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Article

On The Social Complexity of Neurotechnology: Designing A Futures Workshop for The Exploration Of More Just Alternative Futures

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Abstract

Novel technologies like artificial intelligence or neurotechnology are expected to have social implications in the future. As they are in the early stages of development, it is challenging to identify potential negative impacts that they might have on society. Typically, assessing these effects relies on experts, and while this is essential, there is also a need for the active participation of the wider public, as they might also contribute relevant ideas that must be taken into consideration. This article introduces an educational futures workshop called Spark More Just Futures, designed to act as a tool for stimulating critical thinking from a social justice perspective based on the Capability Approach. To do so, we first explore the theoretical background of neurotechnology, social justice, and existing proposals that assess the social implications of technology and are based on the Capability Approach. Then, we present a general framework, tools, and the workshop structure. Finally, we present the results obtained from two slightly different versions (4 and 5) of the workshop. Such results led us to conclude that the designed workshop succeeded in its primary objective, as it enabled participants to discuss the social implications of neurotechnology, and it also widened the social perspective of an expert who participated. However, the workshop could be further improved.

Keywords

Neurotechnology, Social Implications, Capability Approach, Futures Workshop

Introduction

Technology is commonly seen as a path toward human development; however, its deployment might affect society in negative or harmful ways that are not always evident with early implementations. Thus, the proactive approach and anticipation of the social and ethical impacts that novel technologies could cause are highly relevant (Moor, 2005; Tõnurist & Hanson, 2020).

In recent years, non-desirable impacts generated by Information and Communication Technologies (ICTs), or Artificial Intelligence (AI) have been addressed with reactive responses that are ineffective and costly, both humanely and economically. An example of this occurred in the Netherlands in 2019, when the Dutch government revealed that they had been using an algorithm to spot fraud, related to child support benefits. The algorithm led to the false accusation of around 26,000 families, who were requested to pay back the allowances they received. Families were

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impoverished, and over 1,000 children were taken into foster homes. By May 25, 2022, the Dutch government publicly admitted that the algorithm had targeted people for things like "foreign-sounding" names (Amnesty International, 2021). Similar cases can be found in healthcare (Vyas et al., 2020), security (Najibi, 2020), and education (Tawfik et al., 2016), where people have been targeted or affected because of inherent characteristics like ethnicity or migrant status.

Scholars from the field of neurotechnologies and ethics have written about ethical, moral, and social dilemmas (Andorno & Ienca, 2017; Kögel et al., 2020; Wexler & Reiner, 2019). However, they have failed to address the bias that might result from only engaging experts in the deliberation of neurotechnological futures. In technological development, recommendations for assessing social impact and scenarios are primarily provided by experts working directly on the field, ethics, or regulation, among other related areas. While these experts can offer an informed opinion, their approach leaves out other possible futures that could be imagined by experts in non-related disciplines or non-experts who belong to the general public and whose understanding and shared visions about actions, preferable futures, fears, hopes, and experiences are of interest too (Kazansky & Milan, 2021; van der Duin, 2019). Moreover, it has been noted that, when addressing social implications, those who have been systematically affected by technology must be included (Costanza-Chock, 2020; Sloane, 2019).

The present paper starts by reviewing the theoretical background of neurotechnology, social justice, particularly the Capability Approach proposed initially by Amartya Sen, and proposals addressing the social implications of technology. Then, we review design approaches to include the general public in futures deliberation actively. Subsequently, we present the Spark More Just Futures workshop, a proposal to enable non-experts to explore alternative futures. Finally, we present and discuss the results of two slightly different versions of it. We conclude that the workshop succeeded at its main objective, and while it has limitations to be addressed, potentially it could be used to explore other emerging technologies.

Theoretical Background

Neurotechnology

Neurotechnology, referred to as the set of methods and tools that enable a direct connection between technical devices and the brain, is one of the emerging technologies in early stages projected to increase its presence in everyday life. In the last twenty years, we have seen a boom in the research and development of neurotechnological techniques, applications, and devices for therapy, diagnosis, or enhancing people's cognitive abilities. The scope of application is broad, their usage allows us to record brain activity, stimulate the brain directly, and create brain interfaces.

Like other emerging technologies in the past, some authors have suggested that neurotechnology development and its later adoption will impact society to the point of modifying our daily lives (Andorno & Ienca, 2017). While it can be said that developers design neurotechnology intending to improve people's lives, some applications might have unintended adverse effects. Two of the most discussed are the breach of the privacy of the mind and the possible exacerbation of current inequalities due to the disparity in access to it (Andorno & Ienca, 2017; Goering et al., 2021).

Also, organizations like Organization for Economic Cooperation and Development (OECD) have run working sessions to discuss the implications and issues that could arise with neurotechnology. In all cases, anticipating, preventing, and discussing unintended uses, impacts, and consequences seems important before deploying widely. From these sessions, they have generated a reference document on its responsible development (Garden et al., 2019; Garden &

Winickoff, 2018; Organization for Economic Co-operation and Development, 2021).

Social justice as an ethical framework to assess technology

The complex ethical implications of technology have been addressed broadly by ethicists who have discussed scenarios where technology could generate dilemmas including those associated with agency, privacy, and social injustice (Moor, 2005; Sloane, 2019; Zheng & Stahl, 2012).

While ethics can allow us to discuss the possible social implications of a novel technology, it remains challenging to turn those discussions into actions. Authors like Ben Wagner (2018) and Elettra Bietti (2020) have even raised their concerns about ethics-washing, a strategy companies use to shake any concern off and clean their public image without implementing changes in their processes. Mona Sloane (2019), on her part, proposes to focus instead on the social inequality derived from technology deployment. The central idea is that those who have been systematically affected by technology should be at the front and center of the discussion—including human agents and non-human entities. Similarly, Sasha Costanza-Chock (2020) calls for the inclusion of people in the margins when discussing novel technologies. The reasoning is that current development perpetuates the status quo; thus, it keeps further oppressing those who are already oppressed.

As will be further elaborated below, the present proposal approaches social justice through the partial account of social justice proposed by Martha Nussbaum in the format of a list of ten central capabilities (Nussbaum, 2003).

Capabilities approach; assessing the social implications of design and technology

"The capability approach is a broad normative framework for the evaluation and assessment of individual well-being and social arrangements, the design of policies, and proposals about social change in societies" (Robeyns, 2005). The capability approach (CA) was originally proposed in 1980 by the Economic Nobel Prize 1998 laureate, Amartya Sen, but it has been further developed by numerous scholars among whom philosopher Martha Nussbaum remains one of its leading proponents. The CA entails two claims: the freedom to achieve well-being is of primary moral importance, and that well-being should be understood in terms of people's capabilities and functionings (Robeyns, 2005).

