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Designing a Physical Boundary Object to Invite Dialogue about Power Relations Behind AI Systems

Tiwánee van der Horst, Anja Overdiek, and Maaïke Harbers

Throughout society, dialogues about Artificial Intelligence (AI) are dominated by a range of technophobic or techno-solutionist narratives. Both these narratives share a technological focus. To develop responsible AI, however, it is important to look at the systemic ecological and societal underpinnings and repercussions of this technology. These underpinnings easily go unnoticed by decision-makers because of their invisible and intangible character. In addition, a narrow focus on technology distracts from the humans who are responsible for designing AI systems and the power these AI systems have over both humans and the more-than-human. Hence, one challenge in developing AI responsibly is moving from current narratives towards relational 'power narratives' by reframing dialogues in a multi-stakeholder setting. Systemic Design and the research-through-design practice offer several methods for this purpose. One of them is to work with a physical boundary object (PBO). This paper describes the design and use of the PBO 'Who pulls the strings'. The PBO was used in a quadruple-helix co-creative setting. Through intra-action, participants became aware of the influence of each stakeholder within the power system and were able to have an ongoing dialogue about existing power relations and ways to reshape these collaboratively. The contributions of this paper include creating novel insights about what design principles can be used to design a PBO when employing entanglement theory and how a PBO can invite dialogue about the invisible and intangible power relations behind AI systems.

KEYWORDS: AI ethics, AI, power, narrative, boundary object, physicality, social design, New Materialism, entanglement

RSD TOPIC(S): Methods & Methodology, Society & Culture, Sociotechnical Systems

Introduction

People's access to technology in daily life is increasing steadily. Such developments point towards a high level of entanglement of artificial intelligence (AI) systems with humans' identities, wants and needs. It is often claimed that AI holds promise to solve grand societal challenges like those in healthcare and the energy sector. Yet, the rise of AI systems can also lead to an unhealthy living environment for people and the planet. Today, signs of this are already visible. The media is continually displaying headlines featuring urgent ethical and ecological issues such as fake news, systemic racism, surveillance, targeted human manipulation, ghost workers, cheap labour in developing countries, raw material scarcity and the impact of data centres on natural ecosystems (Crawford, 2021; Noble, 2018). In response to these reports, the last few years have seen increased attention to AI ethics (Floridi et al., 2018).

Towards a power narrative

Literature on AI ethics generally focuses on technological risks (European Union, 2023; Green, 2021). They are often geared towards transparency, privacy, non-discrimination, security, safety and data fairness. To a much lesser extent, we find mentions of human rights and the ecological footprint. This technological focus is rooted in a variety of popular narratives ranging from techno-solutionism to technophobia.

Techno-solutionist narratives emphasise ways in which AI can combat climate change, pollution, biodiversity loss, hunger and poverty. Technophobic narratives describe how AI may take over human skills to such an extent that we lose meaning, control and freedom of choice (Cave et al., 2020; Chubb et al., 2022; Coeckelberg, 2021). However, creating AI systems is fundamentally a human endeavour, as is the creation of any other technology: AI is built on human values, habits, biases, perspectives, opinions, cultures, ideologies and politics (Bender et al., 2021; Buolamwini & Gebu, 2018; Lanier, 2020;

Orlikowski, 1992). This means the responsibility lies with us humans, both those who design AI and those who make AI policies and legislation. Züger and Asghari (2022) argue that the AI practice needs a public interest approach, including multi-stakeholder dialogue with the ambition to take responsible action and move existing AI ethics guidelines and legislation forwards (Rakova et al., 2021). Today's narrow focus on technology can lead to a misjudgment of the way AI will manifest itself in reality because it distracts from the humans who are responsible for designing the AI systems and the impact these AI systems have on both humans and the more-than-human (Forlano, 2017). The more-than-human consists of anything that is not human. We choose to refer to the more-than-human because it is a category so big that boundaries dissolve and the interactions within it are what matters. In this paper, we refer to the more-than-human as animals, plant life and raw materials.

The extent to which AI systems are responsible relies on the ability and willingness of those in power to act responsibly, and to take into account diverse multi-stakeholder perspectives. Failure by those in power to do so may result in AI systems that reinforce societal inequality (O'Neil, 2017) and increase the already significant ecological footprint of AI (Crawford, 2021). That being said, designing AI responsibly is a complex problem due to its socio-ecological-technical nature (Franco-Torres et al., 2020). The urgent ethical and ecological issues described by Noble (2018) and Crawford (2021) underscore the need to extend current technology-focused narratives to relational power narratives (Birhane, 2021; Sloane et al., 2020). Narratives have proved to affect the way people have dialogues about AI and instigate action on a policy level (Crow & Jones, 2018).

Design research and organisational research offer methods to change these narratives. In these fields, scholars argue that a particular design thinking tool, namely boundary objects, has proven to be an effective method to communicate systemic properties and bridge stakeholder perspectives in participatory processes (Carlile, 2002, 2004; Cooney et al., 2016). In these processes, stakeholders are mobilised and aligned along a similar goal (such as creating responsible AI) through the making and use of a boundary object.

