intelligibility (explaining how an agent works and why it behaves in specific ways, to improve transparency and help users understand its capabilities and limitations). These qualities touch on the social aspect of interacting with an agent, an important factor in this agent's design. Using this agent, I want to explore what types of authority roles are helpful or supportive for painters and how open they are to feedback on their work.

Smart suit that senses and corrects bad postures

This agent connects to painterly practice in that painters interviewed mentioned having to work in bad poses for extended periods of time that lead to accumulated pain. This suit (Figure 29) is a wearable agent that uses smart fabrics to measure posture and muscle strain.AS muscle pain accumulates while work in bad postures, the suit begins to glow in the affected area and the suit's threads push and pull on the painter to bring them back to an upright position and reset.

This agent provides an opportunity to explore the theme of painter agency and painter well-being as identified in the Annotation activity. These themes focus on the impact of an agent on a painter's agency and decision making, as well as a painter's well-being and self-awareness. This connects to the suit's design to actively correct posture, which can interfere with the painter's activitie, but also focus on the painter's long-term well-being. Looking at the collaboration qualities identified by Cila (2022), this agent also connects to

agents offering help, as the suit is very proactive in helping the painter maintain good posture. In using this agent, I want to explore what level of personal awareness painters currently have and want to have regarding their posture and in which situations an agent should act on behalf of the painter. I also want to explore what types of feedback painters may want from their agents.

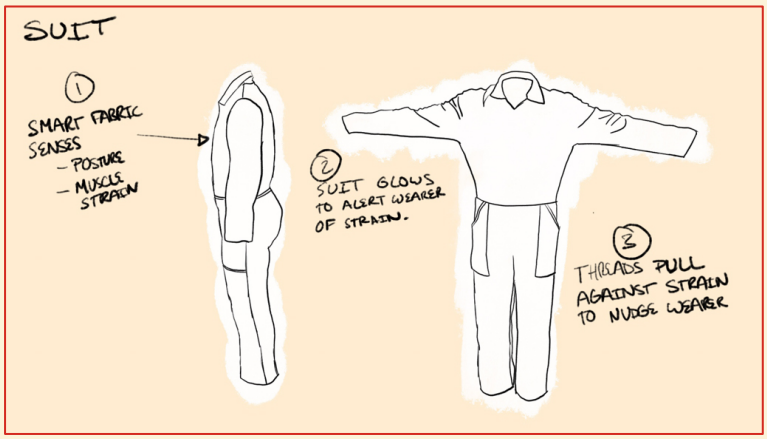

Figure 29. This suit is equipped with sensors to identify and correct bad posture.

Next Steps

In the next chapter, I develop a Design Fiction using the agents introduced here. Information about the agents is summarized in Table 9.

Table 9. Agents designed for the speculation

	Paint & tool carrying robots (1)	**Camera that keeps track of the work quality and progress (2)**	**Smart suit that senses posture and corrects bad postures (3)**
Morphology	Robot	Tool	Wearable
Connection to Painterly Practice	Deal with things that you don't want to carry	Acts as a local foreman and coach; Combines sensor analysis with quality judgements; Keeps painters working on the right task	Working in bad positions for extended periods Building up muscle pain
Theme addressed	Delegation	Authority	Autonomy
Connection to Annotation Activity	Task delegation	Quality Considerations	Painter well-being; Painter agency
Connection to Collaboration Qualities	Task delegation	Code of conduct; intelligibility; autonomy	Agent offering help
Role in Speculation	develop a more nuanced understanding of the painter's craft work and related frustrations and see what tasks painters would delegate to agents if the agents were not painting.	explore what types of authority roles are helpful or supportive for painters and how open painters are to feedback on their work.	explore what level of personal awareness painters currently have and want to have regarding their posture; in which situations an agent should act on behalf of the painter; explore what types of feedback painters may want from their agents

Chapter 4
Developing the Speculation

This chapter focuses on developing the Design Fiction using the agents identified in the previous chapter.

Developing the Speculation

When developing a Design Fiction, we must consider what makes a good Design Fiction. Tanenbaum (2014) identifies good Design Fiction as one that uses elements of good storytelling in combination with an understanding of how readers interpret and understand narratives to create fictional worlds that are compelling and believable.

In developing the Design Fiction, Brush, Camera, Robot, Suit, attention was paid to both the story (Tanenbaum's first point) and the medium (Tanenbaum's second point). This chapter explores the development of the Design Fiction along these two lines. We begin by looking at the story.

Plot focus and considerations

Brush, Camera, Robot, Suit is a Design Fiction that presents a day in the life story of a painter collaborating with agents at his work. It is inspired by the alternative approach to storytelling proposed by Le Guinn (2019) in "The Carrier Bag Theory of Fiction," focused on gathering, sharing, and nurturing diverse narratives rather than emphasizing individual heroism or conflict-based narratives. Such an approach aligns with the focus on reflection in Speculative Design practice. Using Le Guinn's approach, the focus was on piecing together a series of vignettes showcasing various aspects of interacting with the agents without characterizing any one character (human or non-human) as a hero.

