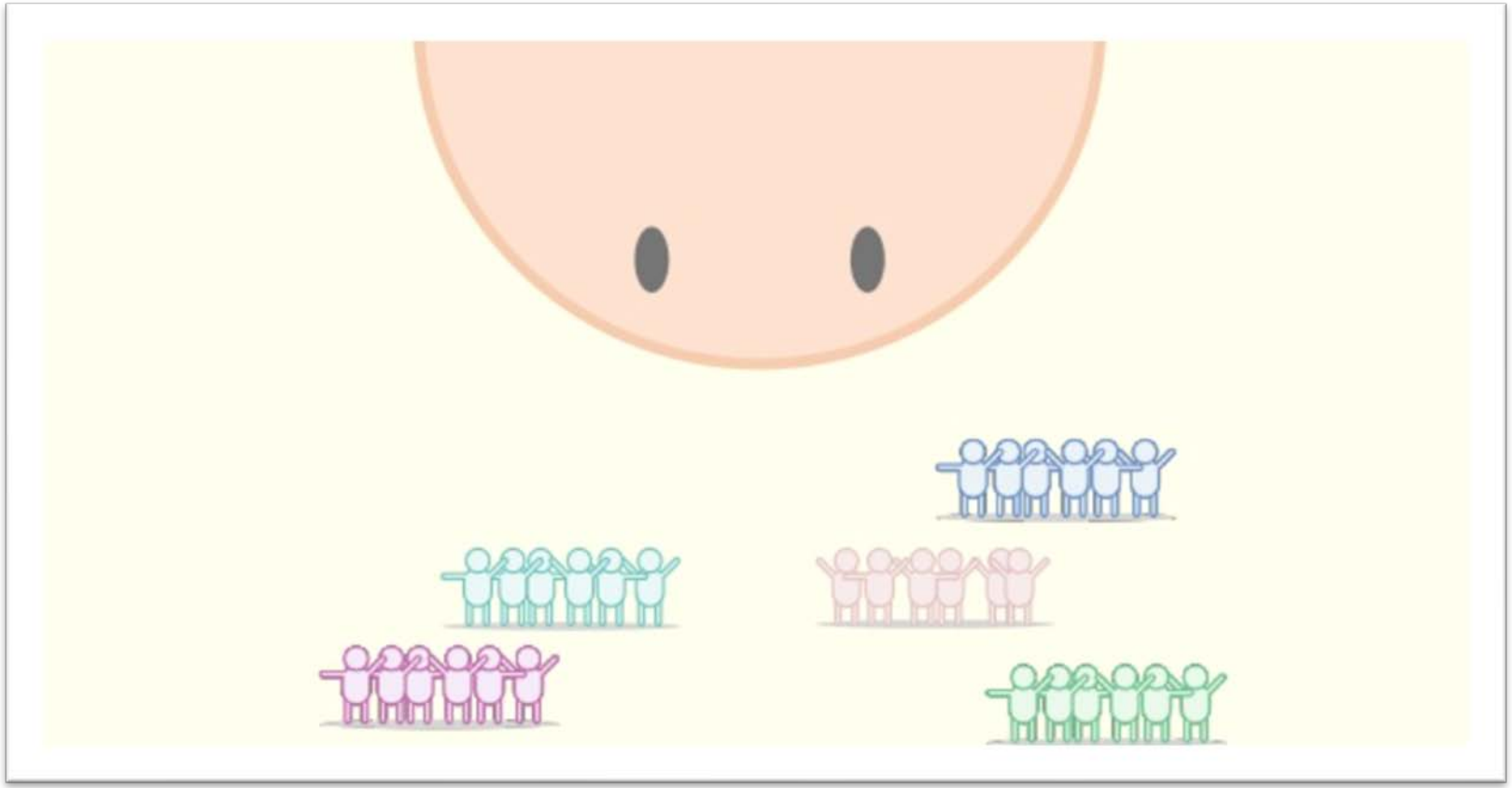
Imagination and Creativity

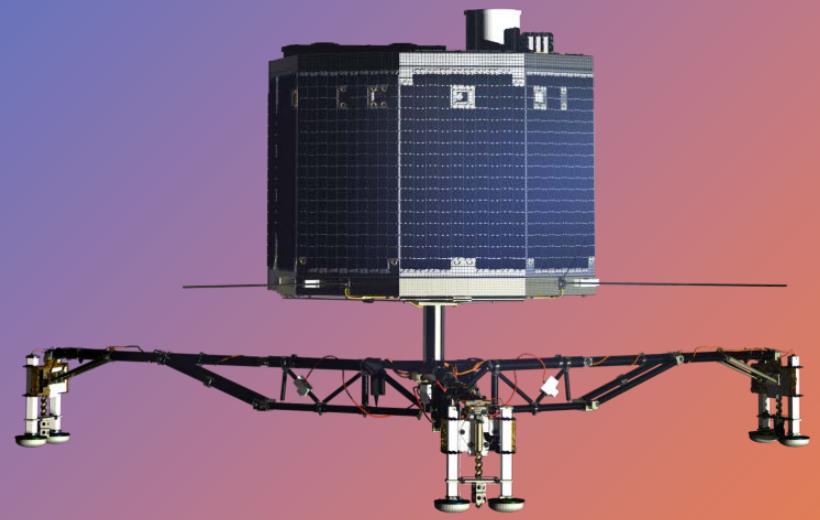
mike.stuart@york.ac.uk

michaeltstuart.com



Ethnography of scientific imagination

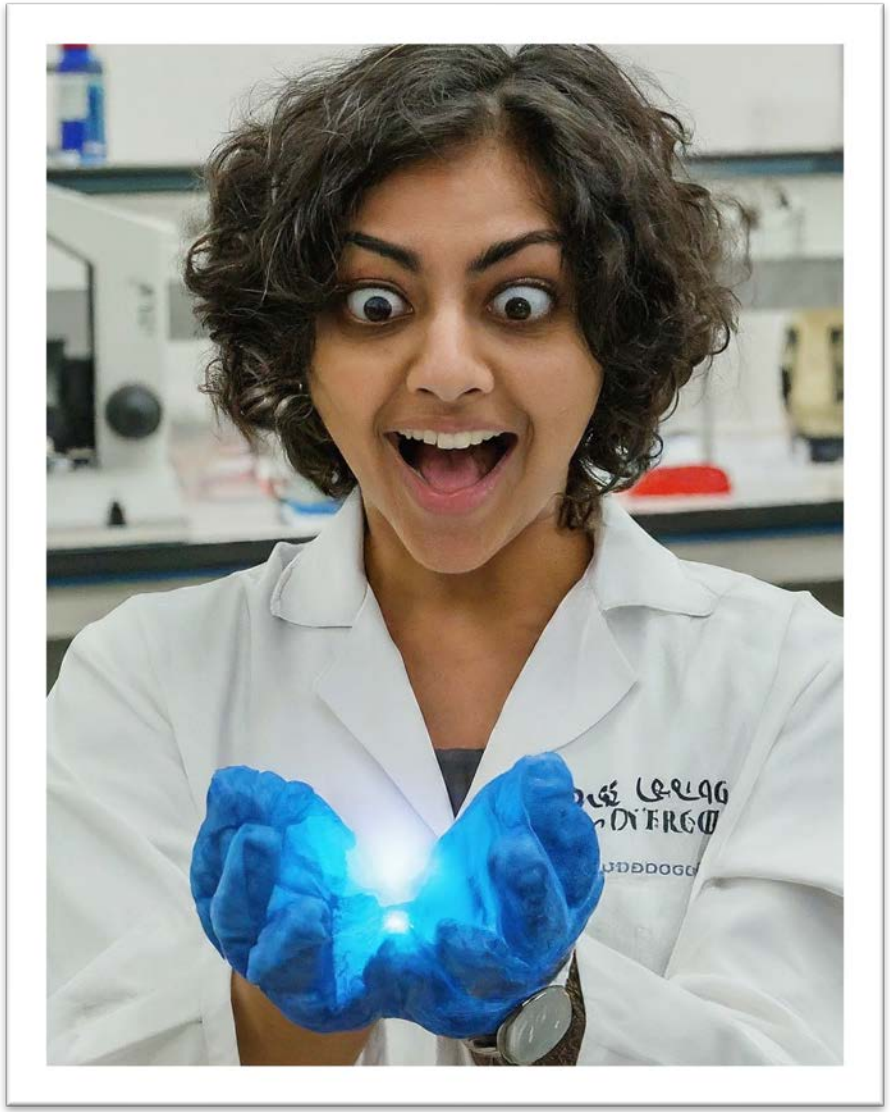
Time image acquired (GMT): 14:38:53
Range (km): 3.1
Field of view (km): 3.4
Resolution (m/pixel): 3.3



Philea lander

"This revealed a suite of 16 organic compounds comprising…water vapour, carbon monoxide and carbon dioxide, along with smaller amounts of carbon-bearing organic compounds, including formaldehyde…some of these compounds detected by Ptolemy and COSAC play a key role in the prebiotic synthesis of amino acids" (ESA)

- It worked so well that now this method is called "sniffing mode," and it has been included on several new missions, and will continue to be used