Functionings is a concept of Aristotelian origin that entails "what renders a life fully human" (Nussbaum, 1997). At a basic level, functionings can be understood as activities and states that can be achieved by human beings, like marrying, educating, or traveling. On the other hand, capabilities are the real opportunity human beings have to achieve functionings, or what people "are able to do or to be" (Nussbaum, 1997, p. 285).

Martha Nussbaum's work on the CA, referred to as a partial account of social justice, is an effort towards constructing a normative conception of social justice that places dignity at the core (Nussbaum, 2003, p. 33). Nussbaum proposes a list of ten central capabilities, as shown in Table 1. In her view, the list compiles the minimum that, in an ideal world, a society aspiring to become fully just, must guarantee to all its citizens (Nussbaum, 2003). Also, by having these central capabilities, a person is able to develop advanced capabilities, including the freedom to do the necessary things for survival (Robeyns & Byskov, 2021).

Table 1: Nussbaum's Ten Central Capabilities with Brief Definitions

Capability	Definition
Life	Being able to live a life worth living, not die prematurely.
Bodily Health	Being able to enjoy and have full access to integral health
Bodily Integrity	Being able to move freely and safely
Sense, imagination, and thought. Emotions	Being able to use and cultivate and use their senses, imagination, and thinking
	Being able to have emotions like loving, suffering, or longing, among others, without fear
Practical reason	Being able to reflect on the planning of one's life
Affiliation	Being able to freely belong to social, political, or religious groups without being humiliated or discriminated
Other species	Being able to relate to other species and care about them
Play	Being able to laugh, play and enjoy recreational activities
Control over one's environment	Being able to participate in their political and social and hold property on an equal basis with others.

The CA has been applied to assess the social implications of technologies. Justine Johnstone (2007) proposed a framework to conduct a better design of technologies. Her central idea is that technology is a medium that can directly enhance or diminish capabilities through its usage or indirectly as a secondary effect of its existence. The evaluation examines how technology could affect: groups or individuals, capabilities, situations, contexts, and interventions (Johnstone, 2007).

Yingqin Zheng and Bernd Carsten Stahl (2012) proposed the idea of the Critical Capabilities Approach to assess emerging Information and Communication Technologies (ICTs). Their proposal is built on four principles that every technology must fulfill:

- Human-centered: technology is a means to an end, not the end itself.
- Human diversity: technology has no universal benefit, and it is necessary to recognize the world's diversity.
- Protect human agency: resist and avoid the reification of technology.
- Democratic discourse: democratic control over technology should be enabled (Zheng & Stahl, 2012).

Technology developments are evaluated by their fulfillment of all four principles. If one or more of the principles is unmet, that technology must be redesigned.

As mentioned before, Mona Sloane's (2019) proposal is centered on inequality, and it includes three aspects for the just design of algorithmic technologies:

- "The social" in data: Data is not objective, but the result of decision-making based on human understanding of the world. These decisions are not neutral; thus, social stratification and oppression might remain.
- Human agency in technology design: While algorithms are non-human agents, humans designate who designs it, how it is designed, and so on.
- Intersectional inequality: By putting the life experiences of those affected at the center, the systemic schemes of oppression are necessarily broken (Sloane, 2019).

In this article, we propose that one way of identifying those affected by the development of technologies is by focusing on non-users.

Non-users

It is important to conceptualize the idea of non-user, since this article originates in the design discipline, where only the people who will use the technology are typically considered. Also, current future portrayals of neurotechnology found in academic sources, pitches made by companies, and science fiction show how the technology will benefit or harm users at various levels. Leaving people who will not be users outside the scenarios, and their life experiences are overlooked.

Sebastian Greger (2011) points out that non-users are not homogeneous, as they have diverse reasons for abstaining from the use of technology. Moreover, opting out of technology might happen voluntarily or involuntarily; in either case, this is not necessarily a perpetual status.

Among the various classifications of non-users examined in Greger's work, the one proposed by Christine Satchell and Paul Dourish (2009) fits with the objectives of the present paper. In their classification, indirect use is considered another form of non-use. Categories and descriptions can be found in Table 2.

Table 2: Categories of Non-Use by Satchell and Dourish (2009)

Category	Definition
Lagging Adoption	People who have not yet adopted the technology and will not necessarily adopt it.
Active resistance	People with a reason to avoid a technology.
Disenchantment	People who used to be users but stopped after finding it does not improve their lives.
Disenfranchisement	People who do not consider the artifact fits with their life.
Displacement	People who might use the technology but do not have direct contact with it.
Disinterest	People who are not attracted to technology because its purpose differs from their needs.

Non-user experiences are as meaningful as user experiences because their lives might be equally impacted. To better understand the relevance of considering non-user experiences, let us analyze the social impact generated by cars in our daily life.

Drivers are the users whose mobility is improved. Drivers, in turn, can impact the mobility of passengers not directly using the technology (displacement non-user). Pedestrians (non-users) see their mobility diminished as they must use the footbridge or wait for traffic lights. Lastly, animals and nature are non-user impacted by technology, as car usage increases pollution, damaging the environment.

Assessing Future Technologies

The exploration of possible social implications of technology, and the wider inclusion of the public in these discussions, is relevant for various fields of knowledge and social sectors. As mentioned, in neurotechnology, this is a direct demand of the OECD. Within the field of design, several authors have also addressed the need for overcoming the over-representation of experts and under-representation of other social actors in the collaborative deliberation of futures, and they have accordingly suggested participative approaches (Candy, 2010; Candy & Kornet, 2019; Kuijer, 2020; Stilgoe & Badstuber, 2020).

Stuart Candy (2010) argued that many foresight strategies are based on numbers and statistics, making them inaccessible to most people in the world who have not been trained to read and

interpret them. Consequently, he proposed Experiential Futures to denote a practice based on the human experience that seeks to provoke more visceral responses in participants, and thus, enable a deeper engagement in thought and discussion about one or more futures. This practice has led other design researchers to argue for the need to develop more innovative participatory methods that might enable citizens to engage deeply in the collaborative deliberation of futures (e.g. Garduño García & Gaziulusoy, 2021).