Future Scenario

The year is 2035, and there are not enough painters working. For every 20 painters that start their training, only one sticks around. With fewer painters, tasks that were easy before became more demanding. Something had to be done to support the ones that remained. Technological advances allow painters to work alongside robots and smart tools to restore, renovate, and improve buildings. They can maintain control of the outcome while being supported by these agents.

Matt is a young painter working for a restoration company, Hoog+diep. At work, he completes his tasks with the help of agents like Asteryx and Obelyx, the Canon P3000 camera, and his smart suit, who support different aspects of his practice. Asteryx and Obelyx carry tools and paints Matt will need for the day's work. The Canon P3000 gives him feedback about his work quality and helps him plan his day. Matt's smart suit ensures he always has a good posture to minimize muscle strain.

The Storyline

As mentioned earlier, the story comprises several vignettes highlighting different agent interactions and providing room for reflection (see Table 10).

Table 10. Vignettes included in the Design Fiction, Brush, Camera, Robots, Suit

Scene	Events	What the scene adds
Introduction	The first part of the future scenario (see above) is shown.	This scene brings the reader into the speculation by setting up the world that gave rise to the agents the painter works with.
Preparing for the day	The painter Matt arrives at the project site. He meets with the foreman Bas to discuss the tasks for the upcoming working day Matt picks up Asteryx and Obelyx and heads out to work	Introduce the characters of the story: Matt, Bas, Asteryx and Obelyx. Tie the story to a real work location with familiar elements for the reader (the background).
Arriving at the site	Matt travels to the last part of the project he has to paint Once he is at the working site, he uses the camera to do an initial scan and plan the tasks for the day.	Show how Asteryx and Obelyx will follow Matt without getting in his way. Introduce the camera agent and it's initial functions.
Sanding	Matt grabs his tools for sanding from Asteryx Matt sands the surface quickly Matt uses the camera to track the progress	Showcase the fact that Matt is using the tools from Asteryx Showcase Matt is still following the traditional process that painters use of sanding by hand

Applying primer and paint	- Matt is painting, getting extra paint from Obelyx as needed. - As Matt paints he overextends himself. - Matt's suit reacts to the bad posture and tries to alert him. - Matt listens to the suit and switches to a roller to finish painting. - Matt interacts with the camera once again and is given feedback that his work was not great	- Show that Obelyx is present when needed, and leaves Matt to work when not needed. - Show how the suit would intervene in a working practice - Show how the camera can provide feedback and explanations when work is not up to quality standards.
Ignoring the suit	- Matt is painting with varnish later in the process. - As he works, his posture begins to deteriorate. - The suit attempts to warn him, but Matt wants to keep going - Matt appeases the suit a bit until it get very strong. - Matt deactivates the suit's warnings with a button - Matt uses the camera one last time after he is done.	- Showcase that Matt as a painter can override his suit's warnings if he wants to push through with what he is doing; he is not completely tied to the suit. - Showcase the camera's function one more time – it lets the foreman know when work is completed.
End of day	- Matt returns to the company meeting area at the project site. - He meets with Bas and asks about the camera's chatty behavior - After wrapping up the meeting Matt heads out for the day.	- Showcase the camera can have different interaction modes based on familiarity with the tool and painting practice. This speaks to the notion of adding value as a smart agent beyond mastery

First Iterations

Working with the Future Scenario and Storyline as a base, I created an initial storyboard (see Figure 30 and Appendix E1) to map out the details needed in the story visuals and narrative. The initial storyboard served as a base for a main script (see Appendix E2) and a guide for making the pictures used in the production (Figure 31).

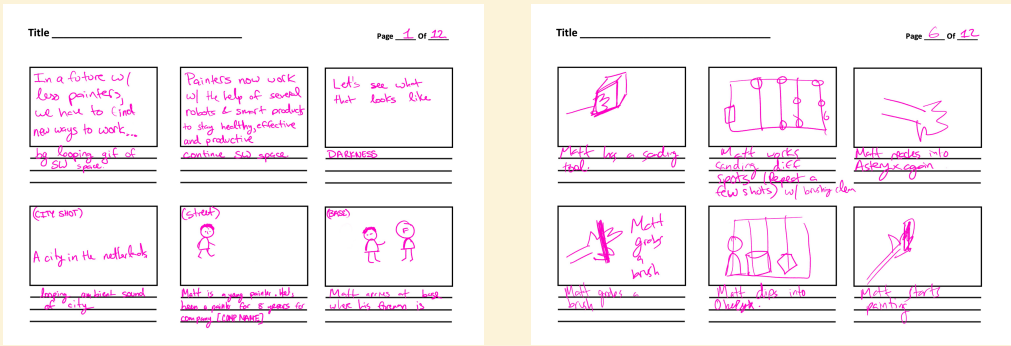

Figure 30. Pages from the initial storyboard highlight the introduction and how Matt sands the work site and switches to his brush afterward for painting. See Appendix E1 for the full storyboard.