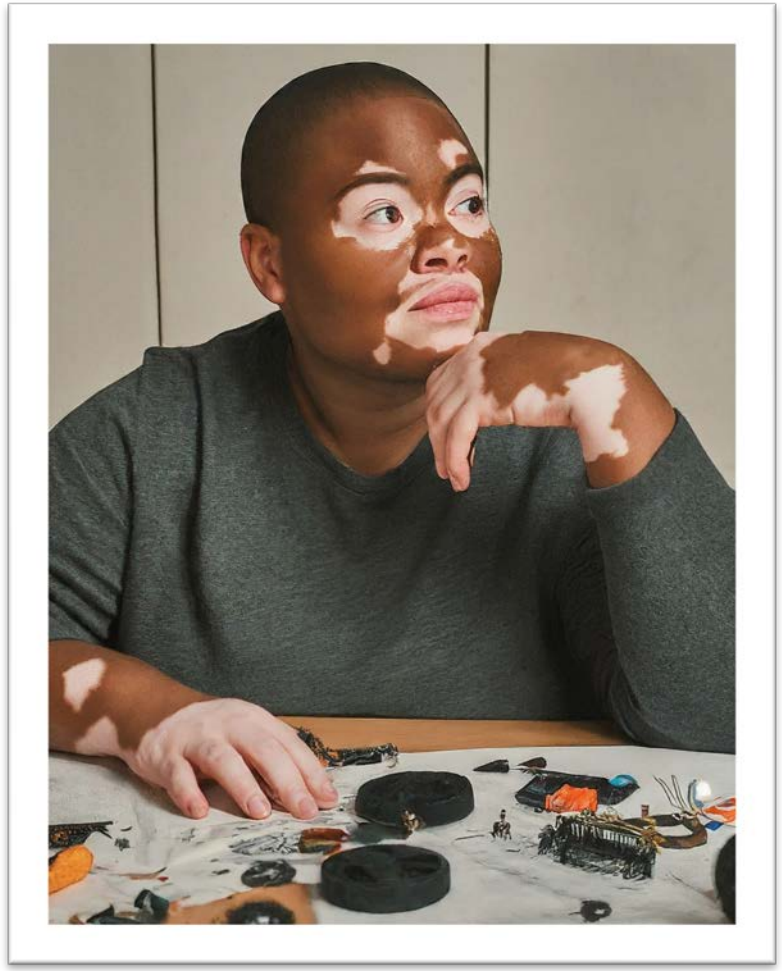


Some quotations

"I cannot think of a scientific field where you could work without imagination" (PI, climate science)

"Imagination is hugely important. There is this absolute requirement to be imaginative" (PhD student, space science)

"Imagination's extremely important to me…[through imagination] you don't just develop new techniques, you also frequently more directly look at whatever it is you're looking at" (PI, computational systems biology)



Some quotations

“The only moment in which you do not have to imagine is when you have to assemble something with instructions, and even then…”

“Any time you have to make some kind of measurement you should have a lot of imagination, since imagination creates the environment for the measurement…Also, when you have your data, and you have to understand your data, or extract from your data something that has not been seen before, you need imagination” (PI, CERN)

“I mean, we’re scientists right? So you gotta be imaginative. There’s imagination in how we present things, which I kind of lack. There’s imagination in finding a solution to a problem. Yeah, definitely. Imagination is important. Because at some point you’re just solving problems all the way to a finish line. You really need to be a little imaginative, in terms of how you solve them. I mean, that’s why we do what we do”

But,

"**I haven't made a process out of it yet, and I should**. Because as a scientist **you should have a process** for thinking. But I mean, I guess I kind of have a process. Like I like **sitting in cafes**, looking at people. I like that movement and the hustle and bustle. It **triggers my creative instinct**. [Or] if I'm writing code, I don't need people around. I probably **just isolate myself**, come into my cubicle…There's this other phase when you want to…**hash it out with your lab mates**, that's actually a very important part of the creative process" (postdoc, systems biology)

Plan

1. The **function** of imagination in science
2. The **distribution** of imagination in science
3. What counts as a **good** imagining?
4. Sharpening the **tools** of the imagination
5. Other ideas

The **function** of imagination in science

- Not for fantasizing and daydreaming
- Imagination is for solving problems
- When asked, scientists say imagination is used to solve **big problems** (e.g., understand dark matter, find a cure for cancer, address the climate crisis)
- In practice, scientists ***do*** use imagination to solve problems, but not ***those*** problems

Stuart, M. T. 2019. "Everyday Scientific Imagination: A Qualitative Study of the Uses, Norms, and Pedagogy of Imagination in Science." *Science & Education* 28(6), 711-730.

