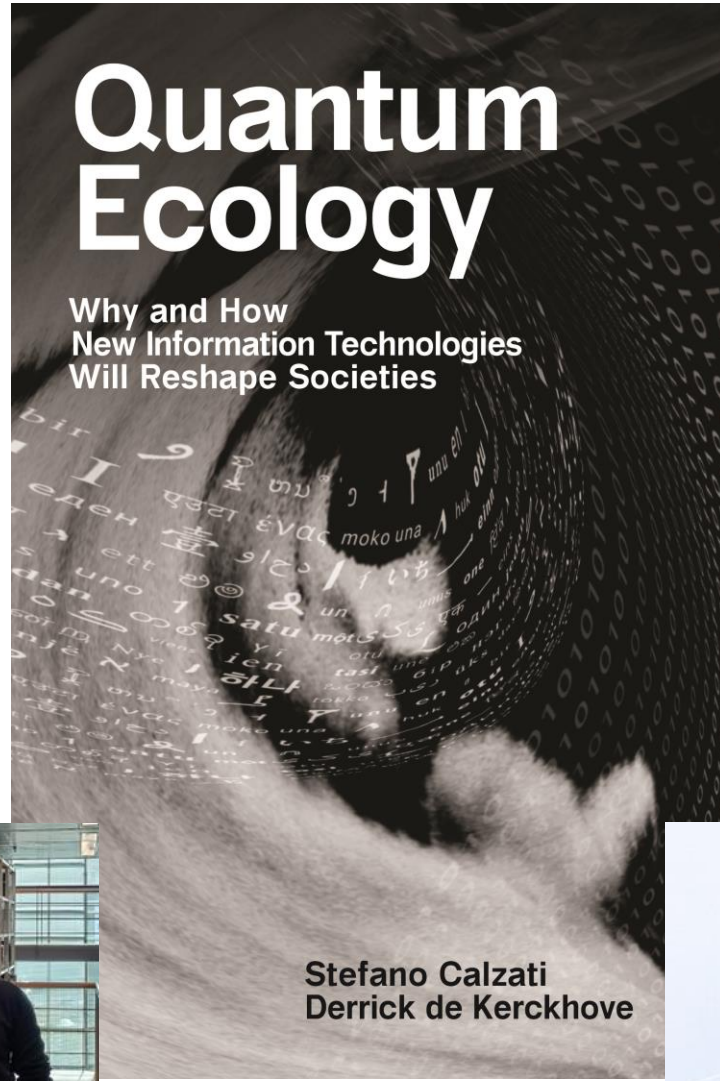


Visualising the Quantum Ecology

Sensing across Sights, Imaginations and Design

Dr **Stefano Calzati** – Independent scholar

Entangled Visions Workshop
2-5 December 2025, OsloMet



Quantum Ecology

[Calzati & de Kerckhove 2024](#), MIT Press

Onto-epistemological framework, whose pillars are, among others, entanglement, uncertainty, complementarity

Technological paradigm, pivoting around emerging Quantum Information Technologies (QITs)



"An ecology has effects, but not causes, at least not causes in the ordinary sense of a direct relationship between cause and effect."
(Calzati & de Kerckhove 2024)

"A key teaching in design is how to visualise abstract concepts."
(Mi Lin, book cover's artist, [Milandia](#) 瀾瀾之域)

Quantum Ecology

Why and How
New Information Technologies
Will Reshape Societies

Stefano Calzati
Derrick de Kerckhove

What's at stake

This talk weaves together **cognition**, **perception**, and **expression**, exploring *quantum-inspired* links across **sights**, **imaginations**, and **visualizations**.



How have we passed from these visualisations...



Entanglement (2019)



Black hole (2019)

to these images?

What does it mean to eventually «**see**» – **beyond our sensorial faculties** – what we have so far only **cognitively imagined** and visualised through design?