We believe that the physicality of the boundary object is especially important within the topic of AI ethics because of the digital, virtual and intangible characteristics of the technology and the complexity of power systems that influence the development of AI

systems. A physical boundary object enables individuals to bodily interact with this object; emotions and bodily sensations that arise can find expression through the (reaction to) the object (Lockton et al., 2020). This expression can then be interpreted by multiple individuals from their perspective, which enables them to respond to it. This would not have been possible without a physical boundary object since, without a physicalisation, dialogue can more easily diverge in another direction. In addition, a PBO can help embrace the complexity of the entangled relationships we deal with in this research. As a result, we designed a physical boundary object, which is a physical translation of a metaphor for power: 'Who pulls the strings' (Figure 1). We use this object to answer the research question:

How can we design and use a physical boundary object to invite dialogue between multiple stakeholders about the invisible and intangible power relations behind AI systems?

To answer this question, the following sections will argue for entanglement as a theoretical lens linked to a research-through-design approach to come to four design principles for the PBO, describe the design concept and prototype and describe and analyse the interaction with the PBO to come to results. Finally, the paper will discuss the results and draw conclusions.



Figure 1: The design of the PBO 'Who pulls the strings of AI?'

Design principles

For this research we embrace the lens of entanglement theory (Barad, 2007), a lens which is increasingly being used by AI ethics researchers (Frauenberger, 2019; Indira Ganesh, 2017). We turn to new materialist thought and place it in dialogue with the research-through-design practice (Koskinen et al., 2011; Stappers & Giaccardi, 2017). The theory described in the following paragraphs enables us to define a set of design principles.

The entanglement theory lens

As mentioned in the introduction, developing AI responsibly means moving towards more relational 'power narratives'. Responsibility has traditionally been addressed through the lens of causality. This implies a one-dimensional understanding of someone

who acts, whereupon this act leads to a change. Accordingly, this lens gives responsibility to the one who acts. The entanglement lens offers a contrasting approach through various theories. We focus on elements of Karen Barad's agential realism in which she introduces the concepts of intra-action (Barad, 2007). Barad has inspired design research to focus on the intra-acting of different stakeholders and to look beyond the usual stakeholders by including not only more-than-human stakeholders but also the agency of systems that include matter and computational devices (Cattabriga, 2022). As such, we include thoughts from James Bridle's book *Ways of Being*, in which he applies Barad's work to come to an understanding of what it means to live in a more-than-human world.

Barad mentions: "Agency is about the possibilities and accountability entailed in reconfiguring material-discursive apparatuses of bodily productions, including the boundary articulations and exclusions that are marked by those practices in the enactment of a causal structure. Particular possibilities for acting exist at every moment, and these changing possibilities entail a responsibility to intervene in the world's becoming, to contest and rework what matters and what is excluded from mattering." (Barad, 2007: p. 287)

We apply Barad's work to our design purpose in two ways:

- If the purpose of a PBO is to create bridges between intra-acting stakeholders by making their boundaries and interrelationships physical, this physicalisation must not represent a one-dimensional structure but rather enable a four-dimensional structure. This structure shows interrelationships across a plane (between stakeholders - two dimensions), across layers (systemic layers - three dimensions), and through time (movement and change - four dimensions). In doing so, the PBO has an open character, which creates the possibility of acting at any moment and responding to changes.
- We need to challenge the entrenched exclusion of invisible stakeholders by those in power. These invisible stakeholders can be minorities and more-than-humans. To exclude such stakeholders is to ignore the entangled relationship and deny their importance in responsible decision making. We can avoid this exclusion by adding a component of randomness (Bridle, 2022) to the PBO design.

In their book *Ways of Being*, Bridle says:

Randomness means and makes sure that everything matters. This 'mattering' is an active verb: by paying attention and giving power to each constituent part of the assembly, we become together, in Karen Barad's sense of intra-action, everything is bouncing off everything else and becoming more as a result. Randomness increases intra-actions. Each and every thing matters; everyone matters. (Bridle, 2022: p. 249)

By adding a component of randomness to the PBO, we can visualise the power of the more-than-human world and include it in our systems of governance and human relationships. Randomness is most easily designed by not designing it. Instead, we incorporate an element of nature in the design of the object, such as water or gravity.

Linking theory with the research-through-design practice of boundary objects

We combined the described entanglement theory with research-through-design practice, in which interest in the use of boundary objects has resurfaced. In different contexts of design research, the words prototype, artefact, model, and instruments are used instead of the word 'boundary object' (Bridle, 2022; Buur et al., 2022; Stompff, 2020), but for clarity's sake, we use the term boundary object throughout.

Boundary objects are solidified knowledge (Stompff, 2020) or epistemic objects. Boundary objects can be emergent and designed (Franco-Torres et al., 2020; Godfroij & van der Lugt, 2021; Star, 2010; Star & Bowker, 1999). In this research, we focus on a designed boundary object. Such an object is specifically designed for a use case or issue in which a bridge needs to be made between the social worlds of different stakeholders. The design aims to generate knowledge that is transferable and communicable (Whyte & Ewenstein, 2009). Research into designed physical boundary objects says that artefacts that retain plasticity and **ambiguity** allow participants to influence how the boundary object meets their needs (Huvila, 2011; Stoytcheva, 2013). To sum up, looking through the theoretical lens of entanglement theory, a PBO should contain the following elements.

