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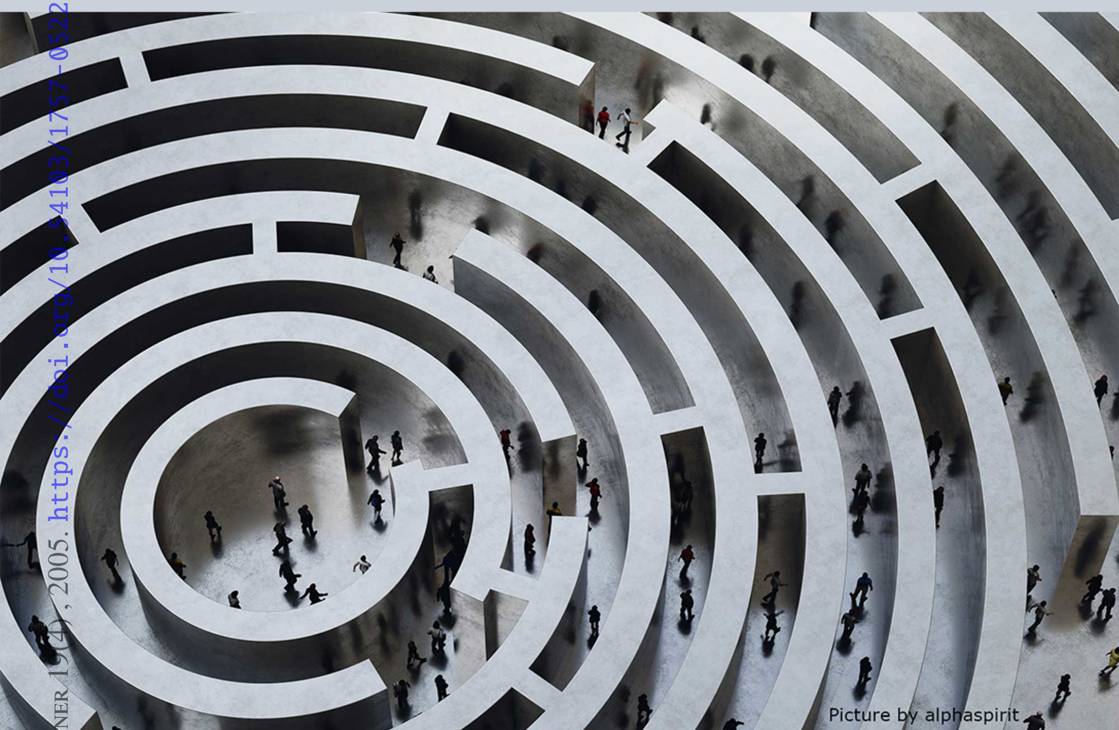

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Special Issue on the “Milan Logic and Philosophy of Science Network Conference”

:: **Ilaria Alfieri, Silvia Larghi, and Maria Raffa**

Abstract
Introduction to the contributions arising from the First Milan *Logic and Philosophy of Science Network* Conference, held at Politecnico of Milan on the 12th March 2025.

Keywords
Logic and philosophy of science.

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The inaugural meeting of the "Milan Logic and Philosophy of Science Network", held at Politecnico di Milano on the 12th March 2025, brought together scholars from across the academic landscape of Milan to explore the intersection of logic, philosophy of science, and contemporary challenges in science and society. This special issue gathers contributions and reflections from that event, showcasing the breadth and depth of ongoing philosophical work on themes of cognition, reasoning, new technologies, natural sciences, uncertainty and, above all, interdisciplinary research.

In a world increasingly shaped by technological innovation, social disruption, and epistemic complexity, philosophy has a critical role to play, not only in interpreting the conditions of knowledge production, but also in contributing to the design of responsible practices, inclusive frameworks, and sustainable futures. The Logic and Philosophy of Science Network was created with this mission in mind: to foster collaboration among philosophers of science based in the Milan area, scholars who often work in close geographical proximity yet remain unaware of each other's research. The network aims to build connections and cultivate meaningful exchanges, with particular attention to the ethical, political, and methodological dimensions of scientific inquiry.

The meeting brought together over twenty contributions from research groups in philosophy of science across the main universities in Milan: Università Statale, Politecnico di Milano, Università di Milano-Bicocca, Università Vita-

Salute San Raffaele, and IULM. The contributions were organized around four key thematic axes, as follows:

The first topic was *Artificial Intelligence, Robotics, and Cognition*, and this section explored conceptual and epistemological questions arising from emerging AI and robotic systems. Contributions included philosophical reflections on human-centered AI and the integration of values into technological design, discussions on the epistemology of mental state attributions to robots, the modeling of cognition through artificial systems, and broader perspectives on the philosophy of AI.

The second thematic axis concerned *Epistemology, Reasoning, and Logic.* Talks in this stream examined foundational issues in reasoning, knowledge, and scientific explanation. Topics included the psychology of extreme beliefs, truthmaker semantics and modal logic, scientific analogies and models, and reasoning in science. Contributions on pseudoscience further expanded the discussion to data reasoning and misinformation.

The third topic tackled *Philosophy of the Physical Sciences, Biology, and Health.* This cluster offered rich insights into how philosophical analysis interacts with ongoing research in physics, cognitive biology, and health sciences. Epistemic cohesion in nuclear fusion research was examined, while contributions from other groups highlighted how philosophical thinking can engage with metaphysical, cultural, and epistemological questions. The program also included con-

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The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30045

tributions on transdisciplinary approaches to cognitive biology and artificial cognition, a rethinking of the conceptual foundations of health in light of emerging data practices, and a critical reassessment of the longstanding philosophical analogy between machines and organisms.

The last thematic axis included the topics of *Science, Values, and Uncertainty*. This section is focused on the growing awareness that science is never value-neutral and that uncertainty is a constitutive feature of both natural and social sciences. Contributions addressed decision-making under risk, the classification of normative kinds, and the epistemic and ethical dimensions of climate modeling. Epistemic injustice in medicine, and the role of values in scientific measurement were also explored.

In addition to the research presentations, the meeting hosted three *World Café* discussion tables that encouraged collective reflection on issues extending beyond academic research, focusing instead on the broader academic environment and philosophy's role in society. The discussions centered on three key topics: gender discrimination in academia, mental health within the academic profession, and philosophy's relationship with public engagement. These conversations resulted in three feature articles.

Together, the contributions in this special issue offer a multifaceted picture of contemporary philosophical research grounded in scientific practice, social concern, and theoretical depth. They illustrate how the philosophical community from the Milan area is actively engaging with global challenges, rethinking AI, scientific norms, health, and epistemic justice. More than just a report on an academic event, this collection signals the emergence of a dynamic interdisciplinary platform, capable of connecting philosophical insight with the most pressing issues of our time.

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The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/

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In Search for an Epistemology for the Sciences of Built Environments

:: **Thomas Bonnin**

Abstract
This article is a call for increased attention to the epistemological challenges in the scientific study of built environments. These issues are acknowledged, yet only superficially discussed, in the philosophy of architecture. While the philosophy of science has recently examined how environments shape human health, the specific problems raised by built spaces remain largely overlooked. However, it is crucial to address the epistemological foundations that underlie the ethical, aesthetic, social, and political dimensions of architecture. Evidence-Based Design illustrates this need: it aims to enhance scientific rigour in building design and improve performance. Based on a systematic review of design research, I argue that its methodological inspiration (Evidence-Based Medicine) is ill-suited to architectural contexts. A constructive update would incorporate insights from philosophy of science on experimentation, pluralism, and the role of theory in practical sciences. This case study exemplifies philosophical engagement with built environments and design research.

Keywords
Architecture; Evidence-Based Design; Evidence-Based Medicine; Applied Sciences; Philosophy of Science in Practice.

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Introduction

We intuitively assume that built environments can have a potent influence on a range of outcomes related to the well-being of its users. For instance, a bright, well-ventilated room with a view of nature appears beneficial; a damp, underground room with dull colours and furniture would instead be detrimental. In this paper, I argue that translating these simple insights into scientific research and incorporating this research into design processes is a difficult, important and, above all, under-explored epistemological challenge.

In *Part 1*, I characterise existing research gaps in the philosophical literature. On the one hand, philosophy of architecture does not explicitly address the field's epistemological foundations. A discussion of the latter matters, as it underpins and interacts with the aesthetic, ethical, political or metaphysical dimensions of architecture. Conversely, philosophy of science does not engage with the specifics of built environments. This lacuna poses a problem, as scientific knowledge about the effects of built spaces is increasingly available, raising numerous epistemological issues, in a context of an applied science characterised by high expectations and high stakes. This article therefore argues that philosophers of science should more explicitly recognise and address the epistemological issues linked to the design of built environments. To illustrate this view, *Part 2* provides a critical discussion of Evidence-Based Design's (EBD) epistemological basis. In *Part 3*, I argue that improving EBD requires an interdisciplinary engagement, bringing philosophy of science into closer dialogue with philosophy of architecture and design research.

1. Research Gap: Architecture as an Epistemologically Neglected Field

Saul Fisher's introduction to the *Stanford Encyclopedia* entry on the 'Philosophy of Architecture' depicts a relatively neglected field of study

'Over the course of Western philosophy, includ-

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

ing the history of aesthetics, architecture has largely failed to attract sustained, detailed attention – particularly as compared with other artforms.' (Fisher, 2015: 'Philosophy of Architecture,' URL = https://plato.stanford.edu/archives/win2016/entries/architecture/, E.N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy*)

It is interesting to notice how Fisher spontaneously considers architecture as a philosophical terrain for *aesthetics*. Discussions of 'architectural knowledge', instead, are relegated to a subpart of the entry within which – uncharacteristically to an encyclopedia entry – only three bibliographical references are mentioned. If the philosophy of architecture is a neglected field, then the *epistemology* of architecture appears even more relegated.