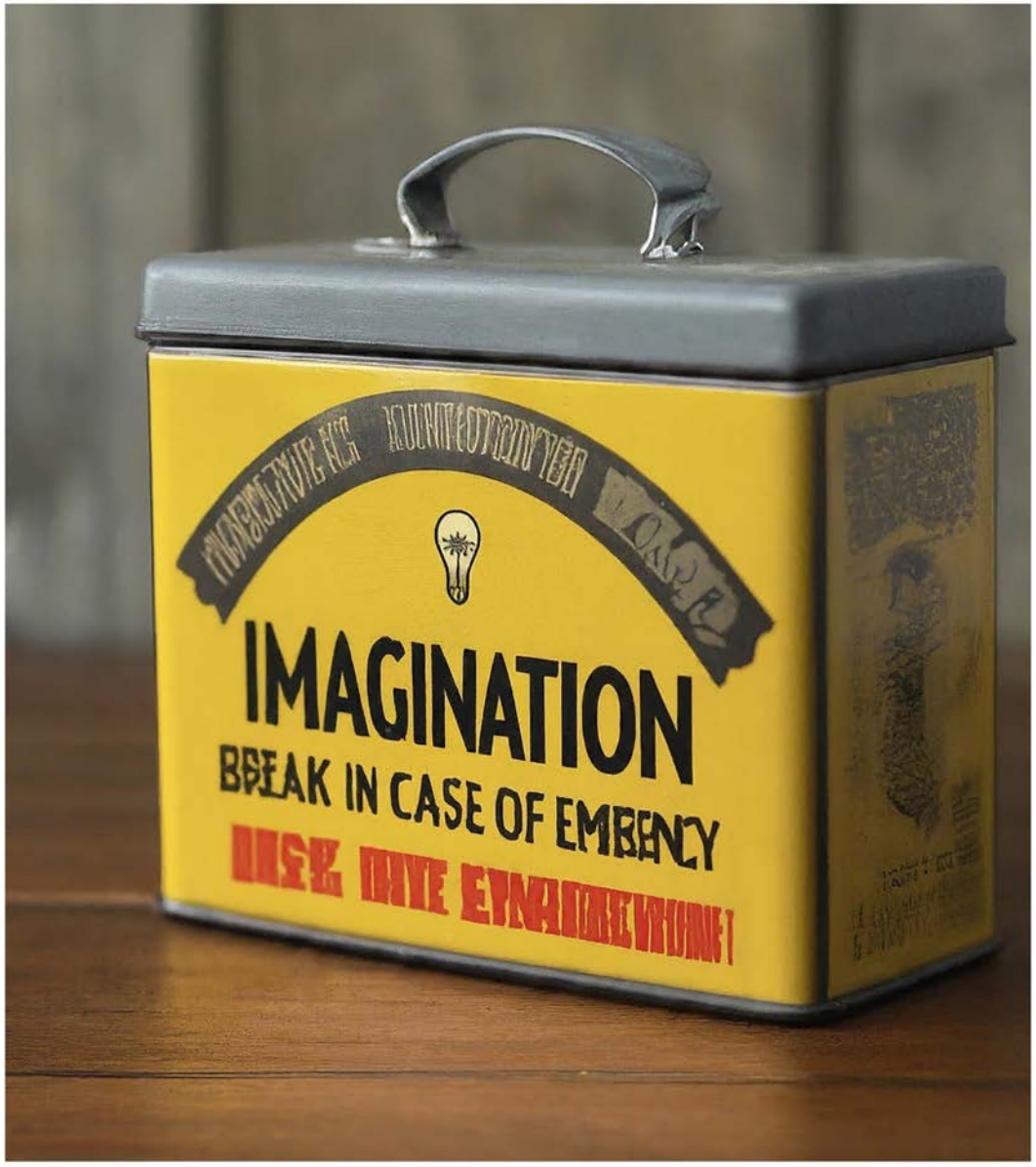
The **function** of imagination in science

- Scientists "whittle down" problems by making them maximally specific
- They do this by bringing to bear all possible background knowledge and experience
- Imagination is the last resort, only to be used on maximally specific problems that can't be solved in the usual way
- Is this for the best?

Stuart, M. T. 2019. "Everyday Scientific Imagination: A Qualitative Study of the Uses, Norms, and Pedagogy of Imagination in Science." *Science & Education* 28(6), 711-730.

Upsides

- Human imagination can’t handle many variables at the same time (Cowan 2001), so the less variables the better
- Imagination needs to be constrained to be useful. Which constraints are useful is easiest to determine when they are as specific as possible



Downside

- Encourages conservativism
- However, the strength of the norm varies inversely with career stage

Plan

1. The **function** of imagination in science
2. The **distribution** of imagination in science
3. What counts as a **good** imagining?
4. Sharpening the **tools** of the imagination
5. Other ideas

The **distribution** of imagination

- Scientists are consistent in their evaluations of some cognitive faculties
- Attitudes about imagination vary depending on career stage and whether someone is from a traditionally minoritized group (or the intersection of several)
- Those scientists express less positive (or even negative) views on the importance of imagination for science, the strength of their own imaginations, and desire to ***outsource*** imagination

Stuart, M. T. 2019. "Everyday Scientific Imagination: A Qualitative Study of the Uses, Norms, and Pedagogy of Imagination in Science." *Science & Education* 28(6), 711-730.

Explanations

- **Othering** leads to low confidence, and confidence is required to develop and use imagination
- Lack of confidence causes people to focus on developing skills that are more clearly celebrated
- Failure of science education, especially at the high-school and undergraduate level

Stuart, M. T. and Sargeant, H. 2024. "Inclusivity in the Education of Scientific Imagination." In E. Hildt, K. Laas, C. Miller, and E. Brey (eds.). *Building Inclusive Ethical Cultures in STEM*. Routledge.