A proposal for stimulating critical thinking towards possible social impacts of future technologies

Based on the theoretical background presented above, we schematized a framework to assess the social implications of future technologies, such as neurotechnology. The main idea of the framework is to serve as a basis for designing a futures workshop rooted in social justice. The objective is to create a space where non-experts are enabled to discuss how a novel technology might enhance or diminish, whether directly or indirectly, the capabilities of users and non-users in a future scenario.

Three main components form the framework: scenario, potential users, and potential non-users. Direct and indirect interactions link these components. We define direct interaction as the one that is mediated by a given technology, while an indirect one is related to how someone's capabilities might be affected because of the existence of a technology with which that person has no direct interaction. A critical remark is that the present proposal includes non-human entities in the non-user category. Figure 1 shows the diagram of the proposed framework.

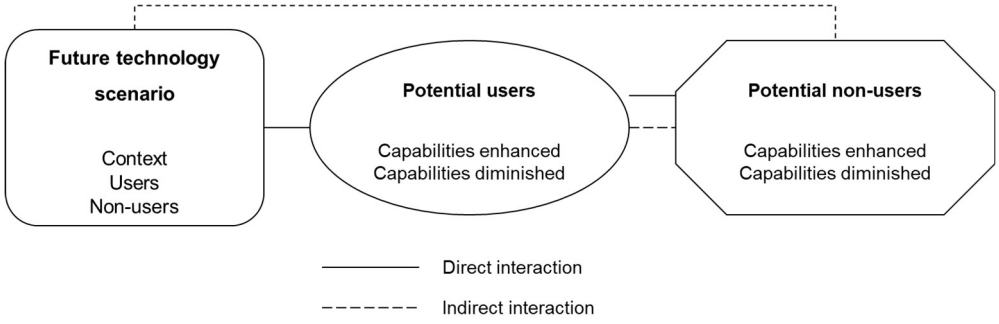

Fig. 1: Framework for Stimulating Critical Thinking Towards Possible Social Impacts of Future Technologies

As shown in Figure 2, we can diagram the previous example of non-users with the proposed framework.

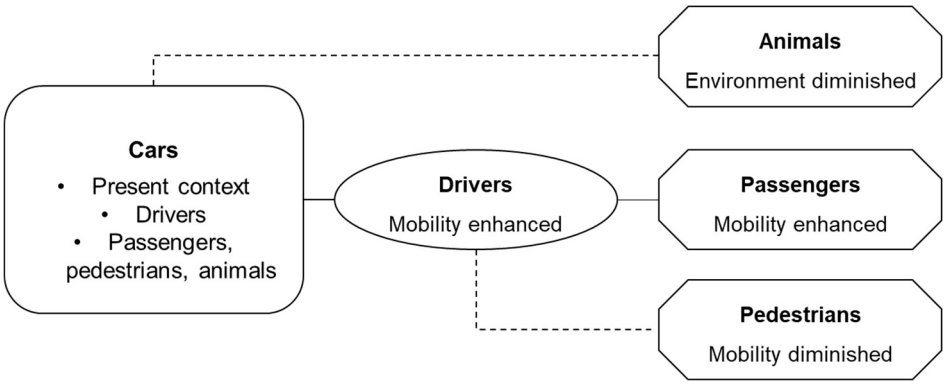

Fig. 2: Example of the Framework in Use

It is essential to mention that the assessment of capabilities in this framework is not meant to be an objective evaluation, but the representation of a person's perception based on their background, life story, and experiences. Its purpose is to stimulate critical thinking regarding possible social impact of technologies in future scenarios. Thus, we do not recommend using it as a tool to evaluate the social impact of technology.

Designing the Workshop Spark More Just Futures

Background and tools

Map of future portrayals of neurotechnology

Before designing the workshop, it was necessary to have an idea of current images of the future of neurotechnologies. Author 1 mapped future portrayals published between 2013 and 2021, which were found in academic articles, outlets of companies, and audiovisual media. The images were retrieved from diverse sources: *Scopus*, *CrunchBase*, companies' web pages, *Wayback Machine*, and *Internet Movie Database*. In total, 76 different portrayals were found and coded using OECD categorization of potential cases of uses categorization: Enhancement, Recreation, Diagnosis, Therapy, Research and learning, Law enforcement/Control, and Governance (Garden & Winickoff, 2018). The resulting Map is shown in Figure 3.

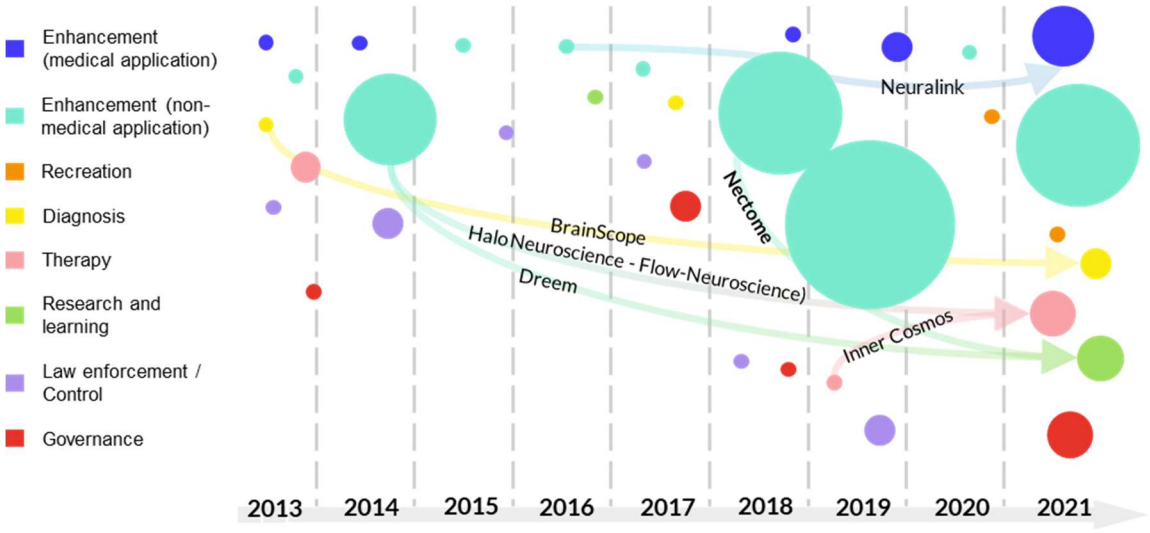

Fig. 3: Map of Future Portrayals of Neurotechnology

Notes to Fig. 3: Found portrayals during mapping are graphed using three dimensions, time in X axis, each color corresponding to one category of neurotechnology, and the size of the circles depends on the number of portrayals. The lines linking to circles are used to highlight companies that changed their pitch. Drawn by Author 1, 2022

Tool 1: Neurotechnologies Deck

Inspired by the postcard from the future created by Viraj Joshi (2021), we transformed this map into a deck of twelve cards, including only applications that fall under direct-to-consumer neurotechnology. Each card contains a brief description of how people will use the technology. Table 3 contains the information on such cards.