One could think there are good reasons for this neglect, namely, that architecture does not present worthy epistemological challenges. I argue, instead, that such challenges permeate Fisher's presentation and deserve explicit scrutiny. For instance, the vitruvian triad *firmitas* ('solidity'), *utilitas* ('utility') and *venustas* ('beauty') still stands as cardinal qualities to be held by built works. It raises, however, a host of questions that link epistemic dimensions with ethical, metaphysical and aesthetic considerations.

In the first place, one may wonder whether these virtues can be measured with scientific instruments. The challenge is to simultaneously account for the context specificity of built environments, as well as for the variable – and equally con-

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30068

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

textual – subjective experience of individual users. It also matters to figure out, at a definitional level, whether these qualities are attributed to parts or to the totality of a built environment, and how parts are being individuated. The satisfaction of vitruvian qualities also poses possible trade-offs: can beauty, utility and solidity always be promoted together? How to characterise and manage possible conflicts between these values?

A recent essay invites reflection on the bioethical dimensions of seeing built spaces as therapeutic interventions (Anderson *et al.*, 2022, 'The bioethics of built space: health care architecture as a medical intervention', *Hastings Center Report* 52(2), DOI: 10.1002/hast.1353, pp. 32-40). While important, I argue that a sole emphasis on ethical aspects is insufficient. The reflections derived from a consideration of the vitruvian triad foreground the need to explore the epistemic aspects underpinning ethical, as well as aesthetical, metaphysical, and political dimensions in the built environment. This approach considers epistemic and ethical issues as *inherently interlinked*, as already proposed by philosophers of science (see Tuana, 2010, 'Leading with ethics, aiming for policy: new opportunities for philosophy of science', *Synthese* 177, DOI: 10.1007/s11229-010-9793-4, pp. 471-492).

Philosophy of science therefore has a distinct and important role to play in addressing the epistemological issues raised by the design of built spaces. In his encyclopedia entry,

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

Fisher mentions a role for two types of scientific knowledge in the context of architecture: knowledge about materials relevant to the structural integrity of buildings, and environmental psychology. The latter identifies 'ways that environmental factors such as colour, shape, light, and circulatory pattern shape our visual reactions and behavioral patterns within and around the built environment' (Fisher, 2015). By scientifically investigating the pathophysiological reactions to built environments, environmental psychology bridges epistemic considerations with the aesthetic and subjective dimensions of architecture. It hence constitutes a valuable entry point to explore how philosophy of science can illuminate the epistemological foundations of design research and processes.

Throughout history, the notion of 'environment' has had multiple meanings, as a result of sustained interest arising from various scientific, philosophical and societal perspectives (Warde *et al.*, 2021, *The Environment: A History of the Idea*, Johns Hopkins University Press). Philosophers of science, in particular, have examined how environments have been conceived and operationalised in the historical, cognitive, and medical sciences, such as epidemiology, exposomics, and toxicology. To my knowledge, such scrutiny has yet to occur in environmental psychology. This analysis would help foreground the distinct epistemological stakes at play in the conception and operationalisation of *built* environments.

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

This leaves us in a situation where architecture raises a variety of epistemological issues which underpin aesthetic, ethical, metaphysical, and political debates. These are sometimes acknowledged, but rarely addressed explicitly by philosophers of architecture. Likewise, disciplines exploring the effects of built spaces – such as environmental psychology – are lacking due consideration from philosophers of science. Because of the broad societal impact of architecture, it is important to tackle both these research gaps simultaneously. Doing so would increase awareness of how scientific knowledge is, and should, be constituted and used in design processes.

This does not mean that the existing philosophical literature is no help in undertaking this task. As discussed in *Part* 3, considerations drawn from general and discipline-specific philosophy of science provide crucial insights. But before that, I propose to ground my analysis on cases drawn from design and architectural practice, as these instantiate proposals which are concrete, relevant and actively debated in these fields. A critical and constructive engagement with such constructs can therefore prove both philosophical insightful and pragmatically useful. In what follows, I illustrate this approach through the case of 'Evidence-Based Design'.

Evidence-Based Design (EBD) is a term coined in 2003 by D. Kirk Hamilton, an American architect, as an approach to the design of built spaces, with a particular focus on health-care infrastructure (Hamilton, 2003, 'The four levels of evidence-based practice', *Healthcare Design* 3-4: 18-26). It promotes the systematic production and sharing of scientific knowledge about the effects of built designs on users, and its widespread and transparent use to ground design decisions. This aspiration makes it a particularly interesting case for an exploration of the epistemic dynamics in the context of the built environment. EBD's main inspiration is Ulrich's work in environmental psychology. More particularly, a retrospective study, published in 1984, serves as proof of concept for the approach. This study observed clinically significant statistical differences between post-surgery patients depending on their window views (Ulrich, 1984, 'View through a window may influence recovery from surgery', *Science* 224(4647), DOI: 10.1126/science.6143402, pp. 420-421).

EBD serves as an anchor to various institutional developments in architecture and design, a field considered to be notoriously research-averse (Chupin, 2024, 'Le Ph. D. en architecture est-il un doctorat en design?', *Sciences du Design* 20(2), DOI: 10.3917/sdd.020.0172, pp. 172-188). It provides the basis, among other things, to a professional accreditation (*Evidence-Based Design Accreditation and Certifica-*

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

tion, EDAC) and to the *Pebble Project*, an initiative gathering and fostering good practices in evidence-based healthcare design. The *Health Environment Research and Design* (*HERD*) journal, created in 2008, is a peer-reviewed publication dedicated to the sharing of EBD-inspired empirical work, and of discussions over the approach's conceptual and methodological foundations. *HERD* articles and textbooks (most notably Hamilton & Watkins, 2008, *Evidence-Based Design for Multiple Building Types*, John Wiley & Sons) thereby constitute precious sources to decipher EBD's epistemological proposals.

In what follows, I provide a brief summary of the results of a critical systematic review of the notion of EBD (Bonnin, under review, 'A critical assessment of Evidence-Based Design's knowledge base and inspiration: a systematic review'). The review particularly focuses on EBD's ambiguous relationship with its main epistemological inspiration, namely, Evidence-Based Medicine (EBM). In addition to bearing very similar definitions, EBD notably imports EBM's hierarchy of scientific methods as a way to discern the value of a given source of knowledge. The most authoritative knowledge, in this view, comes from the aggregated analysis ('meta-analysis') of results from randomised controlled trials, deemed the most reliable scientific method. EBD, like EBM, thereby favours controlled experimental knowledge, and openly seeks to downplay the authority of observational and anecdotal knowledge as well as expert

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30068

opinions which are all purportedly prone to biases.

Simultaneously to these energetic efforts to reform design knowledge, some EBD practitioners are aware of the difficulty of importing epistemological standards from its medical counterparts. They call for amending the approach so that it accounts for the specificities of the design process, and for what distinguishes interventions on built environments from medical ones. The existence of this internal dissonance led me to make a systematic review of this critical literature (which includes 31 publications written by design and architecture researchers published between 2003 and now). My analysis of these arguments made clear that EBM's hierarchy of methods is not the right epistemology for EBD. This rejection is articulated over three reasons.

The first is that an inspiration from EBM amounts to a continuous *precarisation* of EBD's knowledge basis. In clinical medicine, producing a randomised controlled trial represents a noteworthy, but reachable, scientific achievement, as attested by the existence of the *Cochrane Library* which collects meta-analyses in clinical research. Experimental, controlled (not to mention randomised) knowledge about the effects of interventions on built spaces is, to the contrary, much harder to come by. In this view, EBD is thereby constrained to rely on 'lesser' – and more accessible – evidence sources. While being hard to reach, experimental evidence is also criticised for being practically weak. In other words, it is only considered capable of supporting small, in-

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

cremental changes in built designs, and thus cannot encourage broader innovations. Finally, and as already suggested by Fisher, 'we may ask whether an architectural object may be optimized by the lights of environmental psychology yet – and even *consequently*– deficient in some other, architecturally central respect' (Fisher, *ibid.*). In other words, design researchers doubt that the scientific optimisation of built spaces necessarily results in their increased aesthetic or moral values. In sum, emulating EBM's hierarchy of knowledge would entrench the weakness of EBD's knowledge basis with no guarantee of either sufficient or adequate improvements in the resulting built environments.

This state of knowledge paucity, according to critics, needs not be. In this view, an EBM-inspired evidence hierarchy bears with it a devaluation of important design knowledge. Its classification of methodologies is judged too rigid, thereby lacking context specificity. By this, design researchers recognise that experimental and controlled evidence, while potentially powerful, is not the most adequate for all purposes in the design process. For instance, as already mentioned, it is neither capable of strongly supporting innovative proposals, nor is it helpful – compared to ethnographic studies – with providing a rich contextual understanding. The latter methods are even given no consideration (not even negative) in broader EBM-inspired epistemologies (Cartwright & Efstathiou, 2008, 'Evidence-based policy and its ranking schemes: so, where's ethnography?', *Paper pre-*

sented at the Conference of the Association of Social Anthropologists). Because the design process involves a variety of decisions, it can benefit from a similarly wide scope of knowledge sources. Enforcing a hierarchy of knowledge thereby feels contrived. EBD's current devaluation of anecdotal knowledge, while the latter is robustly documented as the central means of communication between different stakeholders in design processes, indicates a misfit of this epistemological proposal with actual practices.