PBO list of design principles:

A tangible representation of an intangible construct, i.e. through the use of metaphors

A four-dimensional structure, i.e. by adding moving parts and layers of meaning

A component of randomness, i.e. by incorporating forces of nature in the design

Inviting ambiguity, i.e. by adding variables

Method

We used the above-stated design principles to design a first concept and prototype of a physical boundary object. We reflected on how our design of the PBO meets those design principles and conceived scenarios on how the PBO can be used. We performed iterative interventions with the PBO, collecting data by participatory observation and transcription of the resulting dialogues. In this paper, we analyse a preliminary experiment of such an intervention with the PBO within a multi-stakeholder setting. This intervention was the first experiment we did with the prototype of the PBO.

The contributing stakeholders of the experiment are part of a learning community in which several partners, with representatives of all four domains of the quadruple helix, form part of a larger research project about responsible AI. We experimented with the PBO in the first partner meeting in which the aim was to invite dialogue about power relations behind AI. The dialogue was held in a timeframe of about an hour. To give each participating stakeholder the opportunity to speak, listen and respond, the group was restricted to 12 people. The dialogue was documented through audio and film recording for later analysis. Prior to the recording, we asked permission of the participants through an informed consent form. Using the audio, we were able to transcribe the dialogue. We analysed the dialogue that resulted from the preliminary experiment by reading the transcription and labelling the text through thematic analysis (Miles & Huberman, 1994; Alhojailan & Ibrahim, 2012) on the topic of power. This method is compatible when qualitative data is collected and compared in different phases of a project. For this paper, we use a broad definition of power in the *Merriam-Webster dictionary* (Merriam-Webster.com, 2023), namely, possession of

control, authority, or influence over others. See the discussion for further elaboration on the definition of power.

Interaction with the physical boundary object

In the following section we describe how the PBO was used in a quadruple-helix multi-stakeholder setting as a preliminary experiment. The PBO was placed on a rectangular table of, approximately 200 x 120 cm. This enabled all participants to stand around the PBO, see the object and easily reach the interactive parts. The participants were then asked to go through the following steps.

1. Choose a pawn that represents you in your daily role.
2. If you think about AI, from what position and role do you have influence on the design and development of AI? Choose the corner that best suits your position of influence: Industry/ Government/ Knowledge Institution/ User.
3. In dialogues about AI, to what extent is your voice valued? Add the corresponding weight to your pawn. Choose weights on a scale of 0-3. Explain out loud why you make this choice.
 - a. Add 0 weights if you feel your voice is not being valued or if you do not get a seat at the table.
 - b. Add weight 1 if you have the feeling that your voice is valued sometimes.
 - c. Add weight 2 if you feel that your voice is valued regularly.
 - d. Add weight 3 if you feel that your voice is valued most of the time.
4. Place your pawn and weight on the board and define the amount of influence you have based on your role.
 - a. Place the pawn in the middle of the board if you have little influence.
 - b. Place the pawn on the edge of the board if you have a lot of influence.
5. Let other players do steps 1-4.
6. After all participants had interacted with the board. The participants were asked to answer one or more of the following questions to start the dialogue:
 - a. Why did you give yourself this weight and position on the board?
 - b. What is the board telling you and the other players?
 - c. Does the board represent reality?

- d. If not, what pawns and weights can be moved, changed or added to represent reality?
- e. How diverse are the pawns on the board?
- f. What does the diversity of roles on the board tell you?
- g. Can the diversity be improved?
- h. If so, what pawns or weights can be moved, changed or added to improve diversity?
- i. How do you translate what you see on the board to real life?
- j. Can you do something tomorrow? What can you do? Will you do this?
 - i. If not, why not?
- k. What (knowledge) do you need to make a first step towards responsible AI?

Design concept and prototype

In this section, we present the design of the PBO and argue how it relates to the design principles developed from theory.

A tangible representation of an intangible construct

The aim was to materialise the power dynamics behind AI and make the interrelationships of the human and more-than-human visible and tangible. We decided that the most effective way to do this was to make an object that has visual meaning through common knowledge (Whyte & Ewenstein, 2009). That is why we chose to work with a literal translation of the metaphor for power: 'Who pulls the strings?'

A four-dimensional structure

The multiple layers within the boundary object were structured as indicated in Figure 2.