Table 3: Neurotechnologies Deck

Application	Description
Brain-Internet Interface	In the future, people will have a neural implant that enables direct connection to the internet.
Brain virtualization	In the future, people will digitalize their consciousness and live in a virtual world.
External thinking	In the future, people will connect their brains to an external computer to process complex information.
Brain recorder	In the future, people will store their experiences and memories externally to watch and share them as they like.
telepathy	In the future, people will have neural implants to communicate with each other through thoughts.
Augmented vision	In the future, people will acquire enhanced vision with Artificial Intelligence for identifying risk and unconsciously processing information.
Brain fingerprinting	In the future, people will use their brain's electrical signals as a password for everyday life to access devices, social networks, or the home.

Academical neurofeedback	In the future, students will acquire systems to improve their cognitive performance in school.
Hybrid intelligence	In the future, people will be able to couple their brains with artificial intelligence to augment their cognition.
Brain-to-Brain interface	In the future, people will be able to connect their brains and share thoughts, memories, and ideas or stimulate each other for entertainment or pleasure.
Abilities augmentation	In the future, people will augment their memory, cognitive, attention, and decision-making abilities on demand.
New senses	In the future, people will acquire new senses beyond physical possibilities (for example, magnetic or seismic sense).

Tool 2: Template for Capabilities Assessment

In addition to the deck, we also designed a tool to make thinking and assessing capabilities more accessible, as we expect non-experts in justice to participate in the workshop. The tool consists of a spider web chart, as shown in Figure 4, where each axis represents one of Nussbaum's ten central capabilities. Instead of the capability name, the chart presents the brief description given above in Table 1.

Participants need to place a mark for each capability and briefly describe the reasoning behind their assessment. As already mentioned, this tool should not be considered an objective evaluation of social justice but a tool to stimulate thinking.

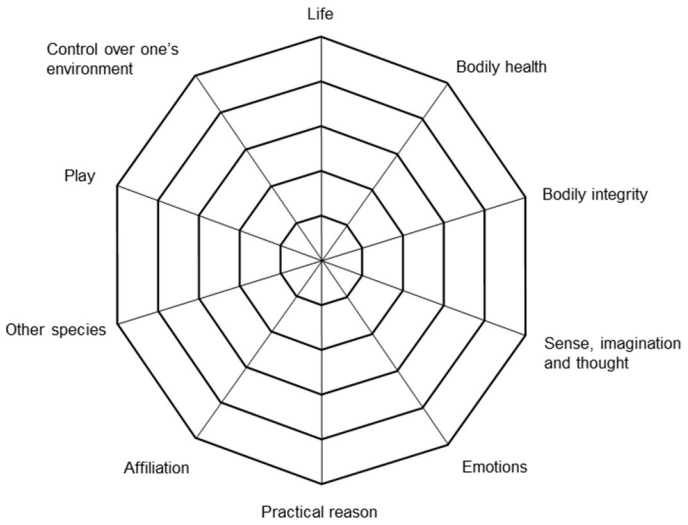

Fig. 4: Capabilities Assessment Tool

Notes to Fig. 4: The chart's center represents an inexistent capability, while the external axis represents a fulfilled capability. Variables in clockwise, starting on the top center: Life, Bodily Health, Bodily Integrity, Sense, imagination and thought, Emotions, Practical Reason, Affiliation, Other Species, Play, and Control Over One's Environment

Tool 3: Non-users deck

The last tool is the non-users deck which is used for role-playing. Cards only include the type of non-user they will have to enact. There are five possibilities: non-user, socially oppressed non-user, non-human entity, nature, and socially oppressed user. As can be seen, the latter does not fit into the non-user category, but it is introduced to open the conversation to that possibility as it might not arise naturally.

Workshop objective

The objective of the Spark More Just Futures workshop (SMJF) is to open the co-creation of alternative futures to the general public through the deliberation of more just futures by challenging the default ones. The workshop tools and facilitation aim at placing social justice at the center of these alternative futures. As the present proposal aims to stimulate critical reflection on the future social impact of emerging technologies, its application is more focused on education than on forecasting.

Our proposal is designed for the public who might not have previous experience or literature on future thinking; this means that neither participants nor facilitators are required to be experts on the topic.

Workshop structure

After several trials, the current workshop consists of six parts: (1) setting, (2) if nothing changes future, (3) capabilities assessment, (4) alternative futures, (5) narratives, and (6) final reflections. These parts are grouped into two sessions, the co-creation session, and the reflection session. Activities one to four take place during the former, the construction of narratives starts in between sessions but is finalized during the second session, along with final reflections.

Capabilities assessment and alternative futures sections can be repeated if the participants wish to, or if the time allocated allows it. Figure 5 shows a diagram of the whole structure, flow, and suggested time slots of the workshop.

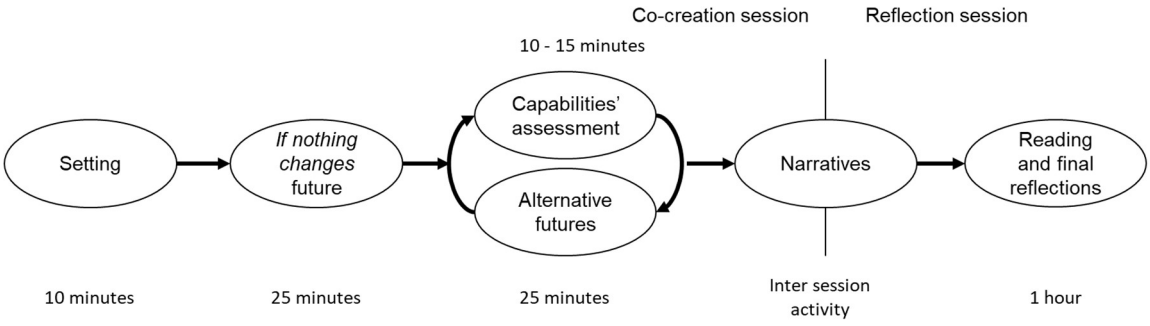

Fig. 5: SMJF Structure Diagram

1. Setting

Before starting, the facilitator welcomes the participants and introduces the SMJF. The introduction is an invitation to think and be open about emerging ideas. As the workshop might situate participants in uncomfortable situations when discussing social oppression, a set of rules is

introduced. These rules are highly based on authors previous experiences in design workshops.

