Helping people think about the future:
Insights from cognitive science

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Abstract
Cognitive science has identified several models of mind and cognitive processes that underpin thinking and decision-making. Understanding and working with these processes will improve the efficacy of scanning, foresight, and vision-building. These cognitive devices include mental models (internalized system maps), mental simulations (for scenario development and testing), inference processes (that explore implications), and assumptions (that summarize and consolidate thinking). This paper describes the cognitive science behind these processes and suggests how we might use them in foresight. Integrating an understanding of cognitive processes in foresight practice will change foresight methods. It also has implications for ownership, trust, participation, and the impact of foresight on decision-making and public policy. The observations and hypotheses grow out of my experience conducting hundreds of foresight projects involving several thousand people in a public policy context. While many of these insights are likely familiar to most futurists, they are rarely explicitly acknowledged or fully utilized.

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Mental models and mental movies play a central role in thinking and foresight
In the late 1980s, I led a scenario project that changed how I conduct foresight. The project explored alternative futures for a major government institution. Through interviews and workshops, we involved key stakeholders and senior management every step of the study. Asked later about the study's impact, the client said: "That study was amazing, and we learned a lot. But, to our surprise, the president had another idea." It was then that I realized managers have sophisticated mental models of the systems they manage. If we surface and work directly with those mental models throughout the foresight process, then people will own and are more likely to use and trust the new insights in decision-making.

Cognitive psychology holds important lessons for the practice of foresight. The vast literature on mental models has major implications for the field that are not widely recognized.

> Mental models are personal, internal representations of external reality that people use to interact with the world around them. They are constructed by individuals based on their unique life experiences, perceptions, and understandings of the world. Mental models are used to reason and make decisions and can be the basis of individual behaviors. They provide the mechanism through which new information is filtered and stored. (Jones et al., 2011)

According to Jones et al. (2011), our mental models are based on our experience in the world, formal learning, beliefs, and values. They can be representational or conceptual. Each person has many mental models they draw on and combine as needed. Mental models are dynamic and can evolve through reasoning, experience, and openness to new inputs. They help us describe and understand systems and how they might behave. Groups and societies share collective mental models, such as images of the future that can guide decisions and actions.

Reporting on a number of experimental studies, Mumford and Standish (2020) note that people with complex mental models were better at creative problem-solving (p. 123). Surfacing and questioning mental models can improve them. The authors cite strong evidence that individuals' mental models account for differences in the quality, originality, and elegance of their proposed solutions. They also report that shared mental models in teams increase creativity, performance, and alignment.

Mental models can combine both verbal and visual elements. Rothman (2023) quotes from Temple Grandin's work (2006, 2022) on three types of thinkers:

1) verbal thinkers who solve problems by talking or writing, in a linear process
2) object visualizers (such as engineers and designers) who have photograph-like images and models in their heads and
3) people able to integrate both words and images, visuals, and abstraction

My experience with thousands of workshop participants is that most fall into the third category and work with both abstraction and visuals. However, the three different approaches help explain some of the challenges that can arise in collaborative processes. People lie along a spectrum of ability. Research shows that almost 4% lack the capacity for visual imagining, known as aphantasia (Dance, 2022).

Mental models inform our mental movies or mental simulations. In mental simulations, we run "movies" in our mind about how the world might unfold in the future (Gureckis, 2021). They can be thought of as the cognitive construction of hypothetical scenarios, including rehearsals of past and future events mixing in hypothetical elements (Escalas, 2004, p. 37). For some people, these movies are narratives in which people say the words and see the pictures in their minds, while for others they are more like visual movies. My hypothesis is the more familiar you are with the story – or with the system – the more likely you can visualize it. In the mental health, sports, and several other fields, there is considerable evidence and several theories that mental simulation does change decisions and behaviour (Hagger, 2020). Guided imaging is extraordinarily effective in helping individuals and groups surface, share, and develop their mental simulations to improve performance or reach objectives.

To summarize, every decision that we make involves an implicit or explicit mental model of the system, problem, or issue, how our decision will impact it, and the expected outcome. Many variables shape the process, including intentions, expectations, and emotions. As a need arises, relevant mental models move from long-term memory to working memory. In working memory, logical reasoning combines with values and emotions to process available information in mental simulations (scenarios) to propose and assess new hypotheses for consideration and ultimately decision or action.

One of the challenges of working with mental models and simulations is they may be misinformed or wrong because of inaccurate inputs, biases, or simplification.

The key point is that mental models and mental movies play a central role in every step of the policy development and decision-making process. People trust their own mental models before anyone else's. Surfacing and working directly with participants' mental models will increase ownership and trust because it is their model – they will use it for planning and decision-making. Good foresight processes should provide the scaffolding and processes to help people share mental models to understand a system and how it could evolve under different drivers. In this way, they build more sophisticated mental models and simulations as a solid foundation for analysis and decision-making.