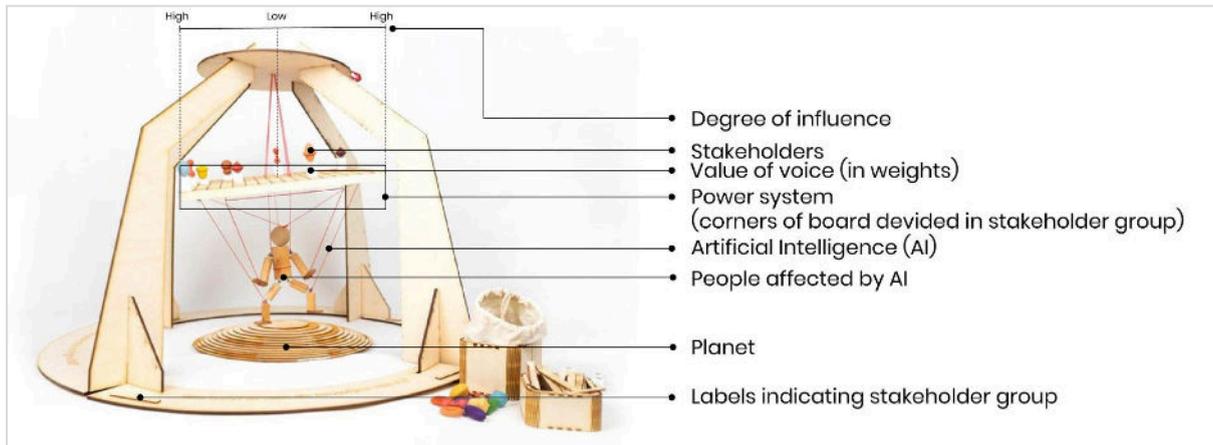


Figure 2 Physical boundary object with an overview of relational and representational parts.

A component of randomness

In our research, we work with power as an intangible construct. To make this tangible we choose to work with weight and gravity as a natural component of randomness. These natural forces are given external factors which cannot be controlled by the designer. As such, the design becomes open to random and unpredictable results. These forces enable the object to move and give feedback instantly without engineering a feedback system or adding a piece of technology. By using forces of nature - instead of, for example, an algorithm - as a component of randomness, the PBO avoids becoming a black box. Figure 3 shows how the weight can be placed and moved on the board.



Figure 3: Placing a pawn with weight on the board.

Inviting ambiguity

Our PBO: Who pulls the strings of AI? invites ambiguity in the following ways:

- The design invites different ways by which stakeholders can add, subtract and restructure elements to materialise scenarios of power relations. The interaction starts with placing stakeholders on the board that represents the power system. The board is divided according to the quadruple helix, Figure 4 and 5. The varying weights of the pawns (stakeholders) and their placement on the board (power system) have an influence on the balance of the entire system that decides if and how AI is designed and implemented. Simultaneously, AI has an impact on the planet. The AI application is not an interactive element in this design; rather, it changes form indirectly by moving pieces within the power system. Emphasising that this is where responsibility starts.

- The corners of the board can represent different categories of stakeholders. We laser-cut labels with categories other than the quadruple helix (Knowledge institution, Industry, Governments, User). In several test cases, the participants added the labels Policy makers, Students and NGOs to better bridge the social worlds that were important for that dialogue.
- The colours of the pawns can be chosen intuitively. In some cases, the participants can decide to assign colours to a group type, such as blue for technical experts and yellow for ethical agents. This use of the boundary object can emerge organically based on the need for an extra layer of information.

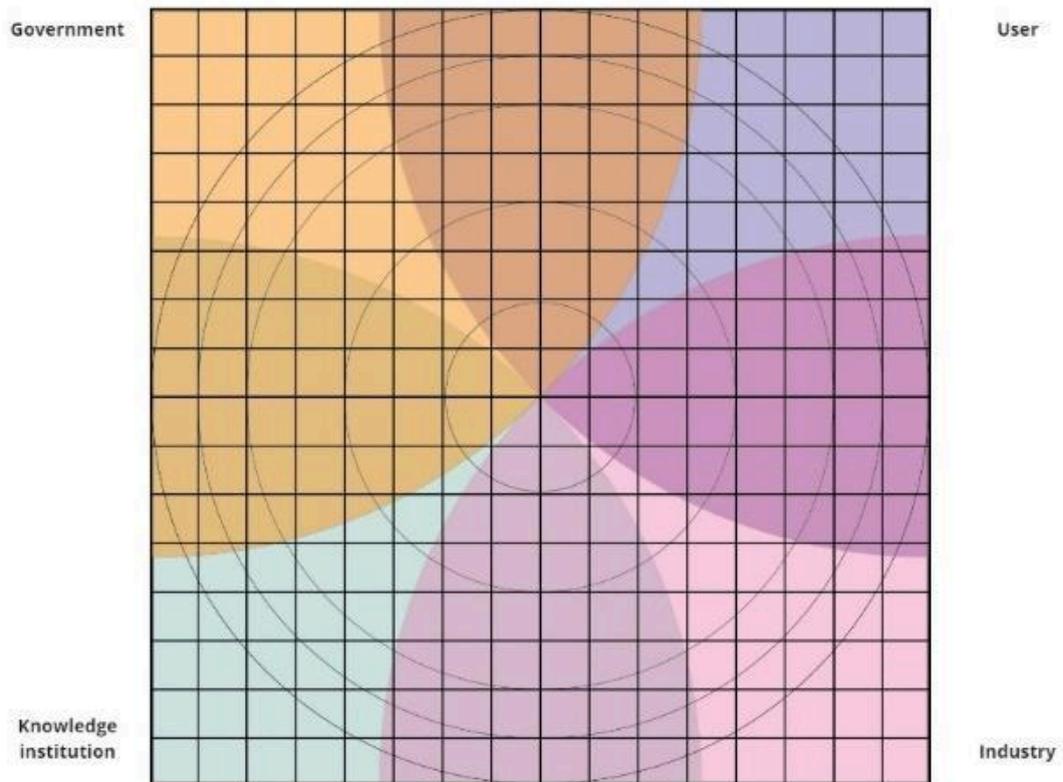


Figure 4: Quadruple helix division on the board representing the power system.