Sight vs imagination

“We have to remember that what we observe is not nature itself, but nature **exposed to our method of questioning.**”
(Heisenberg 1958)

→ **sight** and **imagination** are **dispositif-dependent** and (partially) **incommensurable modes of experience.**

→ “translation” is possible but always as a **partial betrayal**



To see...

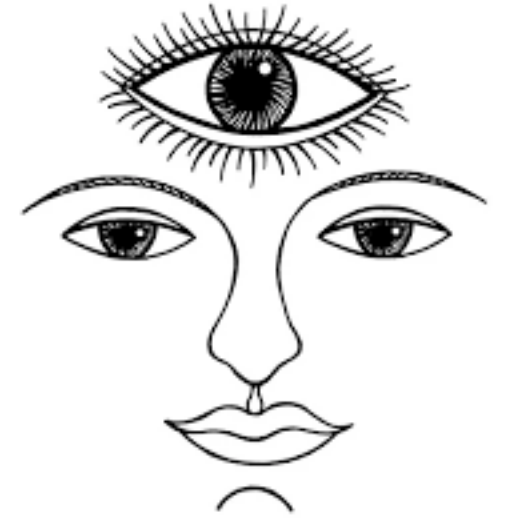


Sight is a **prosthetic faculty**: it can be extended and enhanced, based on certain technological apparatuses



To imagine...

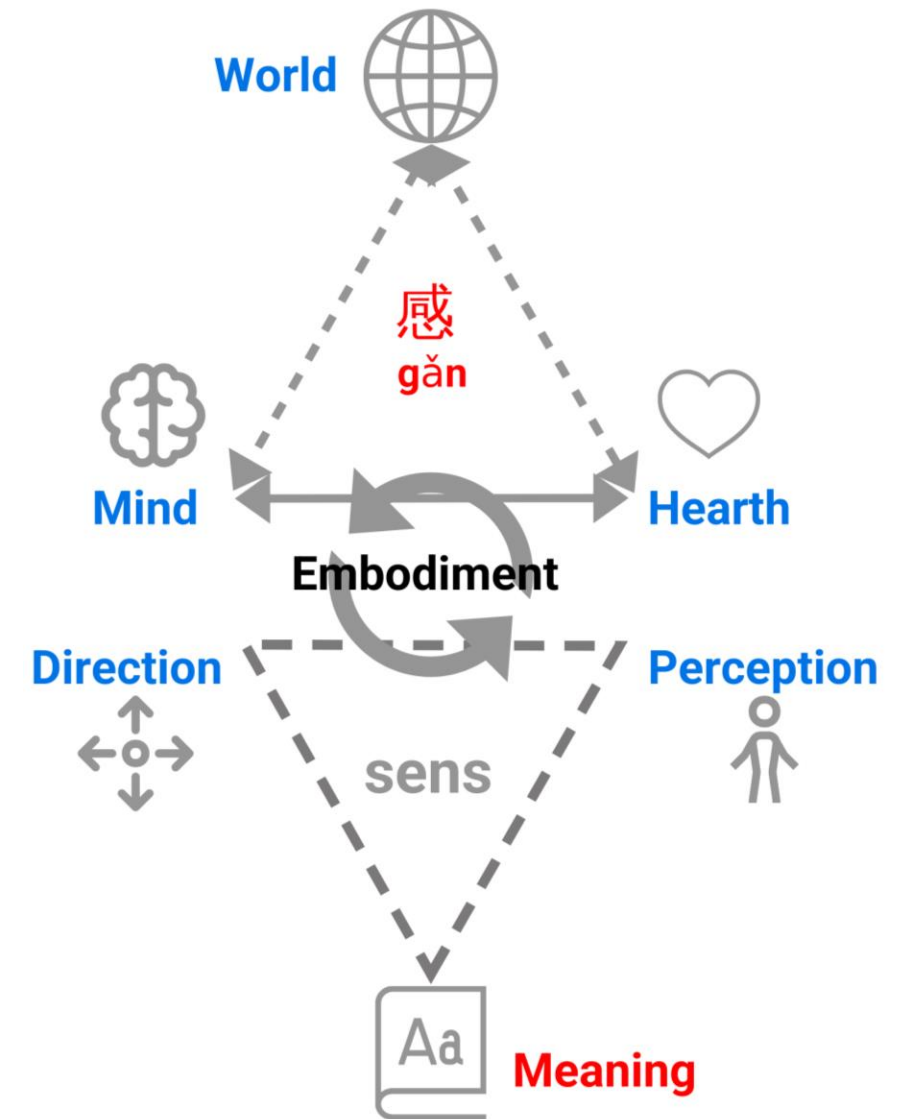
Imagination triggers **in-sights** rather than sights