A static hierarchical framework, which – inadequately, as we have seen – categorically parses out reliable and unreliable knowledge, is finally seen as diverting attention – and providing no solution – to some of the main epistemological issues raised in design processes. It says nothing, for instance, of how scientific knowledge could flow in a variety of communication means, including anecdotes, diagrams and physical simulations ('mockups'). The integration, or triangulation, of different sources of knowledge is similarly not discussed. Its means of adjudicating controversies – by giving precedence to the most reliable source of knowledge – is too coarse-grained for most situations – for instance the assessment of contradictory results stemming from a similar method – and too context-independent to be widely applicable. An EBM-derived hierarchy, while clear on the assessment of a method's *internal* reliability, does not indicate how to evaluate the applicability of such knowledge to practical decisions. The management of conflicting values held by

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

different stakeholders, an intense topic of discussions at the intersection of science and policy-making (Elliott, 2017, *A tapestry of values: An introduction to values in science*, Oxford University Press) is similarly out of the scope of EBD's current epistemological proposal.

In short, this systematic review shows that EBD is still in search of its epistemological foundations. As recognised by several researchers, a strong leaning on EBM's hierarchical view of scientific methods (a) continuously places EBD in a precarious epistemic situation, while (b) neglecting large swathes of relevant knowledge and (c) diverting attention from important epistemological challenges.

This review, however, is more than the occasion to criticise 'native' epistemological frameworks. I mean, instead, this work to lay the groundwork for a constructive epistemological proposal for the contribution from scientific knowledge to the design of built spaces. EBD, in this sense, is heuristically useful to identify areas of further investigation, where existing proposals in philosophy of architecture and philosophy of science will prove useful.

3. Steps Towards a Constructive Proposal

While it is arguably crucial, for EBD, to shift away from a narrow and exaggerated valuation of controlled, experimental evidence, finding the adequate contributions for these methodologies remains to be determined. This is

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

a topic central to other 'Evidence-Based' approaches, notably Evidence-Based Policy (Cartwright & Hardie, 2012, *Evidence-based policy: A practical guide to doing it better*, Oxford University Press), and even within EBM itself (Parkkinen *et al.*, 2018, *Evaluating evidence of mechanisms in medicine: principles and procedures*, Springer Nature). Experiments hinge their legitimacy on their ability to causally isolate, and intervene upon, a variable of interest. The possibility of such isolation harks back to protracted debates, in architecture theory, over the mereology of built spaces (Scruton, 1979/2013, *The Aesthetics of Architecture*, Princeton University Press). Epistemic tangles over causal inference from the environment are similarly visible in epidemiological research (Broadbent, 2013, *Philosophy of Epidemiology*, Palgrave Macmillan), notably once we consider the inextricable intertwining of biological and social factors (Krieger, 2024, *Epidemiology and the people's health: theory and context*, Oxford University Press).

These debates can help design research build realistic expectations of the contribution of experiments from environmental psychology, together with other scientific methods and non-scientific forms of knowledge. In other terms, an improved framework for EBD must address the management of *epistemic pluralism*, not only at the *intra*disciplinary and *inter*disciplinary but also at a *science-transcending* level (Bschir & Lohse, 2022, 'Pandemics, policy, and pluralism: A Feyerabend-inspired perspective on COVID-19, *Synthese*

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

200, DOI: 10.1007/s11229-022-03923-4, p. 441). The context specificity and iterativity that characterises proposals for inclusive and rigorous science-based policy-making contrast with the contrived neatness of EBM's evidential hierarchy (Bonnin & Giroux, in press, "Suivre la science' en temps de pandémie', *Lato Sensu: Revue de la Société de Philosophie des Sciences*).

Epistemological analyses of the sciences of the environment, from philosophers and practitioners alike, have also insisted on the importance of upholding a clear *theoretical framework*. Proposals include the 'ecosocial theory' and the 'exposome' in epidemiology, 'salutogenesis' in population health or 'eco-evo-devo' in evolutionary biology. These proposals include explanatory patterns and constraints to the interpretations of empirical works, provide a heuristic for empirical work, as well as priority topics to be investigated. On this respect, EBD is mainly driven by an epistemic (to ground design decisions on scientific evidence) and production (to make buildings that are measurably better) imperatives. Its theoretical basis includes contributions from individual, environmental and evolutionary psychology (Cushing & Miller, 2020, *Creating Great Places: Evidence-Based Urban Design for Health and Wellbeing*, Routledge). A critical assessment and a synthesis of these variegated, and possibly contradictory, contributions is thereby an important task ahead (see Menatti & Casado da Rocha, 2016, 'Landscape and Health: Connecting Psychology, Aesthetics, and

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30068

Philosophy through the Concept of *Affordance*', *Frontiers in psychology* 7, DOI: 10.3389/fpsyg.2016.00571, p. 571 for a recent proposal in this direction).

Conclusions

This paper has sought to demonstrate the fruitfulness of an explicit engagement with the epistemic issues raised by the conception of well-designed built environments. It opens a field that involves a complex interplay between, among other things, knowledge production, significant societal stakes, value trade-offs, and aesthetic considerations. Philosophy of science, I have argued, has a key role to play in clarifying the epistemic underpinnings of these issues. This task similarly requires a broader interdisciplinary engagement with philosophy of architecture, architectural research, and design practice.

In this context, the critical study of Evidence-Based Design, and the search for an improved proposal, provide an entry point to the broader epistemological interface between health promotion and built environments. Successfully addressing the therapeutic or pathogenic effects of built spaces has long been seen to require an integrative, interdisciplinary response (see Cartwright *et al.*, 2008, *Otto Neurath: Philosophy Between Science and Politics*, Cambridge University Press). The time is ripe to tackle these epistemological issues head-on.

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30068

The case of EBD sheds light on challenges currently faced by architecture and design research more broadly. In this context, increased possibilities in data collection (through sensors) and data analysis (through artificial intelligence) promise to expand the role of scientific knowledge in the design and management of future facilities (for instance, see Capolongo *et al.*, 2020, 'COVID-19 and Healthcare Facilities: a Decalogue of Design Strategies for Resilient Hospitals', *Acta Biomed* 91(9), DOI: 10.23750/abm.v91i9-S.10117, pp. 50-60). In this context, the development of more robust epistemological frameworks is essential to support these technical developments.

A critical study of EBD can also be viewed in the context of the recent proliferation – in the wake of EBM – of 'Evidence-Based' approaches in a variety of applied fields, including education, law, policy, and nursing. The overarching reach and widespread tangible social effects of these approaches make it all the more pressing to understand the conditions for their successful development, at the epistemic, ethical, and societal levels (Bonnin, in preparation, 'Evidence-Based Approaches as Scientific Imperialism: the Case of Evidence-Based Design').

There are, therefore, a number of reasons to draw epistemological attention to the sciences informing the design of built environments.

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The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30052

The Disunity of Robustness: Hubble Tension

:: **Marco Forgione**

Abstract

The paper examines how conceptual disunity in robustness analysis (RA) can generate contradictory interpretations of the Hubble tension, the discrepancy between independent measurements of the universe's expansion rate. I will consider different philosophical accounts of robustness and how they apply to cosmological practice. I then demonstrate how each framework validates conflicting conclusions. More specifically, I show how Levins' model comparison, Woodward's measurement invariance, and Weisberg's representational accounts each justify different interpretations of whether systematic errors or new physics explain the tension.

Keywords

Robustness; Hubble tension

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THE REASONER 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

1. Introduction: The Paradox of Persistent Disagreement

In contemporary cosmology, a puzzling disagreement persists about how fast our universe is expanding. Astronomers call this the 'Hubble tension' – a long-lasting discrepancy between two sets of measurements of the Hubble constant (H_0), the number representing the current expansion rate of the universe. See: Di Valentino, Said, et al. (2025: *Addressing observational tensions in cosmology with systematics and fundamental physics, Physics of the Dark Universe, 1-416*). What makes this tension philosophically interesting (among other reasons) is that both sides appeal to *robustness* to defend their results. Proponents of higher expansion rates (approximately 73 km/s/Mpc) argue that their measurements are robustly consistent across different observational techniques. Advocates of lower rates (approximately 67 km/s/Mpc) maintain that their models are robustly validated by multiple theoretical evidences. This creates a paradox: Although both camps employ robustness arguments, they also reach contradictory conclusions.

Here, I suggest that, together with the observational challenges of determining the Hubble constant, philosophers should acknowledge the lack of a unique and agreed-upon definition of robustness – what I call: *conceptual disunity*. Indeed, different philosophical understandings of what constitutes robustness, either agreement between models, stability under parameter changes, or measurement convergence, allow scientists to draw incompatible inferences from the same data. This paper explores how this disunity affects the Hubble tension debate and points toward the need for a comparative framework to evaluate competing robustness claims.

2. The Hubble Tension and Competing Robustness Claims

Two Approaches to Cosmic Measurement To understand the Hubble tension, we must distinguish two approaches to measuring cosmic expansion. The first, known as the 'local approach', builds what astronomers call the cosmic distance ladder. This is a series of interdependent methods aimed at calculating the distances of cosmological objects that cannot be directly measured with a ruler. Roughly speaking, the distance ladder can be described by three main rungs:

- First rung: The zero-point calibration uses geometric parallaxes to determine the distance of nearby objects with extreme precision within the Milky Way, or in the Large Magellanic Cloud.
- Second Rung: Measurements in the second rung extend our reach well beyond the local group by leveraging objects with predictable intrinsic brightness. For example: variable stars called Cepheids, whose pulsation periods correlate with their true luminosity.
- Third rung: One uses the same principles applied to

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

the second rung and compares the intrinsic and apparent brightness of different standard candles such as Supernovae Type Ia (SNeIa) to measure their distances and the distance to their host galaxies. From the redshift of such distant galaxies one can use Hubble's law $\vec{v} = H_0\vec{r}$ to infer the Hubble constant.