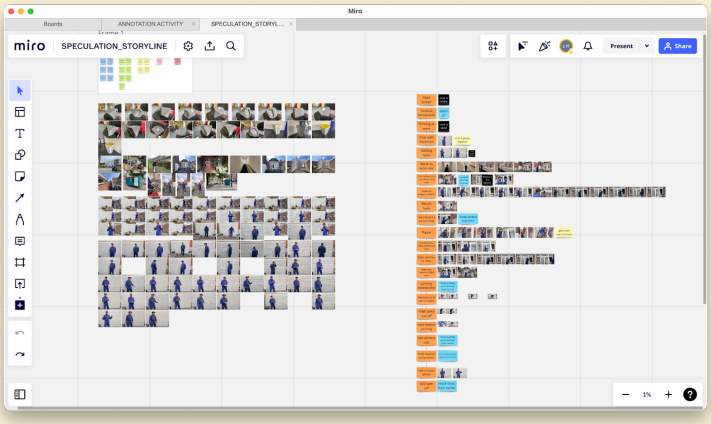

Figure 31. I used Miro to process and organize the images that would be used for production.

Workshop 1: Script

Using the created script and the select images for the story, I conducted a workshop session with three designers to get feedback on the story script. From the session, I wanted feedback on the following questions:

1. Is the dialogue believable?
2. Are there any plot holes or unresolved points in the story?
3. Does the pacing seem off (too fast or too slow)?
4. Are the themes recognizable?
5. Do parts seem too unbelievable or impossible?
6. What could be improved?

Session Structure

Each participant received a copy of the script (see Appendix E2) to read through (Figure 32). After the reading, we had a discussion guided by the questions I wanted to answer. As necessary, I showed images from the initial project photography (see Figure 33) to illustrate the script.

Figure 32. Participants and setup of the session

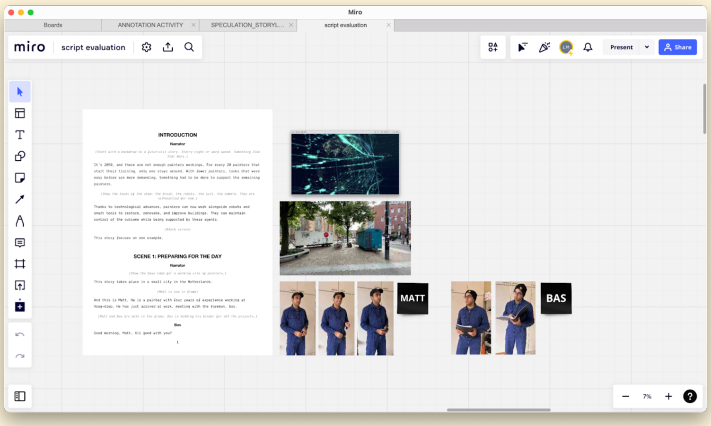

Figure 33. Miro board shown during the session. It contains the script as well as the planned visuals for each scene and character.

Session notes and feedback

During the discussion, participants and I took notes. The following (Table 11) is a compilation of the notes and the related questions.

Table 11. Notes from Script Evaluation Session

Notes	Related Questions
Dialogue between Matt and Bas could be shorter and more direct. Between themselves, the painters are likely less formal and quicker.	Q1
The suit and camera were perceived as annoying and condescending, respectively. This makes them highly provocative agents.	Q4
Outside of the story context, it should be clear to the audience that this is one possible narrative. One idea for expanding the speculation could focus on the breadth of narratives if the painters had choices of how strictly or loosely each agent followed its planned role.	Q6
The robots could do more to show how they enable delegation. They carry the materials but don't do much more in the scenes.	Q2, Q4
The robots having names is useful and makes them more relatable. The other agents (suit and camera) could	Q6

```
also have names, especially if they get their product
shots.

There is a discrepancy between Matt's supposed longer   Q1, Q2
experience as a painter and how much the camera
talks. This could be explained in the end as a
“training mode” that the camera was accidentally in.

The year the speculation is set in, 2050, could         Q5
create higher expectations of futuristic work
conditions. Something closer, but still in the
future, could be easier to work with.
```

Looking at the session, I gathered feedback that helped answer, to some degree, every question except the one related to pacing (Q3). Speaking with participants, judging the story's pacing on just the text is hard. I will use the next evaluation session to evaluate the pacing.

The feedback from this session was useful for tuning the script and getting started on putting together an interactive story. You can find the final version of the script in Appendix E3.