- **“Creativity is not deductive, it is insight... We cannot find new features of the world** by deduction, induction or abduction. Insight is required.” (Kauffman & Roli 2023)
- **“All theories are insights,** which are neither true nor false but, rather, **clear in certain domains, and unclear when extended beyond these domains.”** (Bohm 1980)

A synthesis

From world-view...



...to world-sensing

Sens & 感

Direction & Perception are relative terms: they depend on a certain **point-of-being** in the world (de Kerckhove & Almeida 2016)

Meaning: frames (and is framed by) the other two

→ "meaning as a (**'sixth'**) **sense modality for 'perceiving'** **psychophysical correlations.**" (Atmanspacher 2020)

感 as: whole 咸 + heart-mind 心 = **whole cognition-moral attitude**

Three compenetrating movements: outside→inside;
outside↔inside; inside→outside

Emergent co-development

Sensing arises as the entanglement of the **I-world co-emergence**

Sensing is **expressed (meaningful) perception+cognition**

→ "Consider a bacterium swimming up a glucose gradient. The sugar *matters* to the bacterium" (Kauffman 2019)

Being always already entails mattering/valuing, i.e., **sensing as embodied information processing**

What kind of process is *being as sensing*?

1) It is “**technical**”

→ **Grasping of information:** any-thing exists out of an information symmetry breaking (Simondon 2020)

2) It is “**from within**”

→ Embodied information grasping always occurs **from within** (cf. the “blind spot” Frank et al 2024)

3) It is “**open-ended**”

→ the I-world co-emergence is “**unprestatable**” (Kauffman 2019)

4) It is “**autopoietic**” (Maturana & Varela 1987) + “**sympoietic**” (Haraway 2016)

→ the enactment of any ecology is “**collectual**”

Unpacking the Quantum Ecology

Three (technological) ecologies

- 1) Language → based on **meaningful world-sensing**
(e.g., alphabetic & logographic writing systems)



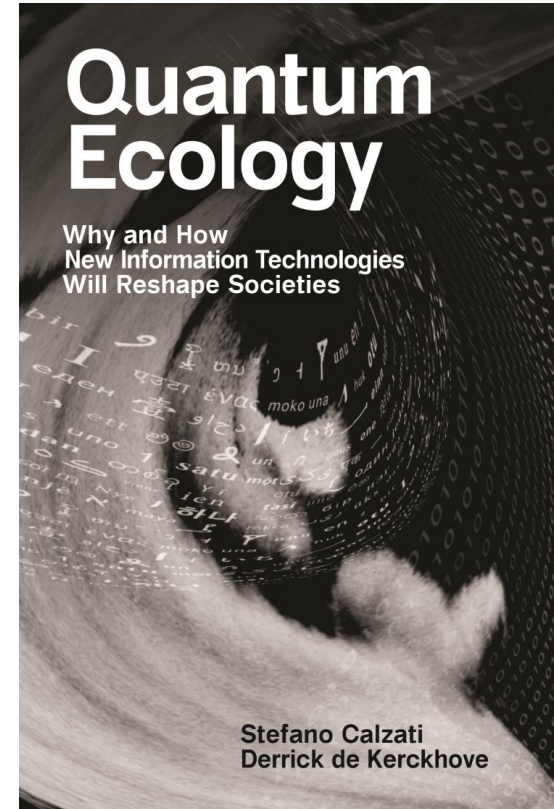
Partial onto-epistemological incommensurability
(LLMs are here!)