- One idea per post-it: Keep it short, easy to read, and avoid complex or technical language.
- Do not criticize peers' ideas: It is allowed to build over the ideas of others, as long as you do not mark them with negative adjectives.
- Do not disclose your peers' ideas or arguments with outsiders: Participants might share personal thoughts during the workshop, so be respectful.
- No disagreement is enough: If the agreement seems impossible, it will be enough if nobody disagrees with an idea.

Finally, participants introduce themselves; however, they are asked to avoid disclosing their academic or professional background during the whole workshop.

2. If nothing changes future

This section aims to identify and articulate ideas of the default future that participants have consumed. First, the participants take two cards from the neurotechnologies deck, presented in Table 3, and read them aloud. The facilitator then asks the participants to imagine a future where those technologies exist, and we reach that future with current patterns of development. To accomplish the task, the participants are given a scenario board, as shown in Figure 6, with nine dimensions: technology, users, health system, economic system, government, equality, environment, family and relationships, and education and work. This approach is inspired by the revised frameworks context consideration and a method of Author 4, which emulates Robert Crumb's (1967) *City of the Future* scenario description.

Participant's ideas must be written in a Post-it and placed in one of the dimensions. All the participants are given the same Post-it color to track later changes. When the time for this part finishes, the facilitator reads the ideas on the board aloud.

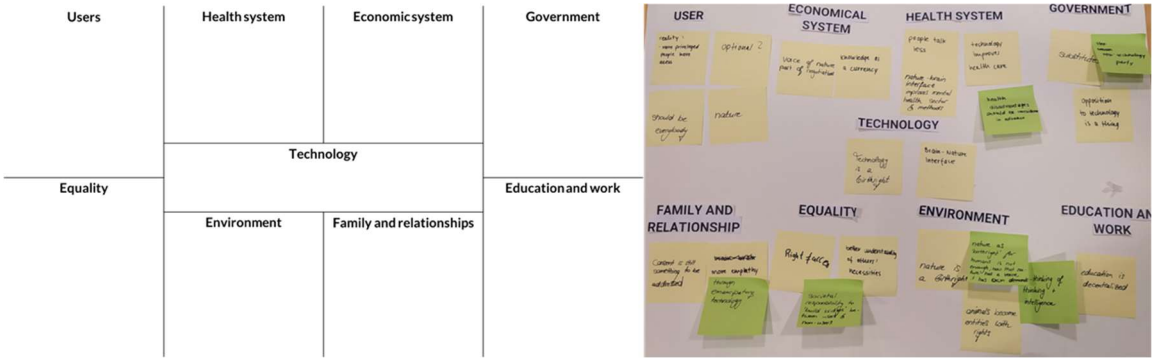

Fig. 6: Scenario Board Template and Example

Notes to Fig. 6: On the left side an example of the scenario template used during remote workshops. On the right an example of how participants were filling the board during version 4.

3. Capabilities assessment

In this part, the dynamic involves a role-playing activity where participants must assume the roles of users or non-users and contemplate their fictional lives within the future scenario previously

created.

First, participants must place themselves and describe a potential user individually. Then, using the tool *Template for Capabilities Assessment,* participants should reflect on the capabilities of that role that are impacted by the technologies. Finally, participants should write a brief reflection.

After evaluating potential users, participants are asked to randomly select a non-user card. Once the participants have their roles, they must repeat the process they did with users: describe non-user, assess capabilities, and do a brief reflection. When the assessments are done, the participants share their thoughts.

4. Alternative future

After assessing the capabilities, the facilitator asks the participants to rebuild the future based on what they found during their assessments. The objective is to deliberate about an alternative future where diminishments of capabilities do not occur, and if possible, achieve the opposite: the enhancement of everyone's capabilities.

Participants can change any dimension, including the technologies, as much as they like. Once again, each participant must write their ideas in a Post-it and place them on the scenario board. It is important to use a different color from the one used during the *if nothing changes future*. If necessary, the facilitator might write ideas that arise during the conversation but were not written.

5. Iteration of capabilities assessment and alternative futures

As mentioned, the capabilities assessment and alternative futures parts can be repeated as many times as time allocated allows it, or as participants like to. We recommend doing at least one more capabilities assessment after rebuilding the future scenario. It should be noted that with each iteration, roles should be rotated among the participants. If roles have been fully rotated, the facilitator can ask participants to select a new non-user card, and thus, create new roles.

6. Narratives

This part of the workshop aims to articulate ideas in a concrete narrative. Participants should individually draft a short story taking the last future they built as scenario, and this task must be done between the sessions.

The story must describe a day in the life of one user or non-user. If participants opt to talk about a user, the story must include a non-user. The minimum length required is half a page. Each story must be accompanied by a collage, as some participants might feel more comfortable with a visual expression than with a written text.

7. Reading and final reflections

At the beginning of the second session, every story is read aloud, and collages are presented. Those participants who are listening are given the task to find positive visions, negative visions, and ideas that they consider development paths.

The workshop ends with a wrap-up of the discussed ideas. The facilitator asks participants to share their thoughts, learnings, and ideas to improve it. To stimulate participation facilitator can present the results from co-creation session. Also, during these final reflections, the facilitator explains to the participants the theoretical background behind the workshop.

Different Versions of the workshop

In this paper, we report the results of the versions 4 and 5 of the workshop. Both had similar structures and materials, with minor changes between them. Table 4 collects the main differences between the versions.

Table 4: Differences Between Versions

Version four	**Version five**
Participants draw three neurotechnology cards.	Participants draw two neurotechnology cards.
The future scenario is described by:	
Technology	
Users	
Health system	
Government	
Education	
Family and personal relationships	Category Education becomes Education and work
Economic system	
Environment	
Equity	
Descriptions of users and non-users are free and not mandatory.	Users must describe users and non-user using a template that includes the following:
	Physical and social environment
	Objectives and motivations
	Life story

The first was held at the Finland Futures Research Center, University of Turku, Finland. The workshop had three participants, all first-year students of the master's program in Futures Studies. The second version was held entirely remotely with participants from Mexico City. Seven participants assisted, all of them Mexicans, with diverse backgrounds. One of the participants fit into the category of expert.

In both versions, the first session lasted about two hours and the second about one hour. Also, in both cases, participants were asked to answer a survey to collect their feedback about the workshop.