My working hypotheses:

1) Mental models and mental simulations are key tools that humans use every day to understand a system, explore how it could evolve, identify alternatives, and make decisions.
2) Decision-makers develop sophisticated mental models of the systems they manage, and they utilize and trust their mental models, and update them when circumstances change.
3) One of the core objectives of strategic foresight is to help people surface their existing mental models and use them to develop more robust mental models and strategically useful mental simulations.
4) People are more likely to own and trust the foresight if their mental model has been engaged and evolved through the process.

Mental models are proto system maps

Cognition theorists state that mental models are models of cause-and-effect relationships among the elements in a system (Goldvarg & Johnson-Laird, 2001; Mumford & Standish, 2020). Mental models are models of systems that matter to the person based on their situation, education, roles, and experience.

Jones et al. (2011) and Doyle et al. (2022) describe a variety of direct and indirect methods to elicit mental models including interviews, surveys, concept mapping, and inviting participants to draw their mental models. Numerous studies demonstrate that ordinary people can describe their mental models. Van den Broek et al. (2023) describes how illiterate fisher people have detailed mental models of the drivers of the Nile perch stock fluctuation in Lake Victoria.

In hundreds of workshops, I have found that most people can draw a simple system map of their mental model of the system. It is useful to have them share their maps with others to build a collective system map. Storytelling around the collective map helps people see connections, impacts, and interdependencies that some participants may not have appreciated. A graphic representation of the system helps the group explore where and how change drivers could impact the system and then explore how those changes impact and transform the system in different scenarios.

In real life, systems are far more complex than the models that people draw in workshops. Important systems will have thousands, maybe millions of nodes. The trick is to generalize – to lose detail in a process cognitive psychologists call "chunking" in which small pieces of information are bound into a larger unit to overcome the limitations of short-term memory (APA, 2023). For instance, participants can use affinity mapping to identify related and interacting elements and put them in one node – in effect, creating a subsystem that the human imagination can expand when needed.

My working hypotheses:

1) With encouragement and an example, most people can draw system maps of their mental models.
2) In foresight studies and workshops, it is efficient to surface and work with these system maps rather than other less explicit approaches.
3) When foresight surfaces and builds on the mental models of participants and stakeholders, they are more likely to understand and support the foresight study results in policy development, strategic thinking, and decision-making.

Inference is the source of most insight in foresight

Drawing on neurobiology and cognitive science, Badcock et al. (2019) offer a unified theory of how the mind/brain works. They describe it as "a complex adaptive system that functions to minimize the entropy of our sensory and physical states via action-perception cycles generated by hierarchical neural dynamics." They propose that the mind is an inference engine. It produces a constant stream of inferences – hypotheses to be tested through reasoning and experience. We build increasingly complex mental models that evolve over time.

Inference is the source of most insight in foresight. Inferring is the process of using reasoning to move from evidence to conclusions. Etymologically, the word "infer" means to "carry forward" (Wikipedia, 2023). I have had workshop participants who seem to think foresight is largely creative thinking. For instance, when using a futures wheel, some people get stuck giving variations on first-order consequences and have trouble getting to second-, third-, and fourth-order consequences. I have found it helpful to explain the three types of inference that help us move into the future: deduction (moving from general premises, assumptions, or frameworks to specific implications); induction (moving from analysis of several instances to synthesis or broad conclusions); and abduction (drawing a probable conclusion from available information – often moving back and forth between deduction and induction several times). Talking about these thought processes gives people examples and confidence because they use them every day. Clear instructions provide the scaffolding to help them generate new hypotheses, assumptions, and insights.

Active inference plays a large role in most foresight tools. While scanning, induction helps us see new patterns in sense-making, and deduction helps identify implications. While developing scenarios, induction helps us distill distinct scenarios from disparate data, and deduction helps develop insightful but coherent scenario narratives. Both assist in identifying challenges and opportunities. I am always amazed at the wide range of speeds and depths at which people produce insights. Some people are fast; others can take a long time to surface mental models and infer insight from them. This diversity can be a challenge, especially in less experienced groups. Good facilitation and process design can help by clarifying the task and giving people time to think.

In most physical and social sciences, the "quality of the data" matters. Unfortunately, in foresight, there is no data for the future – all data is in the past. Extrapolation and simulation can work for stable systems. However, today many important systems are undergoing massive changes, so extrapolation, mathematical simulation, and statistical inference can be quite misleading. The evidence we use in inference can include facts, prior knowledge, perceptions, and assumptions. The validity of the conclusion that we infer depends on the truth of the inputs. One way to improve the reliability of inference is to be aware of the "ladder of influence" developed by Chris Argyris (1990). The ladder of influence consists of several steps: selecting facts, adding meaning, making assumptions, (building

mental models and) drawing conclusions, adopting beliefs, and acting. Critical thinking is necessary at every step to assess the quality and relevance of sources, cognitive biases, and soundness of the argument.