- 2) Digital → based on **computable world-sensing**
(formatting of «sensing» into 0s & 1s)



Partial onto-epistemological incommensurability

- 3) Quantum → based on a **probabilistic world-sensing**
(synthetic sensing)



(Embodied) language ecology

Language is a technology of the mouth as much as tools are technologies of the hands.
(Leroi-Gourhan 1965)

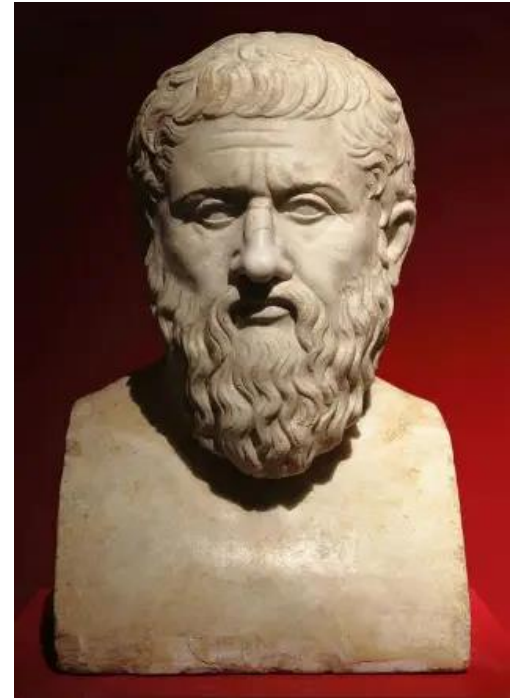


→ “**Language as a co-ontogeny**. With language arises the observer as a languaging entity” (Maturana & Varela 1987)

Fixating language

“Tell me and *I’ll forget*; **show me** and *I may remember*; **involve me** and *I’ll understand*.” Chinese proverb

“If men learn this [writing], it will implant **forgetfulness** in their souls. And it is **no true wisdom** that you offer your disciples, but only the semblance of wisdom, for by **telling** them of many things **without teaching** them you will make them seem to know much while for the most part they know nothing.”
(Plato, *Phaedrus*)



Writing as a technology of language

“Writing is the most momentous of all human technological inventions.”
(Ong 1986)



→the fixation of sounds on supports that could overcome the time and space of oral contingency contributed to **restructure human cognition** (Havelock 1976)

Alphabets and logograms

Writing systems' effects vary, contributing to shape **different techno-cultural fields**.

→ Alphabetic systems represent **speech**; they establish an **arbitrary relation** between signifier and signified; the context (referent) is evoked **through** reading.

→ Logographic systems represent **things or ideas**; each character condenses **shape, sound, and meaning**; the referent is **in** the character.

English	Chinese Character	Pinyin
A	诶	ěi
B	比	bǐ
C	西	xī
D	迪	dí
E	伊	yī
F	艾弗	ài fú
G	吉	jí
H	艾尺	ài chǐ
I	艾	ài
J	杰	jié
K	开	kāi
L	艾勒	ài lè
M	艾马	ài mǎ
N	艾娜	ài nà
O	哦	ó
P	屁	pì
Q	吉吾	jí wú
R	艾儿	ài ér
S	艾丝	ài sī
T	提	tí
U	伊吾	yī wú
V	维	wéi
W	豆贝尔维	dòu bèi ěr wéi
X	艾克斯	yī kè sī
Y	吾艾	wú ài
Z	贼德	zéi dé

Writing systems as techno-cultural fields

Chinese language presents **higher usage efficiency** (requiring less cognitive effort), but **lower acquisition efficiency** (requiring longer time to learn it).

Alphabetic language is **easier to learn** but requires **more cognitive effort** to use.