The second approach, known as the 'global method', examines the cosmic microwave background (CMB) – the faint radiation permeating space that originated when the universe became transparent to light – see: Liddle (2015: *An introduction to modern cosmology, John Wiley & Sons*). This radiation contains small temperature variations that cosmologists analyze using sophisticated models of cosmic evolution, primarily the ΛCDM (Lambda Cold Dark Matter) model. By fitting these models to CMB data, scientists can predict the universe's current expansion rate – see: Agahim, Akrami, et al. (2020: *Planck 2018 results. VI. Cosmological parameters, Astronomy & Astrophysics, 641, A6*).

THE ROBUSTNESS IMPASSE Both the local and global methods appear to be internally robust, and yet they deliver different values for the Hubble constant. Local measurements consistently converge around higher values (H_0 ~73 km/s/Mpc) using different techniques including Cepheid-calibrated supernovae – see, among others: Riess, Yuan, et al. (2022: *A comprehensive measurement of the local value of the Hubble constant with 1 km s^{-1} Mpc^{-1} uncertainty from the Hub-*

THE REASONER 19(4) , 2005. https://doi.org/10.54103/1757-0522/30052

ble Space Telescope and the SH0ES Team, The Astrophysical Journal, 934(1), L7)– , gravitational lensing time delays – see: Wong, Suyu, et al. (2019: *H0LiCOW XIII. A 2.4% measurement of* H_0 *from lensed quasars: 5.3*σ *tension between early and late-Universe probes, Monthly Notices of the Royal Astronomical Society, 498(1), 1420-1439*)– , and water maser observations – see: Pesce, Braatz, et al. (2020: *The Megamaser Cosmology Project. VIII. A geometric distance to NGC 5765b, The Astrophysical Journal, 891(1), L1*). Global methods yield consistent lower values (H_0 ~67 km/s/Mpc) through various analyses of CMB data and baryon acoustic oscillations – frozen sound waves from the early universe imprinted in galaxy distributions. For example: Cuceu, Farr et al. (2019: *Baryon acoustic oscillation and the Hubble constant: past, present and future. Journal of Cosmology and Astroparticle Physics, 2019(10), 044*).

A further distinction that helps clarify the local-global discrepancy is between precision (the tightness of statistical uncertainties) and accuracy (closeness to the true value, accounting for possible systematic biases). Precision can be high in both approaches, but it is achieved under different sets of dependencies: local results rely on calibration chains (distance anchors, stellar-population assumptions, crowding and metallicity treatments), whereas global results depend on cosmological modeling (the structure of ΛCDM, sound-horizon physics, recombination modeling, and priors). Accuracy, in turn, is also conditional: for late-time methods

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30052

it is calibration and population relative, and for early-time methods it is model and prior-relative.

Taken together, these differences lead to a 'robustness impasse': each approach satisfies internal robustness criteria while contradicting the other at a statistically significant level (approximately 5 km/s/Mpc difference, exceeding 4σ confidence). Philosophers traditionally view robustness as a truth-converging mechanism, that is: when multiple independent methods agree, confidence in the result increases. Then, the impasse here is that while the individual methods (distance ladder and ΛCDM-based methods) for calculating H_0 are deemed robust, the same robustness fails when we compare the results across different methods.

3. Philosophical Frameworks of Robustness

Divergent Accounts Philosophical accounts of robustness provide distinct lenses for interpreting the Hubble tension. For example, Richard Levins focuses on the idea of a robust theorem, which he develops by deliberately comparing a collection of simplified models – see: Levins (1966: *The strategy of model building in population biology, American Scientist, 54(4), 421-431*). He observes that each model involves its own artificial assumptions, so one can never be entirely sure whether a given result depends on the genuine features of the system or on the model's simplifications. To address this, he recommends approaching the same problem with several alternative models that share a core assumption but differ in their simplifying details. If all of these models – despite their varied assumptions – converge on the same outcome, then that outcome qualifies as a 'robust theorem', since it depends primarily on the shared core and is largely insensitive to the arbitrary details of any one model. As Levins (1966, p.423) famously puts it: "Hence our truth is the intersubsubsection of independent lies". Yet, while Levins' framework might work for individual methods to calculate H_0, it offers no mechanism for comparing the results obtained from the cosmic distance ladder with those from the ΛCDM model.

A different approach suggested by Woodward (2006: *Sensitive and robust scientific inference, Philosophy of Science, 13(2), 219-240*) distinguishes several varieties of robustness: *inferential robustness* involves the insensitivity of an inference to varying assumptions. *Derivational robustness* occurs when a theoretical result or prediction remains stable under different parameters in the model. *Causal robustness* focuses on the stability of causal relations under different interventions. Finally, *measurement robustness* focuses on the agreement across different measurement techniques or instruments. Notably, local measurements of H_0 primarily emphasize measurement robustness, for example: the Hubble Space Telescope (HST) and the James Webb Space Telescope (JWST) deliver consistent Cepheid results – see: Riess, Scolnic, et al., (2024: *JWST Validates HST Distance*

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

Measurements: Selection of Supernova Subsample Explains Differences in JWST Estimates of Local H0. The Astrophysical Journal, 977(1), 120). On the other hand, global measurements tend to prioritize derivational robustness – the stability of H_0 under variations of the parameters within ΛCDM. While Woodward cautions about distinguishing different types of robustness in order to avoid confusion and misapplications, he does not discuss whether and how different types of robust results can be compared with one another. Without this cross-examination, the robustness of the cosmic distance ladder remains philosophically disconnected from that of the cosmological model.

Another taxonomy of robustness definitions is suggested by Weisberg and Reisman (2008: *Robustness analysis, philosophy of science, 75(1), 106-131*), where they distinguish between three categories. (i) *Parameter robustness*: investigates whether the behavior of a model remains consistent across a range of parameter values. In the case of the Hubble tension, *parameters sweeps* – searching the parameter space for any combination of parameters that would resolve the tension– might expose that no choice of parameters fixes the H_0 tension. Yet, this would not discriminate the existence of some new physics outside the ΛCDM model, or some hidden biases in the datasets. (ii) *Structural robustness*: examines the effects of altering the causal or mathematical structure of the model. But, even if a structural extension could solve the H_0 tension, the risk is to mistake

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

an over-parameterized solution for a genuine resolution of the tension, thereby leaving the fundamental question (new physics vs. hidden systematic) still unanswered. Finally (iii), *representational robustness* evaluates whether predictions hold under different model representations. The limitation is that 'independent' methods often share underlying assumptions (stellar population models, calibrations, etc.). Because of this overlapping, it is difficult to pin down which assumption might be'responsible' for unknown systematics or new-physics.

Orzack and Sober's critique to Levins further complicates matters by arguing that robustness has heuristic value but doesn't guarantee truth – see: Orzack and Sober (1993: *How to be a successful error theorist: the case of Levins' model of robustness, Philosophy of Science, 60(4), 531-550*). They argue that different models can contain false assumptions and yet converge on the same conclusion. Yet, "if every model contains false assumptions, how can we ever hope to discover what is true?" (Orzack and Sober 1993, p.538). Once again, consider how robustness fails in evaluating the results for H_0 using different methods. At best, one can evaluate the robustness of the results of each method individually, but, since each method requires false assumptions and idealizations, it is not possible to determine which method delivers the true value of the Hubble constant.

Finally, Wimsatt (1981: *Robustness, reliability, and overdetermination, in: Characterizing the robustness of science:*

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30052

After the practice turn in philosophy of science (2012), 61-87, Springer.) views robustness as the redundant support of a theoretical framework. That is, whenever there is an inconsistency in a theory due to conflicting idealizations or simplifying assumptions, robustness guarantees that there are alternative derivations of the same conclusions. These alternative (redundant) derivations prevent the inconsistency from propagating to the entire theoretical structure. Unfortunately, this account also provides ambiguous guidance in our case. The local measures of H_0 appear robust through redundant measurement techniques, while the global measures show robustness through model self-consistency. Yet, neither framework decisively resolves which should take precedence when they conflict.

In conclusion, these divergent accounts can be used to validate both interpretations of the Hubble tension: that local measurements contain hidden systematic errors, or that global methods require new physics. Both remain philosophically defensible through selective application of robustness frameworks, demonstrating how disunity permits contradictory conclusions to coexist.

4. The Tension Within the Tension: the TRGB Case Study

A revealing case study emerges from an anomaly within local measurement methods. While most techniques (Cepheid-calibrated supernovae, gravitational lensing) con-

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30052

verge around $H_0 \sim 73$ km/s/Mpc, one method using 'tip of the red giant branch' (TRGB) stars yields a significantly lower value (~69 km/s/Mpc) – see: Freedman, Madore, et al. (2019: *The Carnegie-Chicago Hubble Program. VIII. An independent determination of the Hubble constant based on the tip of the red giant branch, The Astrophysical Journal, 882(1), 34*). TRGB stars are low-mass stars at a specific evolutionary stage where they undergo a helium flash, creating a recognizable brightness cutoff in astronomical observations.