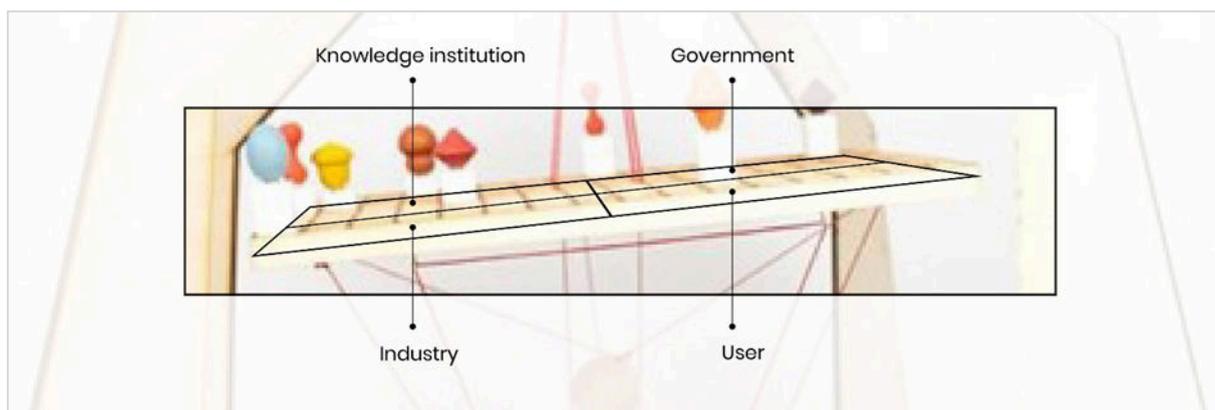


Figure 5: Board representing the power system with quadruple helix division, in this image the balance is tilting towards industry.