→ Alphabetic speakers have a **more flexible inferential space in STM**; logographic speakers have **more stable knowledge in LTM** (Wang 2013)

Linguistic metaphors

Metaphors are **sensing Gordian knots** expressing abstract ideas in figurative ways through embodiment

Time & space metaphors (Boroditski 2010):

- English speakers visualise the past at the back and the future in front
- Chinese speakers are more flexible: they can face the past, with the future behind; they can also enact time as above (past) and below (future)

→ Implications: if the link before-after is not an objective universal but a **linguistically embodied construct**, then causality gets relativized, depending on **how people sense “facts”**.



Expressing quantum through language

“A reliance on **nominal language** containing conceptual metaphors founded on the notion of **substance** and **entity renders misleading** any attempt to describe what amounts to **potentialities** of being” (Burwell 2018)

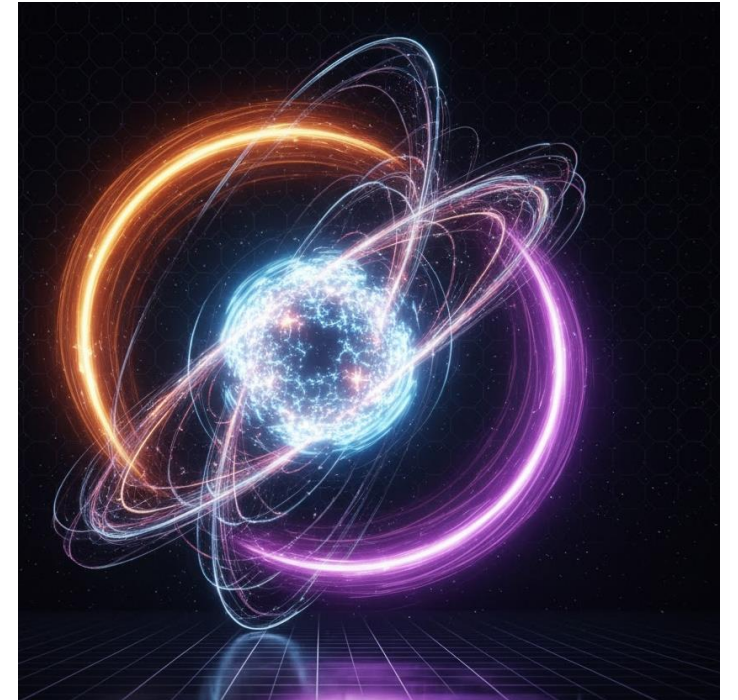
“Schrödinger, Bohr, and Heisenberg spent so much time talking about **why any attempt to describe quantum concepts in language was likely to end in failure.**” (Burwell 2018)

To spin or not to spin

Particles' spin is... not *really* a spin

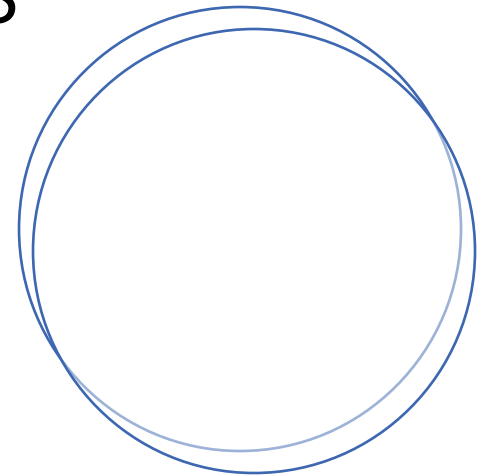
Spin is a **conceptual-linguistic proxy** (→ angular momentum)

- The idea of spin was introduced to describe a fourth degree of freedom of the electron (beyond the three-space dimensions), which Pauli defined as something "**which cannot be described from the classical point of view.**"
- Language always provides a **certain** expression of the experience of the world – **but this also applies to mathematics!**



On the limits of mapping territories

“Ordinary language is a map which has a **certain flexibility** so that it can follow the curved shape of the territory” In math “**the relation of the symbols to our experience is no longer evident.**” (Capra 1976)



“The laws behind the number shall be inscribed in a **much wider context**, which includes **any possible sign** or forms of expression, of which is clear **the deficiency and inadequacy before the infinite sea of possible meanings.**” (Zellini 2020)