Results

Each version was analyzed through the deliverables generated, consisting of transcription of the deliberation, future scenario board, assessment charts, and short stories. The deliberations were automatically transcribed using the platform Dovetail and then reviewed and fixed by authors. Future scenario boards were digitalized. As default and alternative futures post-it colors differ, it was possible to identify the changes participants made. Both materials were analyzed together.

The deliberation analysis was based on the methodology for analyzing the knowledge creation dynamics in workshop discussions proposed by Mikko Dufva and Toni Ahlqvist (2015). The transcription and scenario boards were coded twice; first, to identify if the phrases conveyed a divergent or convergent idea, resulting in the graphs in Figures 7 and 8. The graph is made by adding one number with each divergent phrase and subtracting one with convergent ones as proposed in the methodology, where the X-axis shows the phrase number and the Y-axis, the divergence, the higher the line the higher divergence in the deliberation (Dufva & Ahlqvist, 2015).

The second coding objective was to classify and define the different types of interventions that participants made. The resulting classification is presented in Table 5.

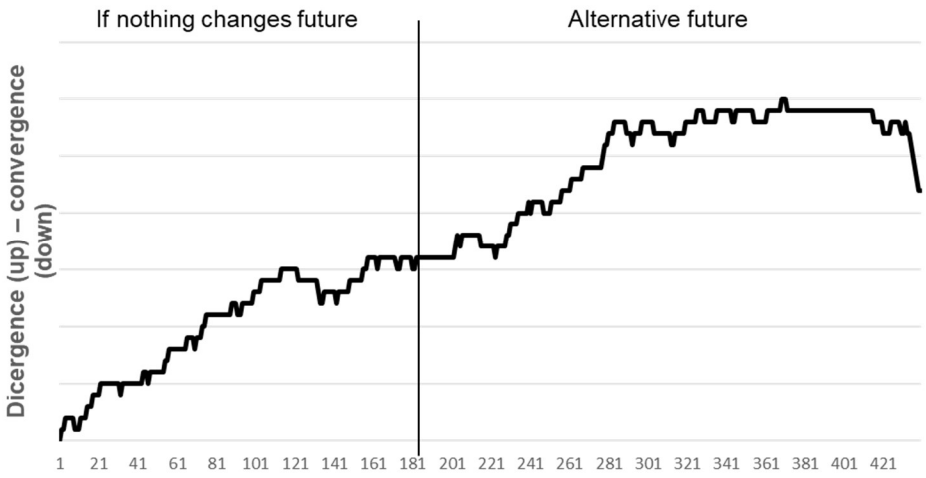

Fig. 7: Graph of Divergence/Convergence of Deliberation First Version

Notes to Fig. 7: Each point in the figure corresponds to one phrase said during the workshop. The line indicates the moment participants did the capabilities assessment.

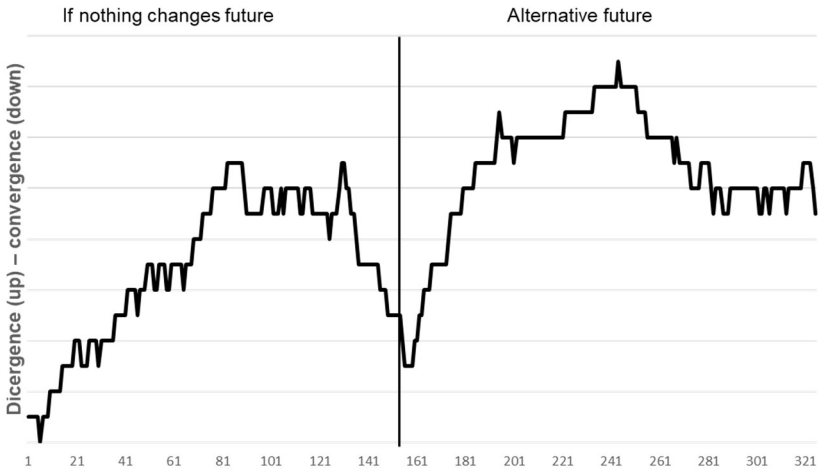

Fig. 8: Graph of Divergence/Convergence of Deliberation Second Version

Notes to Fig. 8: Each point in the figure corresponds to one phrase said during the workshop. The line indicates the moment participants did the capabilities assessment.

Table 5: Differences Between Versions

Type	Description
Critique of the present	The participants identify a situation in the present that is not preferable, which they project into the future.
Repurposing of default future images	The participants bring future images they know from other media to the discussion and repurpose them.
State one's position	The participants state if they see the implication from an optimistic or pessimistic perspective.
Defensive	The participants might open new topics to argue their position about a questionable topic.
After assessment idea	The participants introduced new ideas based on what they explored and experienced during the capabilities assessment.

The capabilities assessment templates were digitalized and converted into polygons, as shown in Figure 9. Polygons were overlapped to quickly compare the capabilities that changed after rebuilding the future scenario, so participants could reflect on it at the end. In total, 27 polygons were generated during both versions.

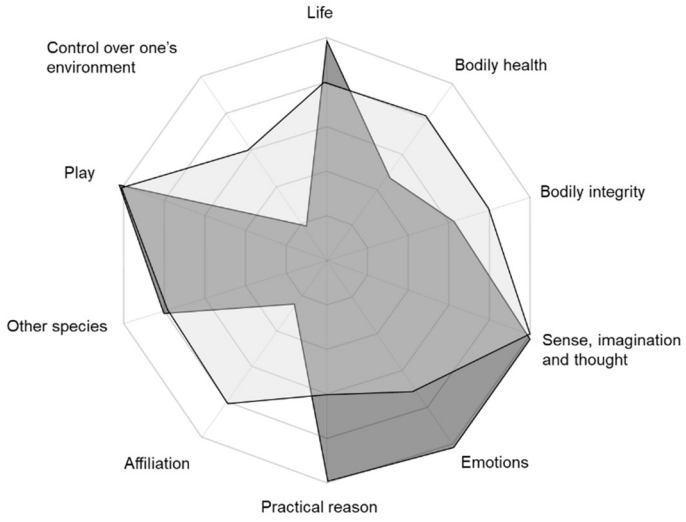

Fig. 9: Example of Capabilities' Polygons Overlapped

Notes to Fig. 9: The darker polygon at the back corresponds to the capabilities in the if nothing changes future. The one on top corresponds to the alternative future.