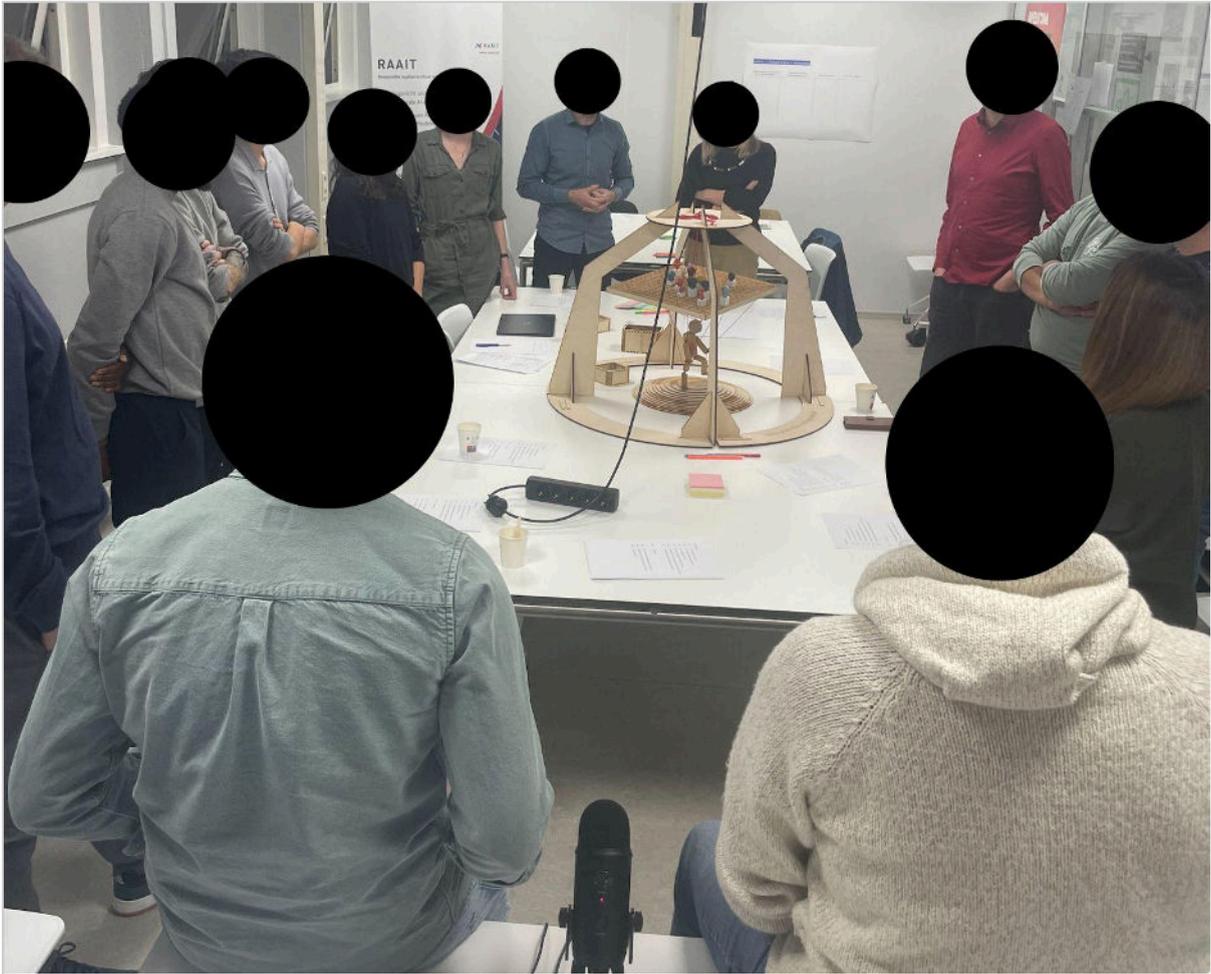


Figure 6: Setting with multi-stakeholder group standing around the PBO

Results

In this section, we describe the process of interaction with the PBO and the multi-stakeholder group (see Figure 6), walk through the dialogue with practical examples of participants' quotes, and touch upon the feedback we received about the PBO's materiality.

Process of interaction

After the recognisable boundaries, the pawns between stakeholders involved were physically mapped on the PBO, and the boundary crossing between those stakeholders started. Stakeholders pointed towards other stakeholders' positions and talked about

their influence on the AI system and their interrelatedness. In addition, stakeholders started to see where currently absent stakeholders still needed to be mapped out, they realised some stakeholders were not present that have or should have a voice in the matter. Some stakeholders realised they had multiple roles; in the end, all stakeholders realised they were users, too. A blurring of boundaries between categories of the quadruple-helix occurred.



Figure 7: Pawns of all present stakeholders mapped on the board

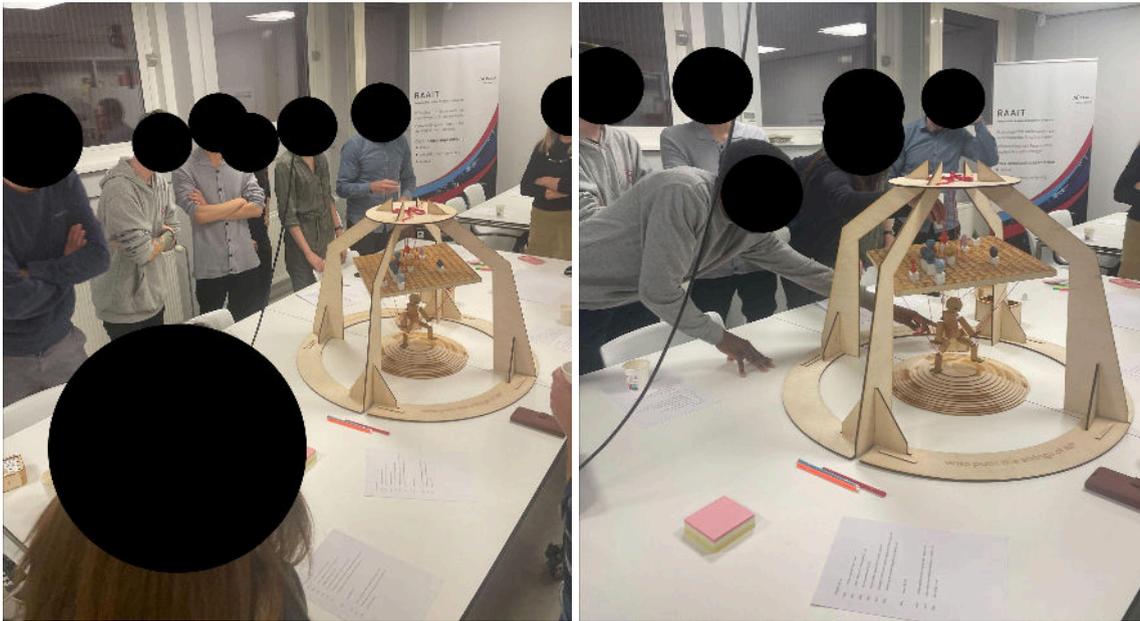


Figure 8: Left: Discussion arises between several stakeholders. Right: Stakeholders add a pawn to the board after discussing.

Thematic analysis of power

The stakeholders started by talking about their own influence over others, reflecting on their level of knowledge and how this contributes to their level of power over the AI system. In the midsection of the dialogue, several ideas and solutions were introduced to mitigate power imbalances. In the final section, there is a clear focus on authority, and the dialogue returns to the level of knowledge and awareness of ethical issues behind AI and stakeholders that need to have a greater voice in the dialogue. The following quotes illustrate this.

I think that you, as a stakeholder that is part of implementation, have more influence than you accredit yourself with. Because we train the models and that knowledge needs to be transferred to those who will use the model. Thus, the person who trains the model can best judge how to make a model responsible. Therefore, it is important to listen to this person and learn to speak their language. —SME stakeholder A

The stakeholders then started singling out dilemmas related to how authorities such as governments and Big Tech exercise power over SMEs. At the same time, the governmental perspective is that SMEs lack the intellectual resources to even start working with AI.

SMEs are not ready for AI. I see them trying to innovate and digitalise. They know they need to do it, but they don't. We hope we can stimulate them with a business case.—Government stakeholder A

The SMEs countered this by saying the government needs to be a few steps ahead and prevent irresponsible action by SMEs by creating a quality mark. They then started referring back to the topic of influence, generally concluding that there is a lack of intellectual resources and moral authority, which leads to irresponsible action. Others mention that they do have enough knowledge but do not feel they have the means to act upon it.