→ Math as the **most imaginative & less sight-based** of all notation systems; yet, **always created, not discovered**: “while the number avoids meaning something, it cannot refrain from **being significant**, establishing a relation with the world.” (Agamben 2025)

At the roots of mathematics

Neoplatonism: numbers as a cognitively universal idea(l)s

Neurobiology: numbers as a sense encoded in the human brain (Dehaene 2011)

Phenomenology: number sensing as a cognitive-perceptual embodiment ([Calzati & de Kerckhove 2025](#))

Language and math configure **complementary “fictionalisations”** (etymology: “models”) of “reality”.

Digital ecology

- **Principle:** binary formatting of the sensible
- **Driving logic:** sheer efficiency
- **Effects:** global networkedness

→ The digital transformation has brought forth a **computability transition** that **challenges biological world-sensing**



Practical Implications

Pervasive computing «**envelops**» (Floridi 2019) reality into an efficient scenario

Envelopment fits **computational agents** but less so **biological agents** “unprestatable”, Kauffmann 2019)

→ implosion of the «rational subject»: **human agents as inherently inconsistent** (behavioural ethics; Pink et al 2024)

→ These inconsistencies will exacerbate and multiply alongside the consolidation of **QITs** – such as ultraprecise quantum sensing – as forms of **diffraction** (Barad 2007) in the sociocultural realm of the **complementarity** between **computation and biological**

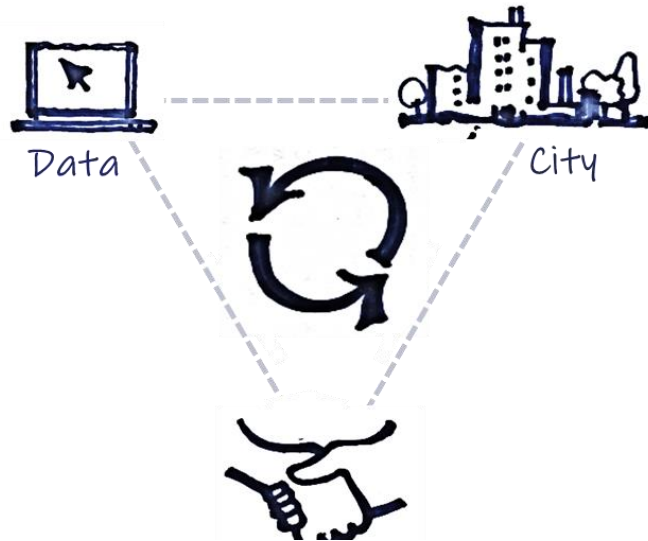
Applying
the
Quantum Ecology Framework

Ethics for the data driven-city

([Calzati & Ploeger 2024](#))

Pillars:

- Data as **sociotechnical bundlings**
- Ethics as a **collective ongoing practice**
- City as a **complex system**



Problem-opening approach

Transdisciplinary standpoint (Nicolescu 2006):

- "Technology is neither good nor bad; **nor is it neutral.**" (Kranzberg 1985) – Technology as *pharmakon*
- their use in complex scenarios produce **value-laden entanglements** (good and bad) **uncertain consequences** (intended and unintended)

Goals (reflect, research, design):

- Think critically about the **definition of problems** (beyond problem-solving)
- Translate such thinking into the **analysis of a case study** (TU Delft campus)
- Materialize the analysis into a **digital or physical artefact** (final assignment)