Downsides

- Causes imaginative scientists to leave science, which reduces the number and volume of voices with different perspectives
- The less different perspectives there are, the less objective science is

Stuart, M. T. and Sargeant, H. 2024. "Inclusivity in the Education of Scientific Imagination." In E. Hildt, K. Laas, C. Miller, and E. Brey (eds.). *Building Inclusive Ethical Cultures in STEM*. Routledge.

A more inclusive education of imagination

- Make clear the career trajectory of a scientist's imagination
- More careful language surrounding imagination
- Courses on imagination aimed at scientists
- Realistic and representative role models (not hero worship)
- Support intellectual courage

Stuart, M. T. and Sargeant, H. 2024. "Inclusivity in the Education of Scientific Imagination." In E. Hildt, K. Laas, C. Miller, and E. Brey (eds.). *Building Inclusive Ethical Cultures in STEM*. Routledge.

Plan

1. The **function** of imagination in science
2. The **distribution** of imagination in science
3. What counts as a **good** imagining?
4. Sharpening the **tools** of the imagination
5. Other ideas

What counts as a **good** imagining?

- This depends on *when* an imagining takes place
- **Past**: good or bad because of the ***consequences*** (problem solved, funding captured, time wasted, etc.)
- **Present**: good or bad when ***responsibly*** conducted (breaking and obeying constraints in a systematic, careful way)
- **Future**: focus on improving *imagination* (not imaginings), by using tools, prompts, and altering the environment

Stuart, M. T. 2022. "Scientists are Epistemic Consequentialists about Imagination." *Philosophy of Science* 90 (3):518–538.

Past imaginings

- Uses of imagination are good when they lead to publications in journals like *Nature*
- Imagination helps find applications for new technologies, which increase problem-solving ability
- Past imaginings might *seem* good, but in retrospect are judged to be bad, because they didn't "pan out" (lead to publications)

Stuart, M. T. 2022. "Scientists are Epistemic Consequentialists about Imagination." *Philosophy of Science* 90 (3):518–538.

Present imaginings

- Perhaps good imaginings are those that are tightly constrained to represent reality accurately?
- "Beliefs about the world…act as constraints on my imagination, just as pre-programmed variables set constraints on computer simulations. When I set myself these imaginative projects, I don't take myself to be completely free. In fact, I don't take myself to be free at all" (Kind 2018, 243)

Stuart, M. T. 2022. "Scientists are Epistemic Consequentialists about Imagination." *Philosophy of Science* 90 (3):518–538.

Present imaginings

- No: you only use imagination when not all the constraints can be obeyed
- Good imaginings respect background knowledge and previous experience ***the right amount*** (and not completely)
- How? Break constraints one-by-one, starting with those we have least confidence in

Stuart, M. T. and Sargeant, H. 2024. "The role of imagination in making water from moon rocks." *Analysis* DOI: 10.1093/analys/anae015.

Upsides

- Going through this process often sheds useful light on scientists' confidence-structures
- Enables us to criticize certain imaginative practices

Stuart, M. T. and Sargeant, H. 2024. "The role of imagination in making water from moon rocks." *Analysis* DOI: 10.1093/analys/anae015.

Downside

- Encourages conservativism

Stuart, M. T. and Sargeant, H. 2024. “The role of imagination in making water from moon rocks.” *Analysis* DOI: 10.1093/analys/anae015.

Future imaginings

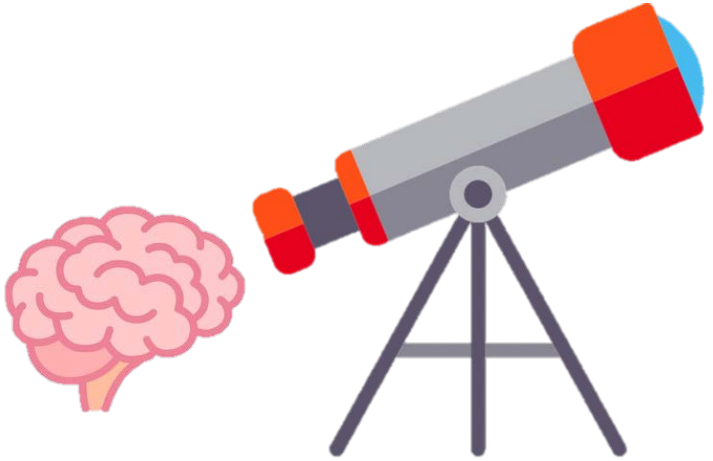
- To increase the use/power of imagination, scientists employ various strategies:
  - Open-ended prompts
  - Encourage a critical attitude and admitting what we don't know
  - Avoid dogmatism and competition

Stuart, M. T. 2022. "Scientists are Epistemic Consequentialists about Imagination." *Philosophy of Science* 90 (3):518–538.