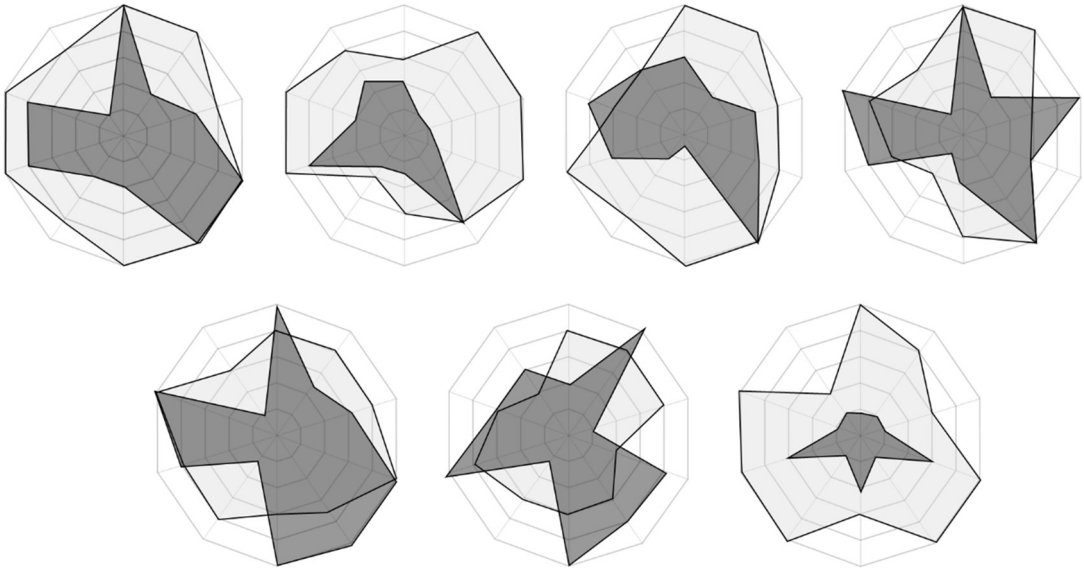

Fig. 10: Collection of Overlapped Polygons

Notes to Fig 10: Collection of polygons generated during version 5 of the workshop.

The short stories were coded using the same process used to code and map future portrayals presented above in Figure 3. From the stories, we extracted the application of neurotechnology portrayed and a summary. Table 6 contains the result. The positive visions, negative visions, and prosed actions found in second version of the workshop are contained in Table 7.

Table 6: Coding of Narratives Written by Participants

Version (Icon)	Narrative	Synopsis	Technology	OECD classification
1 (■)	1	In a world where equality of all living entities has been achieved, a human and an octopus travel around.	Brain implant to enable direct communication with animals	Non-medical enhancement
	2	An animal keeper in the Octopedia finds a connection with an octopus.	Brain implant to record animals' brain activity	Research
	3	A technological development led to the discovery of the shared consciousness that connects nature. Now humans aim at connecting with the shared consciousness.	Brain nature interface	Non-medical enhancement
2 (▼)	4	A farmer using a brain-internet interface is retrieving information involuntarily to solve an issue.	Brain implant to connect directly to the internet	Non-medical enhancement
	5	A mother who decided not to use a brain implant goes to an idea lab to learn about alternatives, so she is not disadvantaged.	General-purpose brain implant	Non-medical enhancement
	6	Dog breeding led to a disorder that limits their learning. A brain implant helps them enhance their cognitive abilities.	Brain-Brain interface	Medical enhancement
	7	A crafter worries about her work and heritage because of the expansion of new brain interfaces.	General purpose brain interface	Non-medical enhancement
	8	After reaching ecological doom, humans develop a neurotransmitter to communicate with the world.	Brain-nature interface	Non-medical enhancement
	9	An older man started using a brain implant, allowing him to connect remotely with his family.	Brain-brain interface	Non-medical enhancement

Table 7: Main Ideas Found by Participants in Narratives

Narrative	Positive visions	Negative visions	Proposed actions
4	Human nature connection Nature health as the primary objective Empathy	Concept of progress linked to technology adoption Technology as control Invasive technology	Neurotechnology enabled aggrotech to "feel" plants Internet of things
5	Possibility to expand her work internationally Agency to opt or not to technology	Extractivism and capitalism remain	Idea lab Telemedicine alternative
6	Empathy with animals	Unregulated genetic alteration Tech solves the issues tech created	Development focused on non-human entities
7	Technology does not substitute culture Handicraft remains	Gap between users and non-users	Space to get used and explore technology
8	Consciousness of habitat destruction Gaiacentrism instead of anthropocentrism Nature has a voice	Habitat destruction is inevitable	Brain-nature interface
9	Strong family empathy Communication and emotions, even in vegetative states Communication with nature	Overwhelming technology Social isolation by not being a user Technology does not replace the physical experience	Telemedicine

Discussion

Main findings

These two versions of the workshop showed that participants of the SMJF succeeded in creating alternative futures of neurotechnology. Even if all the participants have at least a bachelor's degree, only one fitted into the category of expert. None of the other participants work or have worked in neurotechnology or social justice. Thus, the workshop enabled them to discuss the future of a topic they do not typically read or discuss.

The divergences and convergence graph shows the importance of facilitation during the workshop. It can be noticed that both versions have a similar behavior of divergence. The main difference can be seen in the drop that takes place in the second version after building the future scenario and rebuilding it. Both drops occurred after including a wrap-up section to allow the participants to close most of the ideas or discussions. This helped participants to have a more concrete idea of the shared future.

Participants of both versions said that the first future scenario tended to be more pessimistic. There was a relevant conversation on how controlling the technologies were. Also, while medical applications were present, mainly because of the health system dimension, those were never the center of the conversation. Also, participants pointed out the differences that would arise if the technology had to be acquired by users, as not everyone would be able to do so. A last discussion in both versions was the role of different social actors in deploying technology. On the one hand, participants considered it beneficial if the government assumed the costs of making it accessible; on the other hand, participants also considered that it would lead to control systems, as technology would be centralized. In neither version was the case of private organizations considered a good idea, as it would enhance companies rather than the users.

Post-capabilities assessment futures, however, tended to be more focused on the possibilities of increasing agency with the technology and expanding its application from individuals to collectives. The introduction of non-human entities and nature stimulated similar ideas in both versions, and they started to think that technology could not only focus on human benefit. During both versions, the idea of a Brain-nature interface appeared. Of course, similar visions can be found in movies like *Solaris* (2002), and *Avatar* (2009). Nevertheless, the image does not appear naturally during the first scenario building. Participants wondered about open source as a solution, but overall, the agreement was that it needed to be regulated as it would lead to inequality. During the second workshop, the expert discussed the problem of how complex open-source systems are for those who are not trained. Thus, participants suggested that technology should be modifiable by anyone, but before deploying any change, it should be checked by the community and launched free for everyone.