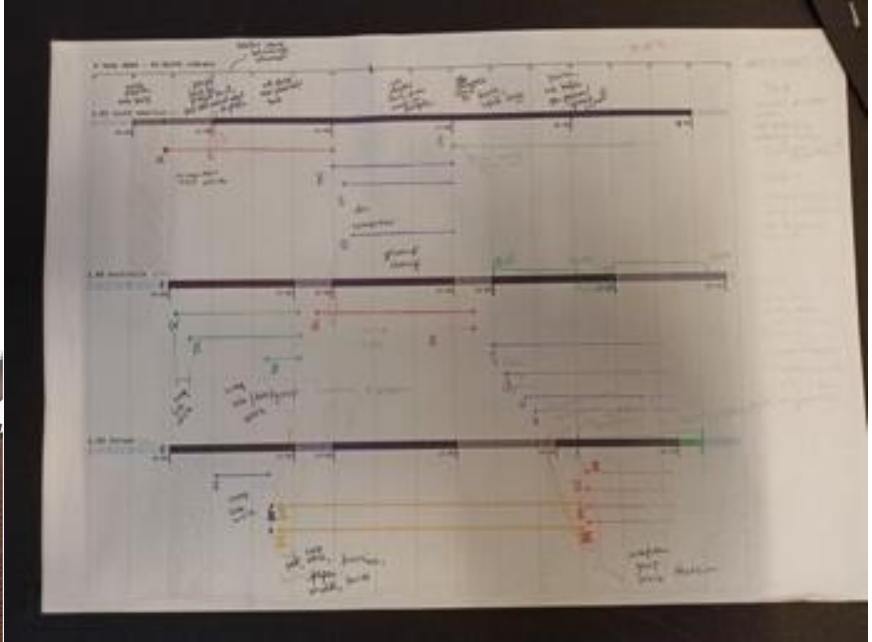
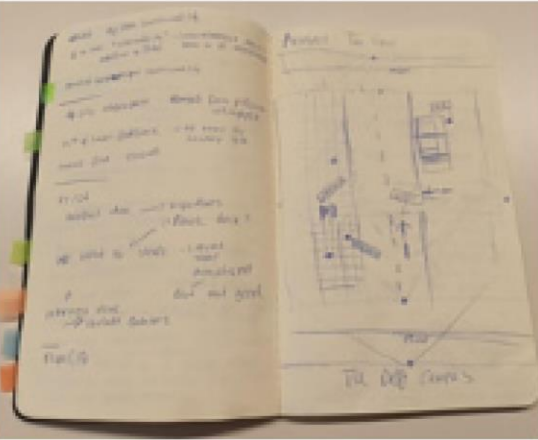
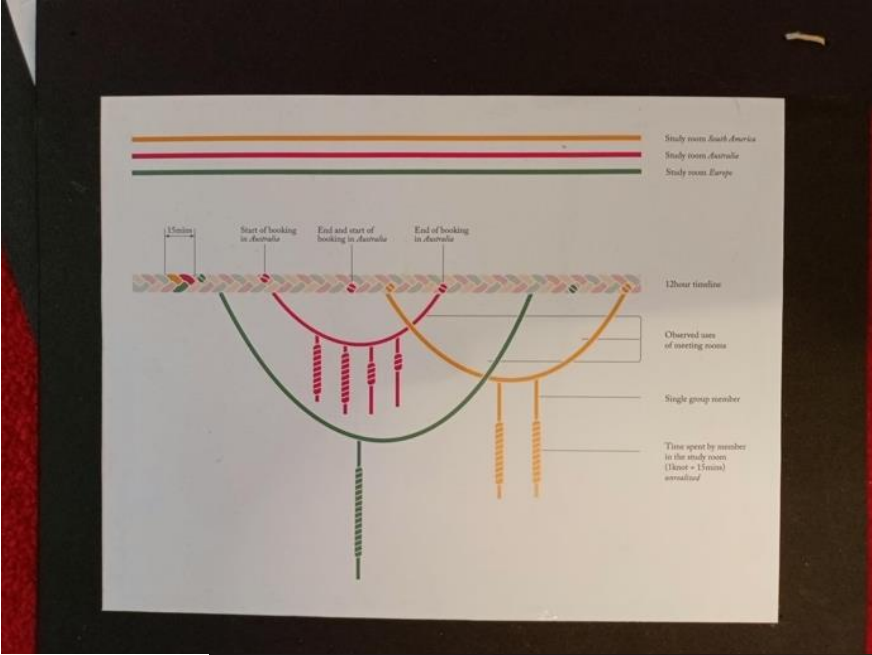
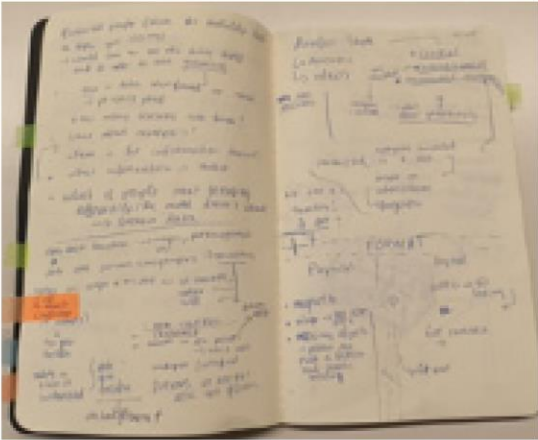
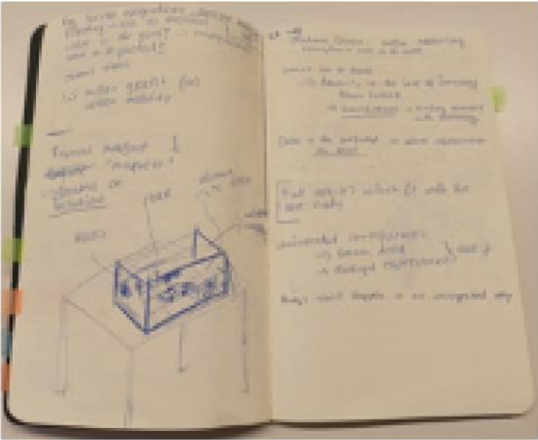
Research & design