Plan

1. The **function** of imagination in science
2. The **distribution** of imagination in science
3. What counts as a **good** imagining?
4. Sharpening the **tools** of the imagination
5. Other ideas

Tools of imagination

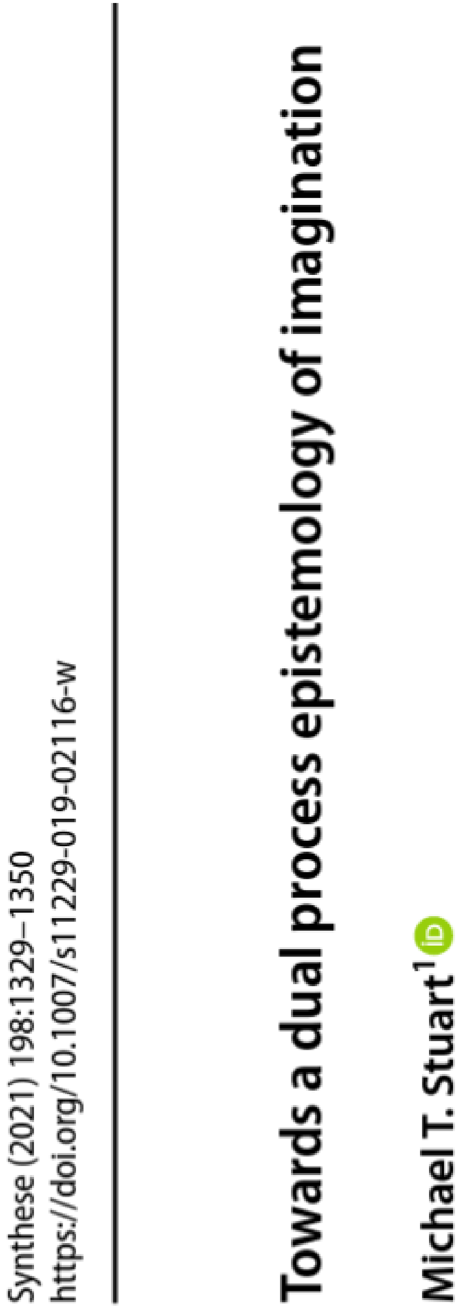


- Scientists use tools to assist their imaginations, by directing/focusing it
- These include thought experiments, metaphors, models, computer simulations, visualizations, jokes, AI, and formal languages
- Tools whose specific consequences are known are good because of their past consequences
- Tools whose imagined specific consequences can be guessed are used when those imagined consequences are good
- Tools whose consequences cannot be guessed are good when they improve the imagination generally

Stuart, M. T. 2022. "Sharpening the Tools of Imagination." *Synthese* 200:451.

Plan

1. The **function** of imagination in science
2. The **distribution** of imagination in science
3. What counts as a **good** imagining?
4. Sharpening the **tools** of the imagination
5. Other ideas


Synthese (2021) 198:1329–1350
https://doi.org/10.1007/s11229-019-02116-w

Towards a dual process epistemology of imagination

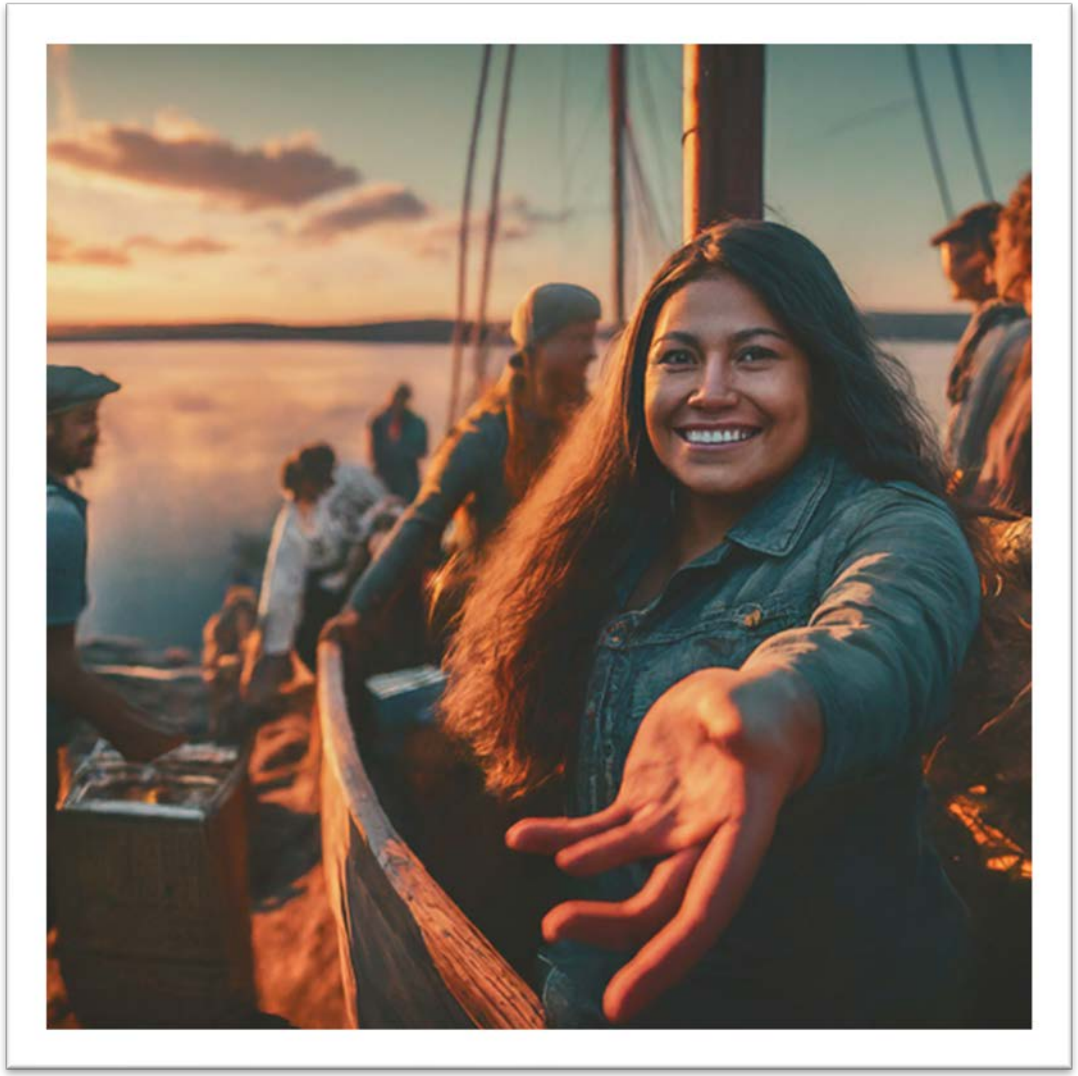
Michael T. Stuart[1]