Developing the Medium

With a final script and images to work with, we turn our attention to the medium of the Design Fiction. As a medium for this Design Fiction, I chose a visual novel format primarily because it combines multimedia elements (image, text, video, audio, and motion) in a streamlined presentation. As a medium, visual novels (Figure 34) relate strongly to graphic novels and comic books, something that resonated strongly with some of the painters during the interviews.

Figure 34. A screenshot from the Digimon Survive visual novel showcases a visual novel's main visual components: text-based dialogue accompanied often by static illustrations.

In creating the visual novel, I focused on designing the fiction to be read on the iPad. The iPad device was chosen purely because of its portability and because it's screen size would make it easier to lay out images and text compared to a phone. As shown in Figure 35, the interface design of the visual novel is direct. The image is stacked on top, followed by the text box for the dialogue. There are buttons for moving forward and backwards in the story and for restarting the story.

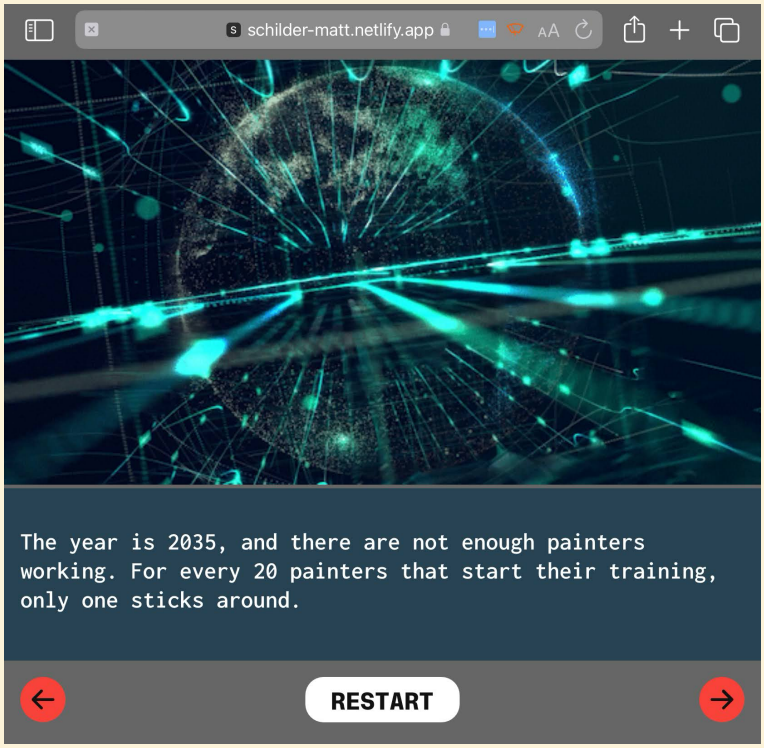

Figure 35. The interface design for the visual novel remained largely unchanged during story development.

Workshop 2: Visuals and Script

While putting together the final iteration of the Design Fiction, I conducted a second workshop session to test the updated story and see how the visuals were understood. In addition to being interested in the same questions as last time, I was looking for feedback on the quality of the visuals and the connection between the visuals and the text.

Figure 36. Participants during the second workshop session.

Session Structure

Each participant interacted with a copy of the story for this session on an iPad (Figure 36). After viewing the story, we had a semi-structured discussion guided by the questions from the last workshop session. At the end we also discussed the plans for the discussion with the painters.

Session notes and feedback

Feedback about the Design Fiction

- Using pixelated transition images confused the readers as they were expecting for something to finish loading.
- The color splashes on Matt's and Bas's dialogue didn't match the character's visuals. This made it harder to keep track of the dialogue.
- It might be helpful to end with drawings of the agents or otherwise have them around so the readers can reference them in the discussion.
- It might be nice to end with drawings of the agents so that the reader can reference them in the discussions.
- Regarding the drawing Style, one participant suggested keeping the slides realistic so the painters could connect with the story better.
- Regarding agent perceptions, the camera was perceived as condescending, judgmental, and controlling. The robots were perceived as a service without autonomy. The suit was perceived as an in-between the robots and the camera regarding judgment and control.
- The Camera's quality judgment is too harsh; it could judge things quantitatively to be less critical.
-
- While discussing the plans for the session with the painters, both participants proposed ideas for improving the experience by adding sensitizing questions prior to engaging the speculation and grounding the interview questions more closely to the Design Fiction itself.

Final Iteration

Using the feedback from the session, I updated the visuals in the story. The final version of the story can be seen at schilder-matt.netlify.app/

Chapter 5
Sessions with Painters

This chapter describes the sessions with painters facilitated by the Design Fiction from the previous chapter and the derived insights

Discussion Sessions with Painters

I conducted a second series of semi-structured interviews with the aid of the Design Fiction to specifically discuss the themes of Authority, Autonomy, and Delegation, as described in Chapter 3. Two sessions took place in person at working sites with painters from Willems and Elk. The third session occurred through Microsoft Teams. I interviewed a total of 8 individuals, which included five painters, two QHSE managers, and one former painting business owner. These sessions use the Design Fiction developed in Chapter 4 to learn about painter preferences and insights related to Authority, Autonomy and Delegation. These insights would be used to develop design guidelines for each theme (see Chapter 6).