This anomaly creates what might be called 'the tension within the tension' – a disagreement within the local measurement cluster that challenges simple robustness narratives. Indeed, different philosophical frameworks interpret this anomaly differently. For example, a Levinsian perspective might view TRGBs as representing a different 'model' of distance measurements. This could suggest that that the use of different standard candles leads to some fragility when it comes to measurements of the Hubble constant. Similarly, when adopting Woodward's *measurement robustness*, the discrepancy might suggest insufficient agreement across techniques, pointing toward hidden systematic errors rather than new physics. Indeed, if different measurement methods yield different results, this undermines claims of robustness for the entire local approach.

Yet, Weisberg's taxonomy offers multiple interpretations: the discrepancy might reflect representational issues (different stellar physics employed), structural differences (alterna-

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

tive calibration pathways), or parameter sensitivities (variations in how metallicity affects brightness). Each suggests different approaches to resolving the tension within the tension.

Most recently, the James Webb Space Telescope, with its unprecedented infrared capabilities, was expected to resolve such discrepancies – see: Gardner, Mather, et al. (2023: *The James Webb Space Telescope Mission, Publications of the Astronomical Society of the Pacific, 135(1048), 068001*). To see how, it is useful to separate again statistical stability (precision) from systematic stability (accuracy), and to distinguish between direct from conceptual replication. The former evaluates precision and reliability by repeating an experiment with (approximately) the same methods but different statistical sample. The latter probes accuracy by altering experimental methods to expose systematic biases – see: Matarese, McCoy (2024: *When "replicability" is more than just "reliability": The Hubble constant controversy, Studies in History and Philosophy of Science, 107, 1-10*). In these terms, recent observations of Cepheids from JWST provide high-precision direct replication of previous HST measurements (same indicator, improved instrument), mitigating crowding and blending concerns. At the same time, TRGBs function as conceptual replications of the distance ladder: they involve different stellar physics, calibration anchors, and selection effects, thus probing accuracy in a way that is partly orthogonal to Cepheids.

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

JWST has confirmed the HST measurements of Cepheid variables with remarkable precision, strengthening claims of measurement robustness for this method – see: Riess, Anand, et al. (2024: *JWST observations reject unrecognized crowding of cepheid photometry as an explanation for the hubble tension at 8σ confidence, The Astrophysical Journal Letters, 962(1), L17*). That is, the improved resolution of JWST indeed resolved possible concerns about stellar crowding, and other systematics, seemingly validating the higher H_0 values. But, at the same time, JWST observations of TRGB stars validated lower H_0 values, preserving the disagreement within local methods – see: Freedman, Madore, et al. (2024: *Status report on the Chicago-Carnegie Hubble Program (CCHP): Three independent astrophysical determinations of the Hubble constant using the James Webb Space Telescope, The Astrophysical Journal, 985(2), 203*).

From the perspective of Levins and Woodward, it seems rational to acknowledge that different robustness dimensions have strengthened the robustness of H_0 estimates within each standard candle method (Cepheids and TRGBs), but the disagreement between the two standard candles remains unsettled – as well as the broader tension between local and global methods.

Following Weisberg's taxonomy, the three notions of robustness can lead toward different conclusions about the Cepheid-TRGB tension within the tension. If modest changes in parameters (e.g., metallicity corrections, extinction models) can reconcile Cepheid and TRGB results, one might infer hidden systematics. Conversely, if no plausible parameter adjustments can bridge the gap, parameter robustness would leave us with an underdetermined conclusion. At the same time, resorting to different calibrators, data processing methods, or representations, could indicate either the distance ladder's fragility or the ΛCDM model's limitations.

To take stock, the coexistence of the strengthened precision for Cepheids and the persistent disagreement with TRGBs demonstrates how technological advances don't automatically resolve robustness disunity. Indeed, they can reinforce existing interpretive frameworks by providing higher-precision data that remains subject to different philosophical interpretations.

5. Navigating Robustness Disunity

The TRGB case above shows that higher precision can strengthen measurement robustness within a method without resolving cross-method disagreement. Therefore, I suggest that the way forward is to structure comparisons across robustness notions so that different robustness claims can be weighed 'side by side'.

For example, both Cepheid and TRGB distances should be compared to multiple independent anchors, and the resulting calibrations should be checked against independent H_0

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

determinations to expose any remaining systematics in the cosmic distance ladder. Examples of such independent H_0 measurements include geometric megamasers (which also serve as anchors), quasar lensing, and prospective ‘standard sirens’ from gravitational waves – see: Perivolaropoulos (2024: *Hubble tension or distance ladder crisis?, Physical Review D, 110(12), 123518*). Results from different anchors should then be reported and compared directly, while holding fixed the sample of Type Ia supernovae and data reduction techniques. By swapping only the rungs of the distance ladder that differ between the Cepheid and TRGB methods, any shift in the inferred Hubble constant can be traced to a specific analytical step. Furthermore, to avoid overstating independence, one should make explicit the shared assumptions and statistical priors used across methods in order to keep track of how calibration steps interrelate. While these tests apply to TRGBs, Cepheids and to the distance ladder, a similar approach should be applied to the ΛCDM model and its inferences for H_0.

With respect to robustness, these tests adopt the form of a bottom-up strategy: (i) start within a single standard candle (e.g., Cepheids or TRGB) and vary likely systematics (crowding, metallicity, photometry) to test measurement robustness; (ii) compare across standard candles to probe representational robustness; (iii) compare across independent distance methods (ladders, masers, lensing, standard sirens) to assess methodological independence; and (iv) finally con-

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30052

front local and global determinations under explicit model and calibration choices to test derivational/model robustness. At each stage, ask whether a result persists under the corresponding stress test. The more layers a claim survives, the more comparably robust it is across these distinct notions, while a failure at a given layer should indicate where disagreement enters.

A note of caution: this method is only provisional and it will not resolve the Hubble tension by itself. The scarcity of truly independent astronomical anchors, despite JWST's power, means the comparative analysis may still rest on a limited and potentially problematic foundation. Similarly, the high statistical uncertainties of methods like megamasers or gravitational lensing limit their power to discriminate between subtle systematic errors in the primary distance ladder techniques. These practical limitations are not merely logistical but are philosophically significant, since they concretely manifest the dependency problem at the heart of robustness disunity. Acknowledging this is crucial to understanding that resolving the tension will require simultaneous progress on both empirical and conceptual fronts.

Conclusion

In this paper I demonstrated how the disunity of robustness allows for contradictory interpretations of the Hubble tension. Yet, this disunity can suggest a productive path for-

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30052

ward for philosophical work: rather than seeking a single, monolithic account of robustness, the focus should shift to developing a comparative framework – a bottom-up strategy – for evaluating different types of robustness claims against one another. Such a framework requires articulating the specific dependencies and idealizations inherent in each method (e.g., the calibration chain for Cepheids, the sound horizon physics for ΛCDM) and then probe those dependencies in controlled ways. The goal is not to eliminate disunity, but to create a structured dialogue between competing robustness standards.

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THE REASONER 19(4), 2005. https://doi.org/10.54103/1757-0522/

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The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30066

"Homo ex Machina": A Historico-Philosophical Analysis of the Machine-Organism Analogy

:: **Maurizio Esposito**

Abstract
From the early modern period onward, philosophers, naturalists, and physicians have speculated on the extent to which the organic body might be understood by analogy with machines such as automata, clocks, and other mechanical artifacts. This paper examines the assumptions underlying these comparisons, tracing the material and conceptual conditions that have shaped the perceived relations between organisms and artifacts. I argue that these comparisons must be situated within two dominant conceptions of the machine: an anthropocentric and a non-anthropocentric one. By reconstructing their historical emergence, I suggest that this distinction is crucial for understanding how continuities and differences between organisms and machines have been, and continue to be, conceptualized.

Keywords
Machine analogies; mechanism; organism; life sciences.

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1. Introduction

Since the Spanish Renaissance physician Gómez Pereira claimed in his *Antoniana Margarita* (1554) that animals are complex machines, many have speculated about the continuities and discontinuities between mechanical artifacts and living organisms. However, what has received far less attention is the nature of the relationship itself. In other words, when and how was the apparently self-evident idea that machines and organisms resemble one another crafted? Why did people come to believe that human-made devices and the living world might share something in common? In this paper, I aim to uncover some of the contexts in which this relationship not only emerged but also acquired its various meanings and legitimacy. More precisely, my aim is to challenge the assumed obviousness of the machine-organism analogy by uncovering the material and intellectual contexts that make it appear somewhat compelling.

This paper is admittedly brief, and I can only touch on the surface of a long and complex history, which I simplify by claiming that it hinges around two fundamental conceptions of mechanical artifacts: an anthropocentric and a non-anthropocentric one. The former defines the machine in relation to its capacity to substitute some aspects of human labor, whereas the latter regards machines as relatively autonomous entities whose organization and function are independent of human intention or utility. For brevity's sake, I will focus on one exemplary moment that illuminate the rationale behind these two conceptions: Marx's famous definition of "machine" in Chapter 15, "Machinery and Large-Scale Industry", of the *Capital*, Vol. 1, along with its fascinating connections to Charles Babbage. Rather than merely offering a further redescription of this episode, which has been aptly chronicled by Simon Shaffer (Schaffer S. 1994, Babbage's Intelligence: Calculating Engines and the Factory System, Critical Inquiry, 10.1086/448746, Vol. 21, No. 1, 203) and, more recently by Matteo Pasquinelli (Pasquinelli M., 2023, The Eye of the Master: A Social History of Artificial Intelligence, Verso Books 2834-703X), my aim is to reinterpret it in light of the long durée history of machine–organism relations and on the conflicting conceptions of what a mechanical artifact is (or might be). Finally, I argue that the most compelling justification for the connection between artifacts and organisms lies not in pretended self-evident isomorphisms or loose metaphors and analogies, but in human labor itself. It is the continuous, embodied experience of working with instruments and tools (later developed into full-fledged machines), that first suggested a continuity between these artifacts and human limbs, and ultimately, between machines and the human (and eventually animal) body.