Other ideas

- General capacity of imagination is exercised in system 1 processes and system 2 processes
- Most important is their interplay
- Each is affected by experience; each can be trained

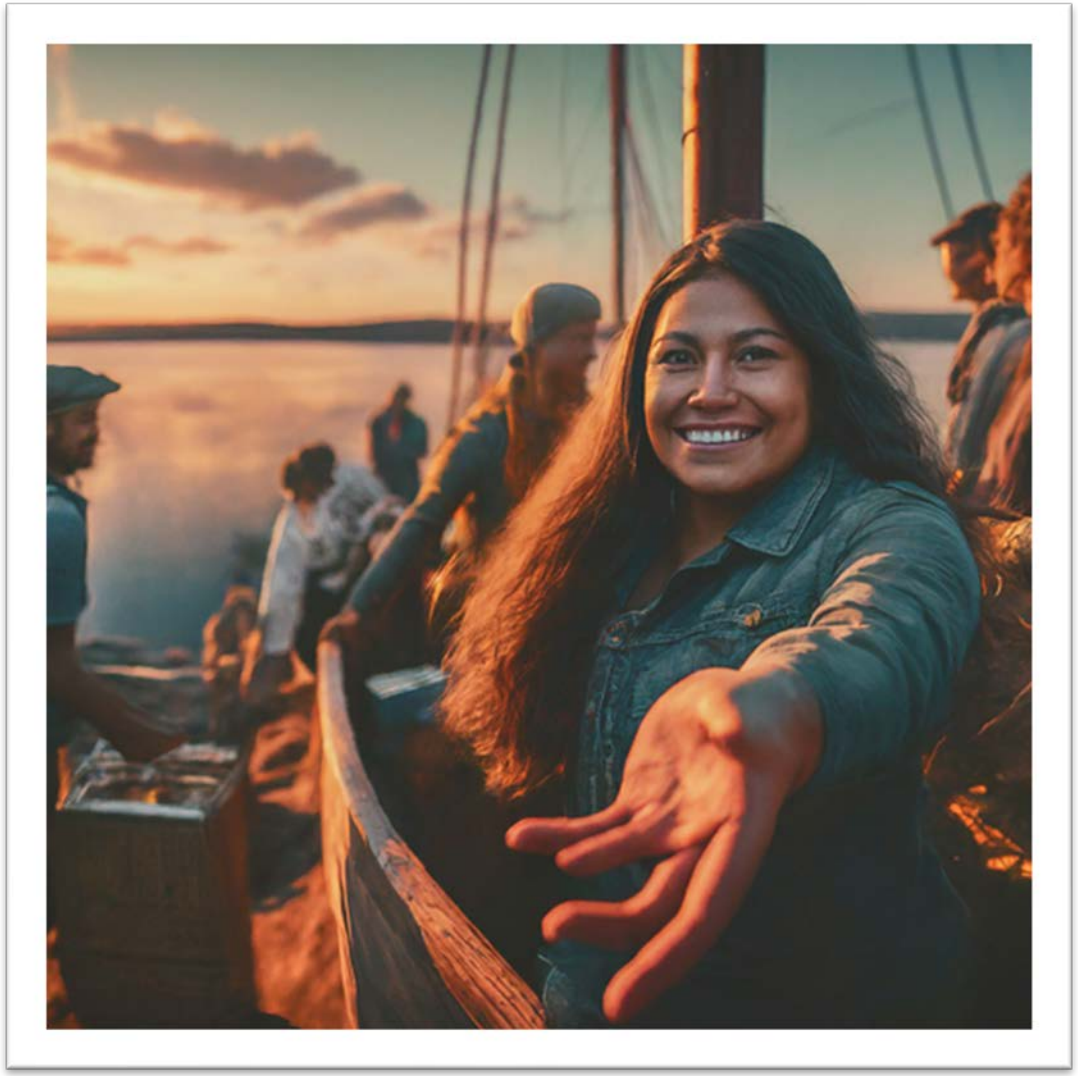
Other ideas

- Imagination is often done collaboratively. How exactly does this work? Can a group imagine something that no member imagines?