Session Structure

Sessions were structured according to the plan shown in Appendix F1, with an initial introduction and summary of the work since we last met, followed by some sensitizing questions to get the participants thinking about the themes of Authority, Autonomy, and Delegation. All participants had a chance to experience the Design Fiction individually or communally with someone narrating the story. Afterwards, the discussion began by looking for initial reactions to this story. Starting from these initial reactions, the discussion sessions narrowed down into questions related to each theme, usually facilitated by discussing the associated agent.

Theme: Delegation

The questions related to Delegation focused on developing a more nuanced understanding of the painter's craft and work responsibilities to see what tasks painters would be willing to delegate to agents if the agents could not interfere in the brush painting process. If presented with an option for a robot that takes away part of their physical labor, would

they run with it and give up other parts of their job, find new uses, or give fewer tasks to an external agent?

Theme: Authority

The questions related to Authority focused on exploring the types of authority roles that may be helpful or supportive for painters. In the Design Fiction, the camera was written to be overbearing and condescending. This was done to provoke a conversation about what good support and authority from machines could look like.

Theme: Autonomy

Questions related to Autonomy focused on understanding when painters would be okay with having an agent act on their behalf. I wanted to understand the level of personal awareness painters currently have and may want to have regarding their posture, in which situations an agent should act on behalf of the painter, and what types of feedback painters may want from their agents.

Session Summaries

Appendices G1–G3 contain the transcripts for each of the interviews.

Session 1: Willems

The session with Willems involved two painters with two months and seven years of experience and a QHSE manager. A Dutch-speaking master's students facilitated the session. The painters in this session bring in the perspective of the new generation of painters. They are typically more flexible and open to considering innovations than the older generation of painters.

During the session, we discussed the benefits of using robots to carry tools and materials, reducing trips to storage and physical strain, and improving efficiency. Participants also considered assigning repetitive tasks like sanding and cleaning to robots, but maintaining control of the visual painting work, as they believed a human touch is necessary to create beauty. We also discussed the lack of trust associated with constant camera monitoring of painters' work, which could potentially aid communication and enhance efficiency, but painters emphasized the importance of autonomy and flexibility in their craft.

The discussion highlighted the tension between authority, autonomy, and delegation. The painters value their ability to exercise individual judgment and adapt to unique restoration challenges, which sets their work apart from standardized settings. They recognize the potential for cameras to provide feedback, but they are cautious about relinquishing control to an authoritative tool. The painters favor collaboration over micromanagement and see technology integration as a means to support and raise awareness rather than enforce strict rules. Overall, the conversation underscores the central role of human intuition, adaptability, and craftsmanship in painting while acknowledging the potential benefits of technological assistance when balanced with artistic control.

Session 2: Elk

The session with Elk involved primarily one painter with 30 years of experience and a QHSE manager who facilitated the session by translating. During the conversation, two other painters joined in on the conversation. The painters in this session bring the perspective of the older generation of painters. The older generation is typically more conservative than the newer generation regarding change and adopting new techniques and technologies.

During the session, painters emphasize the importance of assistance without control. They highlight the need for flexibility in postures, cautioning against forcing uniform poses. Sound and light alerts are preferred for posture correction. While the idea of robots assisting with material transportation is welcomed, some tasks like sanding and painting must be closely controlled for quality assurance. The camera is appreciated for its efficiency in identifying issues like wood rot, but its constant judgment is met with resistance. The conversation underscores the necessity of maintaining the human element in painting, with technology serving as a supportive tool rather than an authoritative force.

Session 3: SUSAG

For this session, I had a one-on-one conversation with Geert-Jan from SUSAG. Geert-Jan previously owned a company of painters and is now president of SUSAG. He has been involved in the overarching project but has not seen my work specifically. Geert-Jan's session provided insights from a business owner's perspective on understanding the needs of painters and ensuring profitability while considering Human-Agent Collaboration.

The main focus of the conversation was on using a sophisticated camera system to monitor and assist painters in various aspects of their work. The camera is a central hub connected to other tools like gloves, a suit, and a respiratory system. The system aims to provide real-time feedback on posture, quality of work, and potential health hazards. The camera can help painters maintain correct posture, manage their workload, and avoid health issues. The foreman's role in supervising and managing the painters is also emphasized, along with the importance of striking a balance between human craftsmanship and technological assistance. The conversation highlights the challenges of

integrating technology while ensuring painters maintain autonomy and decision-making authority. The conversation also discussed how the camera system can be a valuable tool for assessing quality, preventing overworking or underworking, and aiding communication between painters, foremen, and clients.