Research:

- 1) Identification** of a case study
- 2) framing** of the case study (e.g., how it is presented; how it works; etc.)
- 3) data-value entanglements** (e.g., values in/excluded; data in/excluded)
- 4) open-ended scenarios** (e.g., results and possible unintended consequences).

Design:

- a) project journal**
- b) artefact** (e.g., physical or digital object exposing and redressing the ethical tensions identified).
- c) author's statement** describing the artefact



“Design is **indeterminate** in order to be practical”
(Easterling 2021)



Challenging Visualisations

Gearing up...

Every ecology is always **trans-ecological!**

Ecologies are **onto-epistemological configurations**: they coexist, overlap, nest into each others – but they are **neither coextensive nor coessential** (mutual irreducibility)



→ Each ecology **needs recursively other dispositifs to explicate itself**

“At whatever size, all the partners making up holobionts are symbionts to each other” (Haraway 2016)

Ecology as a fractal hologram

A **fractal** is a pattern recurring progressively across scales
→ from the micro to the macro, a **fractal always already contains its own autopoietic be-coming**

In a **hologram**, «the whole is present in the parts, not made up of them” (Wendt 2015)
→ the **parceling of the whole and its own whole-making coexist**

Some ideas in the making

If being is sensing, then

- Ecologies are not connected as if in a network; they are **nested into each other**, through a mutually implicated order of emergence (Bohm 1980)
- Yet they also maintain a **degree of relative autonomy** among them (“lumpability” of complex systems, Rosas et al 2024)
- This autonomy is a **discretional configuration** (Gershenson & Heylighen 2003) and **mappings** across configurations are possible
- From within, each ecology **emerges as a happening**: its becoming can be qualified – i.e., spatio-temporally – through **intra- and inter-ecological comparisons**



How to visualise ecologies as fractal holograms to yield insights into the nature of reality?



How to visualise ecologies as fractal holograms
to yield insights into the nature of reality?

Thank you!

<https://stefanocalzati.com>

[Digital Society](#) upcoming issue

Untangling the Quantum Ecology:
Charting the Impact of Quantum Theory and
Quantum Technologies on Technoscience and the
Digital Transformation

Quantum Ecology

Why and How
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