For me, the problem is that the government, Europe, can stimulate responsible AI, but if BigTech never or hardly comply with that, we as SMEs do not have an advantage within the market.—SME stakeholder B.

After analysing the transcribed dialogue, we can say that it was predominantly about the power relations behind AI systems.

Materiality

We observed that the PBO materialised power relations in an accessible way. This was especially noticeable through feedback we received about the materiality of the object. Many participants expressed their satisfaction with the aesthetic of the laser-cut wood, colourful pawns and 3D-printed weights. They were especially engaged and satisfied with the act of attaching the weight to the pawn through a soft 'click' sound and feel of the magnets. We also received feedback on possible changes, i.e. some participants wanted the PBO to reveal more informative feedback on how the movements on the board are related to the position of the puppet, the impact on the planet, or the colour of the strings. One participant suggested adding an extra feedback layer by adding LED lights in the planet layer that would convey information about the ecological impact of AI.



Figure 9: Stakeholders listening and talking about the position of the board and what it tells them.



Figure 10: Government stakeholder talking about his view on the board.

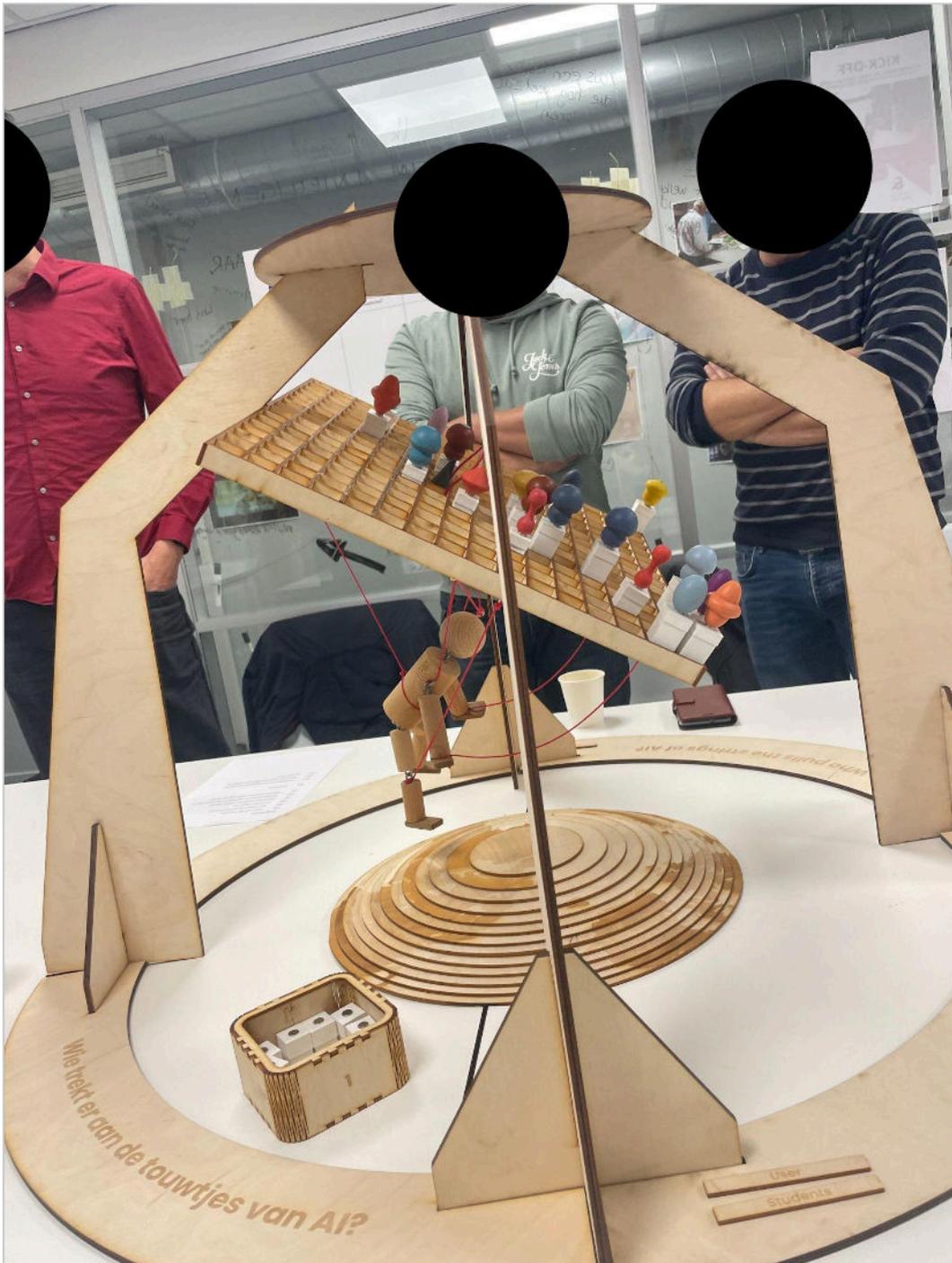


Figure 11: End position of the board after dialogue.