Session Insights

The audio from each session was transcribed and translated into English. Going through each transcript, I gathered notes and quotes relevant to the three themes for a thematic analysis documented in Appendix G4. Below are the derived insights for each of the themes.

Insights related to Delegation

DELEGATION_01	Pride in the result is a crucial motivator for painters. As a result, they want to maintain a strong control of the process, even when delegating tasks.
DELEGATION_02	The robots could provide technical execution, but they are not perceived as being able to provide beauty in their work. This might be because the painters, as trade workers, see the restoration process as creating beauty.
DELEGATION_03	There is a necessary human touch to painting practice. Humans can best collaborate and communicate with clients and themselves to understand and achieve a good outcome.
DELEGATION_04	Painterly understanding of agents is fragmented, with sometimes conflicting expectations. In one instance, one participant began the conversation by saying a specific agent would not be helpful but proposed an idea for the same kind of agent at the end of the conversation.
DELEGATION_05	Most painters were not against delegating tasks to robots. They could see other instances where robots could provide support by helping them prepare work materials and assisting them in carrying and moving materials, either partially or fully.
DELEGATION_06	Painters directly identified tasks involving repetitive actions, like sanding, cleaning, and caulking (applying sealant), as tasks robots could take over.

Insights related to Authority

AUTHORITY_01	Authority figures that focus on micromanagement or demeaning the painters are not appreciated. "If you have peace, you also have confidence. So you also give someone confidence in what he is doing if he stands there all day long."
AUTHORITY_02	As an authority figure, an agent, like the camera, can be seen as a stand-in for the client or the foreman. In the case of being perceived as the foreman, the agent's behavior is perceived as a lack of trust in the painters.
AUTHORITY_03	We discussed a connected version of the future that verged on dystopic and, as a central concept, had a highly authoritative agent camera that was connected to the other agents and could enforce good working practices through collecting and streaming the data and evaluations.
AUTHORITY_04	Improvising and flexibility are essential components of the painter's practice. It's a skill that they develop, and an agent in the role of authority must cope with the painter's shaping of plans and tasks.
AUTHORITY_05	While making extra pictures for an authoritative agent seems inconvenient, the idea of an agent overseeing quality is not unrealistic. It aligns with the push in European legislation to control and verify work quality.
AUTHORITY_06	When discussing authority, data handling was a topic mentioned. Painters felt that keeping the data locally on the camera was more supportive and helpful in building up skills and intuition, whereas transmitting the data to the foreman seemed like betraying the trust of the painters to complete their work.
AUTHORITY_07	The camera agent could be a stand-in for a coach or mentor or even an assistant to a coach or mentor. This authoritative role is perceived as more favorable. It could use the camera function the painters appreciated quality judgment on demand, as a way to build confidence and train painters in consistency and intuition.

Insights related to Autonomy

AUTONOMY_01	When considering agents that could affect their work practice, painters were worried about practical coordination matters with agents being in the way.
AUTONOMY_02	Throughout this discussion, it becomes clearer that the painter wants to retain control of their work. A product/tool agent is welcome for the insights and opportunities it generates but not for how it controls the painter’s action. This ties to autonomy, which is paramount for the painter.
AUTONOMY_03	It's difficult to conceive an agent that enforces good body posture because there is insufficient ergonomic data for painters, and everyone has different postures.
AUTONOMY_04	Painters value their flexibility and idiosyncrasies. Agents that want to affect their autonomy must be flexible as well. This contrasts with industries like manufacturing, where assembly-line work can be automated and analyzed.
AUTONOMY_05	There should be a balance between the painter's intuition and an agent's judgment. Agents should only interact on behalf of the painter when there is an alignment of intention.
AUTONOMY_06	Painters will agree that the agent's intents align with their own if the agent can articulate itself well.
AUTONOMY_07	The suit was a negative incentive for improving posture because it focused on restraining the painter's movement, which goes against the painter's need for flexibility and can be potentially dangerous.
AUTONOMY_08	A secondary function of the suit, the light signaling how overextended the painter is, can signal other painters to comment and correct someone's posture. The painters preferred this social approach.

Chapter 6
Design Guidelines for Human-Agent Collaboration in a Painting Context

This chapter presents a series of design guidelines informed by the insights from the discussion sessions with painters.

Design Guidelines for Human-Agent Collaboration in a Painting Context

Design guidelines are a form of intermediate-level knowledge that bridges high-level design principles, which are quite general, and specific design rules, which are highly detailed, leaving room for the designer's judgment and intuition ("What Are Design Guidelines?," 2021). The design guidelines presented in this chapter are derived from the discussion sessions with the painters (Chapter 5) and focus on the themes of Delegation, Authority, and Autonomy. They aim to provide actionable directions for designing productive human-agent collaborations within the painting context concerning each theme. The following sections will discuss the guidelines according to each theme, summarized in Table 12. See Appendix H1 for the development process.