After analyzing default futures and alternative futures created, four different scenarios could be described as shown in Figure 11.

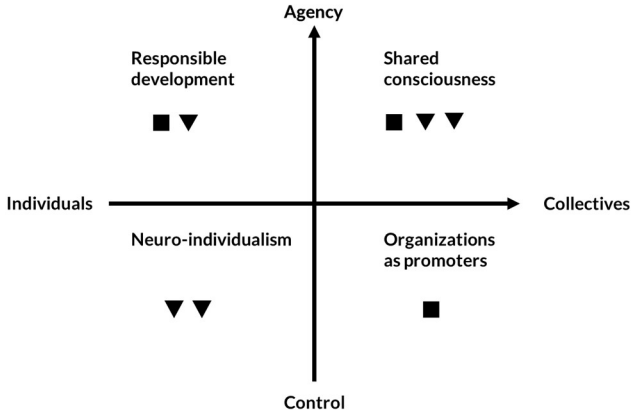

Fig. 11: Types of Visions Generated During Workshop.

Notes to Fig. 11: As indicated in Table 6, squares (■) correspond to narratives generated during version 4 and triangles (▼) to narratives of version 5

The descriptions of these categories are as follows:

- Neuro-individualism: Technology deployment has enhanced users' cognitive abilities allowing them to improve their performance in activities like studying or working. Because of that, the inequality gap between users and non-users has increased. Thus, opting out of technology is a delusion.
- Organizations as promoters: Organizations started implementing neurotechnology to enhance abilities, and possibilities with it. While people do not pay for the devices, those who decide not to use them are excluded. Then, technology is practically mandatory.
- Responsible development: As the usage of neurotechnology for cognitive enhancement started to increase, alternatives for non-users were developed. People can explore the technology before becoming users; if they decide not to, the system offers them choices. This way the technological gap is reduced.
- Shared consciousness: The connection between humans and other entities became stronger

with neurotechnologies that enhanced communication and empathy. Humans started to build closer relations with nature to improve everyone's life. Non-users have representation and alternatives to be part of this relationship.

Five different approaches were identified when discussing how participants reached these visions, as shown in Table 5. The most present one during the default future building was "critique to the present," as many of the interventions were exemplified by present situations. In the case of rebuilding the scenario "after assessment ideas" was the most common as expected. Also, "defensive" approach appeared more present as many participants put themselves into the position of defending their roles.

The capabilities assessment ended up being the tool that participants liked the most. All of them said it was easy to understand but required deep reflection. Some participants referred to a bad feeling after experiencing and evaluating people who are socially oppressed as they considered they created those conditions while building the future. One participant of the second workshop said it was impactful for him to notice that the shared future replicated current kinds of social oppression, as all the socially oppressed roles created were extrapolations of current situations but worsened. So, even if the tool was interesting and likable, this part of the workshop required intensive cognitive activity; thus, it was engaging. As one participant said, "(capabilities assessment) was an easy but valuable tool for "experiencing" this future, which left a strong impression on me."

Writing narratives was the most enjoyable part of the, as participants were free to put down all the ideas and concerns that kept floating around after the first session. Most of the narratives explored non-medical enhancement as these were the applications that more issues generated during the first session. A significant difference from the existing portrayals that were mapped in the initial design phase of the workshop, is that the narratives created by the participants expand communication abilities and look at sharing emotions, feelings, and ideas to increase empathy and understanding. They also included alternatives to the technology that erased any possible gap or inequality that resulted from not being a user.

Participants said the workshop helped them notice they were not considering certain groups in their future thinking. Socially oppressed groups are left outside their typical future imagination. This was one of the aspects that participants considered central learning, the necessity to think about others.

Another learning that participants identified was the easiness of thinking more systematically about the future. Many participants said it was the first time they had a chance to think this far into the future, and that it was not complicated, so it motivated them to continue doing it.

Finally, the expert expressed during his feedback that the workshop helped him see his area of work from different perspectives. He considered that many of the topics covered during the workshop were new as he is more concerned about the technical side without going deeper into the social impact. He stated that it would be a valuable tool for peers, entrepreneurs, and others working on technology and science as it puts you in a situation where you must consider the life of those without privilege.

Problems and limitations

While the workshop stimulated critical thinking, all the participants expressed that they were left with the sensation that the workshop finished abruptly. As the current structure does not include a section for backcasting or actions to change the future, participants were left with the sensation of not knowing what to do next. Also, all participants suggested reserving more time for the workshop as they felt there was a chance to explore more situations and scenarios.

The capabilities assessment was more challenging for some participants who were not used to role-playing. In this case, the facilitator helped the participants build their non-user.

One of the main differences between the first and second versions was how active the facilitator was. During the first version, facilitation was passive, and participants wandered around while building the scenario, which led to a loose shared understanding. Thus, the workshop results could be highly influenced by how the facilitator participates during the workshop.

Another limitation of the workshop is the closeness a participant might have with a certain future scenario. During previous versions, the idea of exploring a particular sci-fi series was tested, but all teams projected negative futures, following the dystopic vision of neurotechnology presented by the show. In the versions herein reported, even when participants were not required to watch or read about any scenario when somebody mentioned one, it became the focus of the conversation. Thus, it is essential to keep an eye on the appearance of preconceived stories as they can highly influence results.

Conclusions

In this paper, we presented the results of version 4 and 5 of the workshop Spark More Just Futures workshop, as a tool to explore alternative futures based on social justice. It is essential to mention that the proposed tool should be considered an objective evaluation of social justice rather than a tool to stimulate thinking.

In the workshop participants assessed capabilities with a tool designed to stimulate critical thinking. The tool was engaging for participants and helped them reflect on the possible impacts the future neurotechnologies could generate. The assessment was challenging, but it was the more impactful task.

On the other hand, writing narratives was the part participants liked the most, as it allowed them to land their ideas. After analyzing these narratives, we identified four types of visions. Differences were the technology approach towards users, individualistic or collective, and if technology-enabled control systems or increased agency.

The current version of the workshop has limitations, like addressing existing portrayals that might influence participants significantly. Also, participants felt the workshop ended abruptly and expected to explore more roles and alternatives.

Finally, we conclude that the inclusion of general public is relevant for the responsible development of neurotechnology. While more work is needed to improve the workshop, it could potentially be used to explore other emerging technologies.

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