Foresight can be mentally demanding. Drawing on the "free energy principle," a model of mind in neuroscience, Badcock (2019, p. 1335) notes the mind attempts to reduce energy use and entropy. If humans notice a change in our environment, we consider prior knowledge and experience to assess the danger. If the change does not fit current models, then we may continue to question the inputs and develop new models and create a new hypothesis to guide action. The danger for rigorous foresight occurs if we decide to conserve energy and stop the cycle of hypothesis creation and testing.

Some people will note that imagination, creative thinking, and intuition are also important sources of new insight in foresight. We all have direct experience with this kind of unconscious cognition. For instance, we see a problem, and a solution pops into our head. Or we go to bed with a problem and wake up with a solution. Or the expert is asked a tough question and draws on well-developed mental models and states an answer instantly. Johnson-Laird (2008) found "Unconscious inferences underlie hunches, intuitions, gut reactions, guesses, and insights." It is not magic. In creative thinking, people are using inference and their knowledge and experience to make sense of external clues. Most foresight methods provide the conditions and prompts to support creative thinking. We can assist creativity by giving people time to think and permission to move outside the box. But there is an expectation that strategic foresight goes beyond creative thinking. It is more rigorous and systematic but open to insight from all sources.

My working hypotheses:

1) The conversation becomes more forward-looking and thus more insightful when participants understand the nature and uses of inference.
2) It gives decision-makers confidence when they can see the reasoning process – the pathway to an insight or conclusion.
3) Uncertainty, emergence, and discontinuity are part of the story – just be explicit where a leap of faith is required to enable readers to assess and follow the logic.
4) Humility is essential in foresight. It turns out that anyone can bring deep insight and breakthrough thinking because they see the problem from a different perspective or drawing on varied experience.

Assumptions are a powerful tool in foresight

According to the Cambridge Dictionary (2023), an assumption is "something you accepted as true without question or proof." As we have seen above, assumptions play a key role in inference and reasoning. They can be conscious or unconscious; implicit or explicit. They are one of the building blocks in mental models. One or more assumptions can synthesize and summarize a conversation or paper. Indeed, several assumptions can help people build a mental model and then test it against their own assumptions and experience to accept, debate, revise, or reject it. In a foresight study report, I usually put the current assumptions shaping public policy and planning on the issue at the beginning of the study. The current assumptions can be found buried in policy documents, legislation, and the ongoing policy dialogue. We test those assumptions for robustness during the study and then put the revised, more robust planning assumptions at the end of the study. It is a very efficient way to communicate findings.

Changing an assumption can fundamentally shift perception of a problem or solution. Quoting Bak and Chen, Badcock (2019, p. 1328) notes the mind has capacity for self-organizing criticality. It is a dynamic state between highly ordered and chaotic states "that optimizes evolvability, because it allows small, extrinsic changes to elicit large, intrinsic reorganizations. It explains the emergence of adaptive behaviors." Surfacing and testing assumptions can be an extraordinarily powerful tool in reframing and reorganizing in foresight.

When working with executive committees, I often ask them to share their current assumptions about the future of their organization as a first step in a foresight process. These assumptions are a clear statement of their expected future – the one they are planning for. Then I ask them to identify some of the disruptive changes they see, and then we review and revise the original assumptions. Exploring underlying assumptions can open a rich and strategic dialogue.

Surfacing assumptions can be challenging, partly because hundreds of assumptions may shape an issue, depending on your mental model and experience with the system. At first, I was surprised at how many assumptions were offered when I asked for them in workshops. Then I realized these assumptions were doors to the experience and mental models of stakeholders around the table. It helped reduce the complexity if I asked participants to sort their assumptions into layers like Inayahtullah's (2004) iceberg. In the public policy dialogue, layers like issues, processes and systems, values, ideologies, and worldviews helped. Examining conflicting assumptions can surface issues needing attention. It is hard work but distilling the assumptions down to the core assumptions can lead to deep insight.

My working hypotheses:

1) Surfacing current assumptions is an efficient way to describe a group's expected future – the one they are planning for.
2) It takes effort, but there is significant value in surfacing and reviewing the assumptions of all the stakeholders in a foresight process.
3) Sorting assumptions into layers (of the iceberg) can reduce complexity and help get to the most fundamental assumptions that are consciously or unconsciously shaping the group's thinking and planning.
4) Assumptions that trigger system criticality and force a reframing of mental models are worth exploring.
5) Summarizing the current assumptions at the beginning of a study – and then testing and revising them at the end of the study to create a set of planning assumptions that are robust across all scenarios – is a great way to communicate the findings of a study. This process helps readers efficiently build and test their own mental models of that system and its futures.