Discussion

The overarching goal of the research presented in this paper is to move from a technological narrative towards a power narrative by using a PBO. Based on this preliminary experiment, the PBO seems to invite the topic of power into the multi-stakeholder dialogue about responsible AI. Changing the content of the dialogue does not mean that the narrative has also changed. More research will be needed to study how interaction with the PBO can affect narratives on AI in the long run.

Thematic analysis

Our analysis of the data from the explorative experiment was focused on a thematic analysis based on a broad definition of power as described in the Method section. Another possibility would be to perform a thematic analysis based on different or systematic definitions of power. For example, we could label the transcription based on a more detailed Merriam-Webster dictionary definition of power (*Merriam-Webster.com*, 2023). We would then check the text on the following sub-themes of power: ability to act or produce an effect, possession of control, authority, influence over others, physical might, mental or moral efficacy, political control or influence and hierarchy. This would allow us to analyse future sessions in a more granular way. Thus, we could find out what level or part of power is most alive and predominant within the contributing stakeholder groups. This would be valuable if we want to compare power narratives between different multi-stakeholder groups and cultures.

Culture

The preliminary experiment was performed in the context of a Western European culture in which most of the participants were white and had a Dutch nationality. We are aware of the fact that in this culture, people are more willing to talk about power relations than in other cultures (Basabe & Ros, 2005). This is a challenge if we want to compare how the PBO works within different cultures or online.

Physical and virtual

Our physical boundary object is limited by its case-by-case physical facilitation mode. In order to perform experiments with the boundary object on a broader societal scale, an online model would be an effective option to scale up and gather larger amounts of data. That being said, another valuable research direction would be to create and experiment with an online version of the PBO. With an online version, we can compare the interaction and the dialogue with the PBO with the physical version. In doing so, we could also focus on research on the physicality of a boundary object and how the physicality adds value to inviting dialogue on intangible constructs such as power.

Ecology

In the partner meeting we did not find any mentions of the impact of current AI systems on the planet. This was to be expected as the design of the PBO was not intended to invite the topic of ecology into the dialogue. We can say that the PBO is predominantly oriented toward the socio-technical aspect of AI. More experiments with the PBO as it is now, are needed to confirm this. As described earlier, a more holistic view is the socio-ecological-technical view. If, in the future, we want to address the full complexity and systemic implications of AI systems, we need to adopt this holistic view. An interesting direction for future work would be to include the planet, the more-than-human, as a stakeholder in the PBO design. We would need to make the more-than-human as a stakeholder physical and visible in a similar way as the human stakeholder.

Even though the more-than-human is represented in the design as the planet (see Figure 2), it is a passive component of the PBO and, therefore, does not invite the participants to interact with it. For future design iterations of the PBO we can invite interaction in the planet layer by assigning pawn colours to the more-than-human stakeholder and by adding a feedback layer that translates any movement in the power system layer to possible ecological impact.

Design considerations

The current design corresponds to the list of design principles by adding elements of balance, weight, amount and diversity of pawns. The design still has some limitations when we look at the shape of the board. The square shape limits an open interpretation of the hierarchy of power relations. For example, the shape enforces the idea that there can only be one stakeholder with the most influence per category. On top of that, we introduced this PBO to engage in dialogue between industry, knowledge institutions, users and government. Other distributions of categories are thinkable, i.e. Western and Southern countries. A future design iteration of the PBO could answer the question: What shape can invite a variety of viewpoints about hierarchy within a power system?

Material considerations

Some participants wished to see more complexity revealed in the model. At the same time, we noticed how the current materialisation of the PBO allowed participants to embrace complexity through the simplicity of the model. Here, we find a link with the *ambiguity* principle: not everything needs to be or can be defined in a model.

Conclusion

This research has discussed how we derive design principles from the entanglement theories of Barad and Bridle and how they can be applied to design a PBO which can invite dialogue between multiple stakeholders about the invisible and intangible power relations behind AI systems. Within these entanglement theories, new materialist thought has provided foundational knowledge to develop four design principles for the conception and prototyping of a physical boundary object. Observations of the use of the PBO and a thematic analysis of the dialogue gave insight into the influence of the PBO to invite dialogue about power relations behind AI systems within the context of a preliminary experiment. An important result was that this dialogue was predominantly about social power relations. Thus, within the researched context, we can say that the PBO was effective in inviting dialogue on power relations behind AI systems. However, several variables such as culture, method of thematic analysis, physicality and design

need to be considered to gain knowledge about why, when and how a PBO can invite dialogue about power relations behind AI in a broader context.

Finally, the knowledge generated from this design research is useful for future design iterations of the PBO 'Who pulls the strings of AI?' and also for other attempts to design a PBO geared to make multi-stakeholder dialogues more systemic. Also, future research can be done to find out how new materialist thought can provide more insight into design principles that can be used to design objects that make intangible aspects of AI tangible. In doing so, future iterations of this PBO and the related design principles can generate new knowledge on how the research-through-design practice can have an impact in shaping the way we deal with the complexity of the systemic societal and ecological underpinnings and repercussions of AI and other systems. The research shows us how complex interrelationships between people, power and the system can be represented in a design for a physical boundary object. As a result, the physical boundary object can become a dominant part of a multi-stakeholder dialogue, and this can be a start towards inviting a power narrative about AI on a societal level.

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