2. The will to "machine"

Strictly speaking, the origins of the organism-machine analogy long predate Gómez Pereira, Descartes, and other Renaissance thinkers, reaching back to antiquity. In *De Motu Animalium,* for instance, Aristotle famously compared animal motion to that of automata: "The movement of animals is like that of automatic puppets...the cables are released and the pegs strike against one another" (Aristotle, 1985, *De Motu Animalium*, (ed.) Nussbaum M., Princeton University Press, 9780691020358, 701b, 1985, 42). One may ask: why did Aristotle consider mechanical devices relevant for understanding a biological process such as animal motion? If anything, what ultimately justifies linking an artifact to a natural phenomenon? Aristotle himself expressed some hesitation regarding how far the analogy could be extended. In fact, in the very same paragraph quoted above, he noted that, unlike machines, animals possess internal processes like sensation and imagination. Aristotle cautioned against equating automatic puppets with genuine physiological processes, noting that any similarities we perceive are more pedagogical than ontological. His warning

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30066

underscores that the analogy was far from transparent and required constant qualification. I argue, in fact, that for the analogy to be useful, the conceptual link had to be constantly reinterpreted and readapted to different disciplinary contexts, whether physiological texts, biological writings or mechanical treatises. Perhaps, a useful starting point is to trace the genealogy of the concept of 'machine' itself, and to see how the concept was originally intertwined with the organic and human world, is the pseudo-Aristotelian text *Mechanical Problems*.[1] In it, we find an influential and revealing definition of a mechanical device:

> For in many cases nature produces effects against our advantage; for nature always acts consistently and simply, but our advantage changes in many ways. When, then, we have to produce an effect contrary to nature, we are at a loss, because of the difficulty, and require skill. Therefore we call that part of skill which assists such difficulties, a device (Pseudo-Aristotle,

[1]In this context, Espinas A, 1897, *Les Origines de la Technologie: Étude Sociologique*, Paris : Felix Alcan continues to offer valuable insights. For a more recent study on the history of "machines" in the ancient and modern world, see Riskin J., 2016, *The Restless Clock: A History of the Centuries-Long Argument over What Makes Living Things Tick*, https://press.uchicago.edu/ucp/books/book/chicago/R/bo21519800.html, Chicago, University Press, 10.1007/s40656-018-0227-9; Di Pasquale G., 2020, *Le macchine nel mondo antico*, Roma: Carocci Editore, 978-8843095896

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30066

> 1936, Mechanical Problems, (ed.) W. S. Hett, Loeb Classic, https://www.loebclassics.com/view/LCL307/1936/volume.xml, 847a, 331)

The apparent simplicity of this definition can obscure their deeper philosophical significance. It suggests that the real essence of a machine does not lie in its materials, structure, or functional organization, but in its ultimate function of a tool designed to assist or replace human labor. Implicit here is the central role of the human body and its limitations, as we build machines to perform tasks we cannot or prefer not to do ourselves. There is no generalized, theoretical or metaphorical resemblance between organisms and machines, but a direct, functional continuity: machines are extensions of the organic body designed to fulfill the same or comparable human tasks.

A similar perspective reappears in the first century BC in Vitruvius's *De Architectura*, where he defines a machine as "a combination of timbers fastened together, chiefly efficacious in moving great weights" (Vitruvius, 1914, The ten book in Architecture, Trans. M.H. Morgan, Harvard University Press, Book X, 283). To Vitruvius, a machine is any artifact made by humans to harness or resist the forces of nature in order to fulfill some specific labor. These definitions, drawn from both the Peripatetic text and Vitruvius, illustrate what I call the anthropocentric conception of the "machine"; according to which what matters most is not its structure,

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30066

organization, or design, but the function it serves in fulfilling human needs. And because machines were understood as *proxies* of animal or human activity, it was scarcely conceivable to *identify* living organisms with machines. The former, after all, provided the original models for mechanical design, not the reverse.[2]

In the late nineteenth century, the geographer and philosopher Ernst Kapp expanded on this insight through his theory of organ projection, which suggested that every technical artifact was, in essence, an unconscious projection of a human organ.[3]

Interestingly enough, since the advent of Cartesian modernity, the explicit connection between machines and the organic body has become increasingly implicit. The idea of machines as *proxies* for human or animal labor gradually faded into an unexamined background, while the structure, kinematic and design became much more significant to define what a technical artifact is. Most importantly, the technical artifact was no longer regarded as a mere derivative

[2] Of course, in *Politics,* Aristotle entertained the possibility of a world in which automata could replace slaves. Yet this example did not imply that organisms are machines; rather, it suggested that slaves functioned much like machines.

[3] On the hypothesis of organic projection, see Esposito M., 2019, In the beginning was the hand: Ernst Kapp and the relation between machine and organism, https://revistas.uv.cl/index.php/RHV/article/view/1942, Humanities Journal of Valparaiso, 10.22370/rhv2019iss14pp117-138, 14:117-138

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30066

of the organic body but became the very principle through which that body could be explained. For many Cartesians, machines were significant less for their power to replace human labor than for their epistemic role in explaining life itself. That is why by setting aside the "human premise", the machine came to serve as the fundamental prototype for understanding organic entities. This "non-anthropocentric" perspective made it possible, at once, to conceive the machine as a prototype of life and to legitimize its identification with living systems.

Descartes exemplified the shift between anthropocentric to non-anthropocentric conceptions vividly. His idea of a 'machine' was not a proxy for specific human activities, but a template used to understand physical and biological phenomena. At the very beginning of his *Treatise on Man*, Descartes famously writes: "I suppose the body to be just a statue or a machine made of earth… We see clocks, artificial fountains, mills, and other similar machines which, even though they are only made by men, have the power to move of their own accord in various ways." (Descartes R., 2004, *The World and Other Writings*, Cambridge: CUP, 10.1017/CBO9780511605727, p. 99) Descartes did not start by defining the concept of a machine and then applying it to organic entities. Instead, he immediately compared organic entities to machines, treating the analogy as self-evident. He based the analogy an epistemic continuity between human and God. Just as the former build machines, the latter fabri-

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30066

cates living bodies. In this sense, machines are not only artifacts governed by natural laws or devices built to do some work: they are nature itself. The cosmos is a vast mechanism composed of smaller ones, including human beings. In this turn, the "machine" no longer reflects human labor or purpose; it becomes an abstract, non-anthropocentric model of the universe. This unique and powerful conception of "machine" becomes a heuristic template capable of mirroring both the microcosm and macrocosm.

The Cartesian view was widely adopted by most mechanists who followed in Descartes' wake. Nearly a century after his death, the French physician Julien Offray de La Mettrie, in his famous and controversial *L'Homme Machine* (1748), argued that the organic body was nothing more than a complex, self-regulating machine. It is the "machine" that explains the organic body, not the other way around. In the late nineteenth century, the British physiologist Thomas Huxley, in his influential essay "On the Hypothesis that Animals Are Automata, and Its History" (Fortnightly Review, 1874), maintained that the Cartesian project of using machines as templates for understand organic phenomena was more valid than ever.

Yet perhaps the most lucid articulations of this Cartesian, "non-anthropocentric" outlook emerged not from philosophers or physiologists (who seldom sought to define what a machine is) but from the makers of machines themselves. Indeed, just three years after Huxley's paper, the German

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30066

nineteenth-century mechanical engineer Franz Reuleaux, in his influential *Kinematics of Machinery* (1876), defined a machine as nothing more than: "... a combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinate motions" (Reuleaux F., 1876, *The Kinematics of Machinery: Outlines of a Theory of Machines*, Macmillan and CO. 978-0486611242, p. 35). Reuleaux's definition aligns with many others of its kind, though he acknowledged that definitions of "machine" often vary and rarely agree with one another.[4]

Reuleaux, of course, did not entirely dismiss the role of human intention in defining machines. But he thought that the human element was relevant insofar as the specific performance of a machine is considered, i.e., in assessing how, and to what extent, the artifact accomplishes the task for which it was designed. However, the idea that a machine is essentially an extension of human labor is notably absent from Reuleaux's definition, as well as from those of many other 19th-century mechanical engineers. To summarize, since Descartes, machines are reconceptualized as ahistorical entities, as objects that can be studied and understood independently of the historical and contextual circumstances of their production. As they lose their ancient connection to human needs, machines begin to be seen as quasi-natural

[4]Reuleaux listed over twenty definitions of "machine", but most of them omit the human element entirely.

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30066

entities in their own right.

There is no doubt that many philosophical debates since the 17th century have unfolded against the backdrop of this remarkable modern idea: the non-anthropocentric conception of the machine. Yet, if machines are understood as extensions or projections of living organisms (as the anthropocentric conception holds) should the machine-organism analogy be radically reconsidered?[5]

In the next section I will provide only a very partial, short and tentative answer.