Table 12. Design Guidelines for Human-Agent Collaboration in a Painting Context

Design Guidelines	Associated Theme
Enable painters to delegate tasks to agents flexibly, offering an option to resume control when needed or desired.	Delegation
Allow painters to override an agent's task plan, leveraging their understanding of the desired outcome.	Delegation
Empower painters to gradually increase the complexity of tasks they delegate, aligning with their comfort and comprehension of agent capabilities.	Delegation
Assign agents tasks that involve repetitive actions or precision, such as sanding, cleaning, and applying sealant.	Delegation
Agents in positions of authority must maintain confidentiality of data shared between themselves and the painter.	Authority
Agents should allow painters the freedom to complete tasks in their preferred manner and should not impose specific methods.	Authority
Agents should refrain from assuming negative authority roles that could hinder productive interactions.	Authority
Design agents to empower the painter's autonomy while ensuring alignment with their intentions.	Autonomy
Agents should communicate their intent to act and await confirmation from the painter before proceeding.	Autonomy
Agents should offer actionable feedback that respects the painter's autonomy, enabling them to perceive and act upon it freely.	Autonomy
While the painter is working, agents must refrain from physically intervening or acting on the painter's behalf.	Autonomy

Design Guidelines related to Delegation

Enable painters to delegate tasks to agents flexibly, offering an option to resume control when needed or desired.

Flexible task delegation here means the painter can assign a task to an agent and later take over working on the task depending on the painter's judgment. An agent could begin a task completed by the painter, or the painter could start a task that the agent completes. Approaching delegation in this manner respects the painter's desire to control the process, which results from the strong sense of pride in the outcome that painters feel.

`Derived from: DELEGATION_01, DELEGATION_05`

Allow painters to override an agent's task plan, leveraging their understanding of the desired outcome.

Working in a painting context requires a lot of flexibility and changes in working plans based on what is needed. Humans excel in this aspect when compared to agents who can excel at technical execution. As a result, painters should be able to override the agent's task plan (the plan of how the agent will complete a task) when delegating a task, ensuring that the outcome better aligns with what the painters and client desire.

`Derived from: DELEGATION_02, DELEGATION_03`

Empower painters to gradually increase the complexity of tasks they delegate, aligning with their comfort and comprehension of agent capabilities.

Painters need a more cohesive understanding of what agents can accomplish and a desire to control the process. A task delegation system that progressively allows painters to delegate specific tasks can enable painters to align the agent's support with their own needs, comfort, and understanding of what the agent can accomplish. This approach can result in agents that assist painters in carrying part of their load, performing specific motions, or only assisting in small tasks.

`Derived from: DELEGATION_01, DELEGATION_04`

Assign agents tasks that involve repetitive actions or precision, such as sanding, cleaning, and applying sealant.

Painters explicitly indicated tasks such as sanding, cleaning, and applying sealant as tasks they would delegate to agents because they are repetitive, tedious, or lack an interest factor. Agents who excel at working on repetitive tasks and technical execution could support painters by working on these tasks.

`Derived from: DELEGATION_02, DELEGATION_06`

Design Guidelines related to Authority

Agents in positions of authority must maintain confidentiality of data shared between themselves and the painter.

Painters welcomed the idea of data-driven feedback from agents as long as they do not share the data with other authority figures (human or non-human). Sharing data with supervisors was perceived as a lack of trust in the painter's ability to do their work. However, getting data-driven feedback created a perception of room for self-improvement.

`Derived from: AUTHORITY_01, AUTHORITY_02, AUTHORITY_03, AUTHORITY_06`

Agents should allow painters the freedom to complete tasks in their preferred manner and should not impose specific methods.

Improvisation and flexibility are core components of the painter's practice. Agents in authority roles should consider this and avoid suggesting task completion methods. Painters are open to agents offering task plans, as this happens in their daily practice without agents. Still, they want to decide when to follow and when to deviate from the plan and how to execute the plan to achieve the best quality result based on the intuition they have developed in their practice.

`Derived from: AUTHORITY_01, AUTHORITY_04, AUTHORITY_05`

Agents should refrain from assuming negative authority roles that could hinder productive interactions.

During the discussion, we discussed three roles that the camera agent could stand for: the foreman, the client, and a mentor. Of the three roles, the agent assuming the camera role was seen as the least helpful because it created a perceived lack of trust in the painter's ability. The role of the client was seen potentially as a neutral role. Painters have pride in showing the quality work they can accomplish, and having someone to show it to aligns with this concept, but if the agent requests too much from the painter in terms of attention, there is a breakdown in interactions. The most positively perceived role was that of the mentor or coach, which turned the interactions of having the work progress tracked and judged into an opportunity for developing a better intuition about the needed quality and technique.