- Imagination and credit: how do scientists assign credit for imaginings, especially in cases of collaborative or extended imagination?



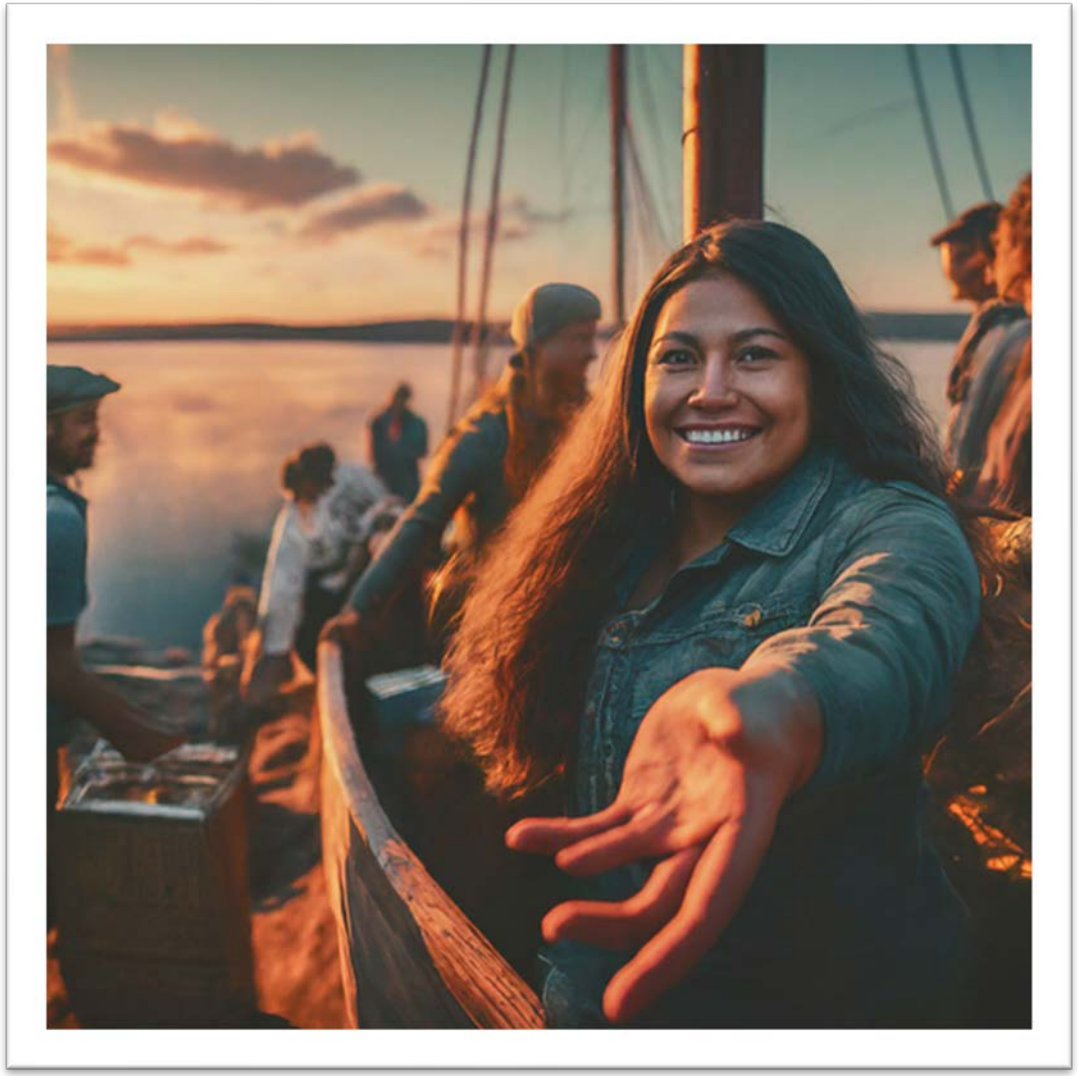
Other ideas

- Aphantasia – hyperphantasia spectrum
- Imaginative resistance
- Imagination and emotion (e.g., curiosity)



Other ideas

- Imagination and embodiment
- Scientists care about consequences, but ***which consequences***?
- Quantitative methods



Thank you!