Summary: How cognitive processes can assist in foresight

These cognitive processes are a central element in most foresight exercises but are often not fully appreciated. They can assist in a foresight study or workshop in the following ways:

1. Surfacing the assumptions buried in recent planning documents and conversations is a useful snapshot of the expected future – the future that people and the organization are planning for.
2. At the beginning of a foresight study, participants are using their prior knowledge and experience, as well as intentions, analogies, and biases to develop a mental model of that system. It is useful to

make their mental models explicit rather than leaving them implicit and unexamined. There is considerable research evidence that most people can draw simple system maps of their mental models.

3. Using the individual system maps to develop a collective system map provides an external memory aid for the group that can help facilitate dialogue, clarify different interests, correct misinformation, and make the whole exercise more strategic.
4. In practice, participants are consciously or unconsciously surfacing their mental models of the system when scanning, identifying change drivers and weak signals, and exploring their impact on the system. The clearer the mental models, the more likely they are to produce strategically useful insights.
5. In some scenario methods, we are using deductive inference (e.g., 2x2 matrix, thematic, or contrast scenarios) to deduce potential scenarios and impacts. In other scenario methods (e.g., the Oxford method), we are using inductive inference to surface new patterns or emergent phenomena to identify potential scenarios. Understanding the underlying inference process helps participants contribute more effectively.
6. The more we work with or experience a system, the more likely we are to be able to visualize it and run mental movies. Then, guided imaging becomes very effective in scenario development and wind-tunnelling.
7. Each new scenario or vision is a new mental model that benefits from sharing, dialogue, questioning, and testing.
8. Summarizing study findings as a set of assumptions can help readers quickly and efficiently build a new mental model as well as test the robustness and clarify their current mental model.

Conclusion

Explicitly integrating an understanding of these cognitive processes can make foresight more effective in the following ways:

- Increases productive capacity of participants: Making participants aware of these cognitive processes seems to help most people understand how to be more productive.
- Increases confidence of participants: When participants understand that deductive and inductive inference are key tools to create new insight in foresight, they seem to feel the veil has been lifted. Foresight is not just creative thinking. It uses intention, scanning, knowledge of the system and the inference processes embedded in a variety of foresight tools to create new mental models (e.g., scenarios, visions, strategies, solutions, etc.) that are the inputs for reasoning and decision-making.
- Helps participants become more strategic thinkers: While we cannot predict the future, as people's mental models of the current system, potential scenarios and credible visions become clearer, it helps them infer more strategically useful implications, insights, and strategies.
- Helps the facilitator understand what they are doing: Facilitators design processes to help people organize their thinking and structure the dialogue. Being clear about the internal cognitive processes that participants actually use can improve process design and outcomes.
- Values diversity: It is helpful to have stakeholders with a variety of experience of the system in the workshops and on the team. Each may bring knowledge of a different part of the system and related systems. The challenge can come when participants cannot or will not build bridges between their mental models and the experience of others. It is helpful to recruit people who are curious and open-minded and have good group skills.

- Assists with decolonization: Demystifying the thought processes of foresight, and surfacing, sharing and co-creating a range of alternative futures, can be a modest first step toward building a more equitable, just, and sustainable world.
- Helps build ownership and trust: When stakeholders and decision-makers see their mental models evolve through the foresight process, they are more likely to trust and own the conclusions and have greater commitment to implement them.
- Enables more rigorous and systematic foresight: One of the most important but unstated objectives of foresight is to help people surface and examine their existing mental models and use foresight processes to develop more robust mental models and mental simulations to improve decision-making.

Biography: Peter Padbury is one of Canada's most experienced futurists. Over his career, he led hundreds of foresight projects that developed vision, policy, and strategy with federal government departments, NGOs, businesses, and UN agencies on a wide range of themes – from the future of primary health care in Asia to the future of the UN Security Council. Between 2008 and 2021, he played a leadership role in building a foresight centre in the Canadian federal government, Policy Horizons Canada, that has become one of the world's leading government foresight centres. He has undertaken extended work assignments in Costa Rica, Brazil, Indonesia, Thailand, the Netherlands, New York and Geneva and work-related travel in more than 50 countries. After retiring in 2021 as Chief Futurist with Policy Horizons Canada, he set up a "boutique" foresight centre to assist governments and NGOs with capacity-building, advice, mentoring, and evaluation as well as foresight and vision-building for transformative change. Peter has an MSc in Future Studies from the University of Houston with a focus on participatory foresight methods. He is a founding member of the Association of Professional Futurists and has served on the board of directors of several organizations. He has developed two foresight methods that integrate the findings outlined in this paper: the Horizons Foresight Method (can be found at https://horizons.gc.ca/en/resources/) and the more recent Systematic Imagining Method (can be found at foresightlab.net).

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