3. Marx among the "machines"

> On a closer examination of working machine proper we rediscover in it as a general rule, though often in highly modified forms, the very apparatus and tools used by the handicraftsmen or the manufacturing power... The machine, therefore, is a mechanism that, after being set in motion, performs with its tools the same operations as the worker formerly did with similar tools (Marx K., 1990, *Capital,* Vol 1.,

[5] On the hypothesis of machines as extension of the organic body, see also Canguilhem G., 2009, "Machine and Organism", in *Knowledge of Life*, https://www.degruyterbrill.com/document/doi/10.1515/9780823291977/html, Fordham University Press, 10.1515/9780823291977-007, 75-97.

https://www.penguinrandomhouse.com/books/261069, Penguin Books, p. 494)

This famous passage appears in Book I of Marx's *Capital*, in Chapter 15, "Machinery and Large-Scale Industry." It exemplifies a well-known anthropocentric view of machines shaped by Marx's analysis of industrial production. The key message here is the conceptualization of machines as material extensions of human labor that replicate and replace human activities. Marx was possibly acquainted with the pseudo-Aristotelian definition of machine, but his explicit source of inspiration lies elsewhere. In fact, he was deeply indebted to Charles Babbage and his 1832 work *On the Economy of Machinery and Manufactures* (Babbage C., 2010, On the Economy of Machinery and Manufactures, https://www.cambridge.org/core/books/on-the-economy-of-machinery-and-manufactures, Cambridge: CUP, 10.1017/CBO9780511696374).[6] Known today as the father of the "computer" for his Difference and Analytical Engines, Babbage's deeper project reflected a unique view of machinery. Originally, a "computer" was a person who performed calculations. Babbage himself applied for such a role in 1814 but found it tedious, prompting him to invent a machine to replace human computers. While preparing his book, Babbage toured workshops and factories across England, studying manufacturing and exploring how to reorganize labor scientifically. In the early 19th century, figures

[6]Which was mainly discussed by Marx in the *Grundrisse*.

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30066

like Babbage participated in industrial tours that were both educational and ideological performances. As Simon Schaffer noted, Victorian guides often celebrated machines not only for their technical prowess but also as symbols of industrial progress "...which enables a child, or the machine itself to operate on masses of metal, and to cut shavings off iron, as if it was deprived of all hardness, and so mathematically correct that even Euclid himself might be the workman" (Schaffer, 1996, 220).

Victorian enthusiasts imagined a future where sophisticated machines were operated by unskilled, cheap labor (mostly children or untrained workers). In this context, Babbage's Analytical Engine was more than an academic feat and marked a turning point in industrial rationalization. Designed as a Turing-complete machine, it could execute any instructions encoded on punched "numerical cards" that embodied human intentionality. The machine could act as a tireless, obedient servant to factory managers, enabling them to replace many workers with precise, docile automatons controlled by numerical input. But beyond its political implications and impact; what does it really mean that human labor is replaced by semi or fully automatic machines? Marx had his answer: through Babbage, he saw the machine as a human *proxy* synthesizing and embodying multiple tasks once requiring many hands and minds; "...the product is entirely made by a single machine, which performs all the various operations previously done by... several handicraftsmen

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30066

successively, either separately or as members of a system of manufacture” (Marx, 1990, 500)

A sequence of discrete operations could be reduced to a limited set of instructions, then encoded and effectively "compressed" into a machine, enabling a single device to perform the work of many laborers, whether skilled or unskilled. Babbage championed technological progress and genuinely believed (or at least professed to believe) that automation would liberate human beings from monotonous, dangerous, or physically exhausting tasks. Marx, by contrast, entertained no such optimism. In Volume I of *Capital,* he opens Chapter 15 with a revealing quotation he got from John Stuart Mill: “It is questionable if all the mechanical inventions yet made have lightened the day’s toil of any human being.” (Mill, quoted in Marx, 1990, 492). This line succinctly captures the central argument developed throughout his long chapter: the replacement of animal and human labor by machines did not improve the condition of workers: it worsened it. The true function of machinery, Marx argued, was never to lessen the worker’s burden, but to increase the surplus value extracted from labor within the capitalist production process.

Under capitalism, machines serve a singular, overriding purpose: to reduce the cost of commodities by accelerating production. The immediate consequence of large-scale mechanization was the displacement of skilled workers, who were replaced by unskilled laborers; primarily women and

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30066

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children. This dynamic followed what became known as the "Babbage Principle," which held that complex tasks should be performed by highly paid specialists, while simpler, repetitive tasks should be assigned to lower-paid, less-skilled workers. Yet Babbage's ultimate vision extended further: to eliminate the need for skilled labor altogether by substituting machines and cheap, easily managed human labor.

Machines did not just replace human effort broadly; they took over complex, time-consuming tasks suited to mechanization. Tasks that remained for humans were typically assigned to unskilled laborers, as their wages were lower than the costs required to automate those tasks. For Marx, in fact, automation under capitalism followed a harsh pattern: machines replaced animals, then adult men, and finally pushed women and children into remaining roles. Rather than providing human emancipation, machines increased and deepened subjugation and enslavement. Marx saw machines as embodying the accumulated skills of human labor and offered a distinctly anthropocentric definition. Inspired by Babbage's manufacturing philosophy, he noted that machines replace not only human limbs but also mental work. Both saw machinery as collective social intelligence embodied in concrete artifacts, but while Babbage viewed the process as a positive outcome of science, Marx saw it as a potential burden imposed on workers by capital.

What I have shortly sketched here is the context and sub-

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30066

stance of a more recent anthropocentric conception of the machine. According to this view, machines are *proxies* of certain functions of organic labor and thereby form an intimate connection with the living body. So intimate, in fact, that it is often mistaken for an identity. But by forgetting the diachronic ties between technologies and organisms, we also lose sight of the simple fact that mechanical technologies are nothing more than contingent outcomes of the unpredictable course of human history. This should seem deeply problematic to anyone who views machines and living beings as essentially the same. After all, why assume that technologies that came out of a specific and accidental history can tell us how living systems work? The supposedly ahistorical and non-anthropocentric idea of the machine (so dominant in our culture) is itself the product of a very specific history, one that we have yet to fully uncover and understand.

4. Conclusion

The concept of the "machine" has historically been framed in anthropocentric terms. It was conceived from the beginning not as an independent entity, but as a projection of human labor; a means of extending and substituting the capacities and tasks of the human body and mind. Yet, throughout modernity, this intimate bond between human bodies and mechanical artifacts gradually waned. As machines increasingly supplanted human labor, the human element was paradoxically and deliberately bracketed out. Following Descartes' enthusiastic embrace of mechanical philosophy, a non-anthropocentric and de-historicized conception of the machine emerged; one that no longer regarded the machine as a derivative or proxy of human activity, but rather as the prototype for explaining all organic processes and functions. And yet, throughout the 19^{th} century, anthropocentric views were often recovered from their temporary neglect. Babbage himself imagined machines capable of replicating the dexterity of human hands and the precision of human thought, an idea that deeply intrigued Marx. For both thinkers, machines were not alien entities, but projections of human labor, deeply rooted in the social and material fabric of life.

I suggest that this anthropocentric framework be seriously reconsidered today when examining the relationship between organisms and machines. The anthropocentric view shows that machines can only simulate those aspects of the organic world as functional stand-ins for human activity. But the persistent tendency to de-historicize mechanical artifacts have often obscured the way machines become "organs" for human labor. Acknowledging these anthropocentric origins allows us to understand machines not as objects independent of human *praxis*, but as historical and contingent artifacts that embody specific dimensions of human agency. In short, when we adopt an anthropocentric conception of the machine, the question of whether organisms are machines takes on a distinct philosophical (and often ethical) signifi-

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30066

cance, as the cases of Babbage and Marx compellingly illustrate.

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THE REASONER 19(4), 2005. https://doi.org/10.54103/1757-0522/

Which Role Should Philosophy of Science Play in the Public Discourse?

:: **Stefano Canali and Carlo Martini**

Abstract
This feature reports the content and result of one of the World Café sessions held at the Logic and Philosophy of Science conference (12th March 2025), which focused on the role that philosophy of science is playing and could and should play in the public arena.

Keywords
Public Philosophy; Science Communication; Public Understanding of Science

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Stefano Canali and Carlo Martini. *Which Role Should Philosophy of Science Play in the Public Discourse?*. THE REASONER 19(4) 2025. https://doi.org/10.54103/1757-0522/29895

At the Logic and Philosophy of Science event held in Milan, the philosophy researchers gathered at the conference discussed the topic during a double World Café session. Early-career scholars, postdocs, and faculty members engaged in an open conversation about the role that philosophy of science is playing and could and should play in the public arena. This World Café session was elicited by the recognition that several philosophers play the role of public intellectuals in many European countries, including Italy, and are asked to comment on several timely issues in the general media. Yet most of the time it remains unclear what kind of expertise philosophers bring to the public discourse and most of the time none of the philosophers who currently engage with the public discourse are philosophers of science. At the same time it seems to us that philosophers of science have expertise that can be helpful to many areas of the public discourse, including issues such as climate change, technology development, public health crises, mis- and disinformation, gender issues, and more. We thus wanted to use some time during the Logic and Philosophy of Science meeting to discuss these issues and collect insights from participants, and we did so with a number of conversations that spanned a wide range of topics we illustrate below.

A first topic of discussion had to do with the cultural context of public discussions to which philosophy of science can contribute. Many of the participants said that the cultural context in countries such as Italy comes with what can

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/29895

be considered prejudices or at least implicit assumptions on what philosophy is and what counts as philosophical expertise. The image of the philosopher seems to be still very much equated to Continental and Post-modern ideas, where the philosopher is most often an intellectual that is versed in literary studies and the history of ideas. This is in stark contrast to contemporary philosophy in general and philosophy of science, whose experts are rather interested in the role of science in society. At the same time the fact that philosophers – even if a more traditional type of philosophers – are often called to comment on current affairs and in the public discourse was considered generally positive and a starting point for more public engagement from philosophers of science. Moreover, the increasingly specialist nature of philosophy of science – we are increasingly experts in the philosophy of a specific discipline, like medicine, economics, or physics, rather than philosophy of science tout court – was mentioned as a possible obstacle for public engagement, as something that does not make it easier for the media to receive our expertise.