`Derived from: AUTHORITY_02, AUTHORITY_07`

Design Guidelines related to Autonomy

Design agents to empower the painter's autonomy while ensuring alignment with their intentions.

Painters have a strong desire to be in control of the process and to work in a way that is personally comfortable and flexible to the changing needs of a restoration project. Within such a practice, agents should act in a way that aligns with the painter's intentions and empowers the painter's autonomy (the painter's ability to work independently).

`Derived from: AUTONOMY_02, AUTONOMY_04, AUTONOMY_05, AUTONOMY_06`

Agents should communicate their intent to act and await confirmation from the painter before proceeding.

Painters strongly value their autonomy but are open to working in new ways if they can understand how it produces better results. By having agents communicate their intent before acting, painters can decide when and how to get support, respecting their autonomy and ultimately protecting the quality of the outcome.

`Derived from: AUTONOMY_04, AUTONOMY_06, AUTONOMY_07`

Agents should offer actionable feedback that respects the painter's autonomy, enabling them to perceive and act upon it freely.

When discussing feedback mechanisms, painters wanted to have control of when and how they respond to agent feedback to avoid situations where the agent acts on their behalf in

cases that may be unstable. The painters appreciated feedback like sounds and light that can be acknowledged and addressed without affecting their movement or work progress.

Derived from: AUTONOMY_04, AUTONOMY_07, AUTONOMY_08

While the painter is working, agents must refrain from physically intervening or acting on the painter's behalf.

When considering agents that could affect their work practice, painters were worried about practical coordination matters with agents being in the way. The suit was a negative incentive for improving posture because it focused on restraining the painter's movement, which goes against the painter's need for flexibility and can be potentially dangerous. By having agents refrain from physically acting on the painter's behalf, the painter has to pause to actively delegate a task or request support, aligning with the painter's desire to work independently and have control of the outcome.

Derived from: AUTONOMY_01, AUTONOMY_07

Chapter 7
Conclusions

This chapter provides final remarks on the project and outcomes.

Conclusions

Painting has proved to be an interesting and challenging context to introduce agents into. While painting as an activity is something most of us have done and understand, working professionals have a sense of pride and skill in their motions that would be difficult to replace with agents. Painters are generally conservative and wary of innovation, as they deeply enjoy the process of restoration, but they are also a profession that is finding it difficult to recruit as many people as before. This project focused on exploring how agents could support painters to work sustainably, to see what possibilities exist for collaboration.

To that end, I wanted to consider Speculative Design methods as a way to explore human-agent collaboration without a focus on the technical feasibility of the agents. I focused on creating a Design Fiction grounded in painting practice to develop an idea for how agents and painters could collaborate when working outdoors. A varied set of activities focused on building a knowledge of the painter's practice (interviews and an ecological analysis) and Human-Agent Collaboration (agent brainstorming session and identifying designerly concerns in Human-Agent Collaboration) informed the Design Fiction that focused on three themes related to Human-Agent Collaboration: Delegation, Autonomy, and Authority. The Design Fiction was used as a tool to facilitate a discussion with painters around the three themes, and an anlysis of these discussions informed the development of the design guidelines presented in this report.

In order to develop a more robust set of design guidelines for Human-Agent Collaboration in the painting context, the process undertaken in this report would have to be repeated for different themes. For each theme, new guidelines would arise that would lead to a broader understanding of Human-Agent Collaboration in the outdoors painting context.

Limitations as opportunities for Future Work

Target Group

For this project, the target group consisted of painters in the Netherlands. Painters are generally conservative group, with not a lot of interest in changing their practices. This seemed to be the case more with the older painters than with the younger ones. These differing attitudes showed up during the interview and discussion sessions, as well as with the presentation of the design fiction, where a painter didn't finish the story. More time and consideration into developing materials and approaches for engaging with the different painters would have been helpful to this project and would be a point to consider in a future project.

Moreover, while I had assistance in communicating with the painters and we were able to have conversations partially in English, as a non-Dutch speaker, I felt I was lacking a bigger understanding of the conversations in the moment. While this limitation felt frustrating at times, it might be interesting to review activities and create new materials in collaboration with a native speaker.

Outdoor and Indoor Context

The design guidelines developed through this project are geared towards painters working outdoors, which is a related but different enough experience from painting indoors. When working indoors, there are less environmental weather factors and different activities like working with wallpaper and painting around radiators or other home appliances. Because this project was limited to the external context, it would be useful to test if these guidelines do surface when considering human-agent collaboration indoors.

Speculative methods

During the course of this project I considered other Speculative Design methods, such as Material Speculation, and Speculative Enactments, before settling on Design Fiction. Future explorations could work with Material Speculation or Speculative Enactments to focus on the embodied dimensions of agents involved in speculation or the participatory dimension of collaborating with agents, respectively.

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