A series of considerations focused on when and how philosophy of science should engage in the public discourse. Public engagement may be considered among our responsibilities but can be very time-consuming and should probably require acquiring new skills for the task. In this direction, many commented on the fact that this is most often an activity that won't get recognition and consideration in the CV

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/29895

of philosophers of science or amongst colleagues. Indeed the increasing visibility that may come with public engagement might be seen as a problem by colleagues and its results can be difficult to measure and qualify. The problem is that, while we have tools to measure the outcomes and quality of research and teaching we don't have something similar for public engagement.

Several participants to the World Café session discussed the topics where philosophy of science expertise would be important and to which ends engagement on these issues should point towards. There are several topics that are central to the public discourse on which philosophers could discuss as experts, at the same level as other scholars and scientists. And yet media discussions often take place at a time scale that makes it difficult to philosopher of science to engage – many participants mentioned the pandemic as a clear example in this direction, where philosophy of science expertise could have contributed to better understand several issues (e.g. the role of models, the implications of fast science, private-public interests in medicine, etc.) but the media cycle was very fast and changing.

We concluded this session with a set of critical remarks but also a range of suggestions and directions where we could go as philosophers of science contribute to public debates. Our role is changing and perhaps should change – in the direction of better informing the public and colleagues on the nature of scientific knowledge, its capacity and limitations, and the

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/29895

role it can and should play in our societies.

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The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/

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COSMOS: The History and Philosophy of Cosmology Network

:: **Silvia De Bianchi**

Abstract
Overview of the aims, scope and results obtained within the CARIPLO funded COSMOS research project (2021-2026)

Keywords
Philosophy of Cosmology; History of Cosmology; Astrophysics; Epistemology; Universe; Black Holes; Simulations.

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COSMOS (2021-2026) is sponsored by Cariplo Foundation and hosted by the University of Milan. The project aims to create a network of experts from the fields of astrophysics, astronomy and cosmology that can systematically interact with philosophers on topics concerning the study of the universe, its phenomena and laws, in order to develop categories suitable for the understanding of cosmology as a unique practice of human beings. COSMOS relies on the consideration that our ability to do cosmology is deeply rooted in the foundations of mathematics, technological innovation and anthropology and on the awareness that only a multi-disciplinary collaboration can grasp all implications that theoretical and observational cosmology brings with it.

COSMOS main research questions are addressed by the network members who can interact through a platform (Slack) and can meet online in Virtual Labs to present and discuss their ideas, independently from the research pursued by the core research team. An annual meeting is held online and open to all members of the network who can also interact during our biennial conferences in History and Philosophy of Cosmology (1st H&PCC was held in 2022, the 2nd in 2024 in Milan and the next one will be held in Athens in 2026).

COSMOS research questions include:

1. The idea of universe: why does the need of modeling the universe arise? Is there a functionalist reading

of the dark sector and objects, such as black holes? (VIRTUAL LAB 1)

2. Paradigm/testing relationship of a theory and its models: How do we use high-energy physics to study matter and the early stages of the universe? How do we use nuclear physics and other branches of physics to understand the evolution of stars and map the observable universe? Which aspects of these practices show continuity/rupture with the past? (VIRTUAL LAB 2)

3. What is the role of analogical reasoning in astrophysics and cosmology? How could we attain confirmation from this? Which kind of inferences were used in the past when talking about the universe and its properties? (VIRTUAL LAB 3)

4. Which theoretical and observational challenges our physics encounters and which ones should be addressed in a new fundamental theory? (VIRTUAL LAB 4)

5. Which theories and ideas about the origin and development of the universe crossed the history of philosophical thought and cosmology? (VIRTUAL LAB 5)

Throughout the years, the core research team was constituted by the PI (Prof. Silvia De Bianchi) and postdocs (Dr

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30077

Laura Marongiu, Dr Laura Follesa, Dr Marco Forgione, Dr Federico Viglione) from different backgrounds, including the history of ancient and early-modern cosmology, the philosophy of physics and the philosophy of time. The team regularly publishes on peer-review journals of high impact and their research addresses hot topics in cosmology and theoretical physics, such as the nature of black holes (is it possible to avoid singularities in a GR setting?), cosmic time (what is the nature of cosmic time and its consistency with positions in the philosophy of time?), and the Hubble tension (i.e. there is a discrepancy in the measured values of the Hubble constant, which describes the universe's expansion rate, depending on methods at hand; is this due to epistemic biases or points to new physics?), by discussing the philosophical assumptions and implications they bring with them.

Among the publications of the team, it appears the volume Time and Timelessness in Fundamental Physics and Cosmology (2024) that brought together historians, philosophers and scientists to discuss major open questions in the philosophy of cosmology and quantum gravity. With regard to observational cosmology, both the PI and Dr Forgione are working on the epistemology underpinning the EUCLID mission and to elaborate a suitable notion of robustness in dealing with problems such as the Hubble tension, respectively.

Thus, COSMOS has four main objectives:

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30077

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30077

1. To **implement** research in the history and philosophy of cosmology, including topics from space sciences.

2. To **establish** a network of scientists (astrophysicists, cosmologists) and philosophers to pursue the development of categories suitable for the understanding the universe and its processes.

3. To **create** the possibility of inserting the history and philosophy of cosmology between training subjects in higher education.

4. To **share** knowledge with the public on the challenges of the 21st century concerning our understanding of the universe and the use of space.

With regard to objective 3, the BA in Philosophy at the University of Milan - STATALE counts on a course in Philosophy of Physics that includes a practical lecture on the use of telescopes and the integrated study of cosmology and philosophy that led to increase the number of students writing up their thesis on philosophical questions surrounding our current models in cosmology and astrophysics.

Further information and the library of videos and publications can be found on the website https://cosmosproject.unimi.it.

Selected list of COSMOS publications

- De Bianchi, S. (2025) “Null geodesics, causal structure, and matter accretion in Lorentzian-Euclidean black holes” (with S. Capozziello & E. Battista). Phys. Review D DOI: 10.1103/ybjp-8w2w
- De Bianchi, S. (2025) “Atemporality from Conservation Laws of Physics in Lorentzian-Euclidean Black Holes” (with S. Capozziello & E. Battista). Foundations of Physics 55, 36.
- De Bianchi, S (2025). Open Questions on Spacetime and Gravitation. Journal of Physics: Conference Series proceedings of DICE2024.
- De Bianchi, S. (2025). “Achronotopic Interpretation of Quantum Mechanics: Quantum Objects and Their Measurement in Emergent Space–Time Scenarios”. (with I. Szapudi), Foundations of Physics, 55(1), 4.
- De Bianchi, S. (2025). “Time and Cosmology”. In Emery, N. (ed) Routledge Companion to the Philosophy of Time. Routledge.

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Reasoning with Data (ReDa)

:: **Hykel Hosni**

Abstract
Overview of the aims, scope of the Reasoning with Data (ReDa) research project (2024-2028), funded by Italian Ministry for University and Research under the *FIS1 Advanced Grant* scheme G53C23000510001

Keywords
Reasoning with data; statistical inference; data-driven inference; logic; medical decision-making.

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Hykel Hosni. *Reasoning with Data (ReDa)*. THE REASONER 19(4) 2025. https://doi.org/10.54103/1757-0522/30344

Data abounds and our ability to process it algorithmically is unprecedented. This opens up exciting prospects for scientific and technological advances that were unimaginable only two decades ago. Data-intensive and AI-driven methods are therefore likely to shape a significant proportion of science in the decades to come. This requires us to rethink the very idea of scientific knowledge, from the way it is produced to its technological and cultural transfer to society.

During its five year span (2024-2028), the *Reasoning with Data* (ReDa) project will aim to advance the state of the art in the methodology of reasoning with data. It is funded by Italian Ministry for University and Research under the *FIS1 Advanced Grant* scheme G53C23000510001, and it is hosted by the Department of Philosophy at the Università degli Studi di Milano.

ReDa tackles two ambitious research objectives: the identification of criteria of logical validity for data-driven inference, and its impact on the construction of scientific evidence, especially in the context of rare cancers.

Logical validity for data-driven inference

We assume that data, however produced, can lead scientists to reject or to support, to some degree and possibly by mistake, any given scientific hypothesis. Our goal is to put forward consequence relations whose intended semantics capture established patterns of data-driven hypothesis-rejection

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30344

as well as data-driven hypothesis-confirmation. Unlike the large literature taking issue with p-values or Bayesian confirmation, ReDa takes logical perspective on the problem. This means that we seek criteria of validity that are independent (to the largest possible extent) of the specific philosophical views a methodologist may have on the foundations of statistics.

Our initial results are encouraging. In Baldi et al 2025 (P. Baldi, E. A. Corsi, and H. Hosni. "A Logical Framework for Data-Driven Reasoning." *Logic Journal of IGPL* 33(3) 10.1093/jigpal/jzae113) we have put forward a rather general method based on imposing logical constraints on how data may reject hypotheses and shown how this leads to a family of consequence in the style of the KLM approach to non-monotonic logics. In current work we are extending this framework to the recent Grünwald et al's *E-values* as well as to more traditional *Bayes factors*. On a related but independent research track, we are working on the formalisation of Polya's *patterns of plausible reasoning*.

Methodology for the construction of probabilistic evidence in rare cancers (MePeR)

How can probabilistic evidence be constructed when data are gappy, scarce and unreliable? To tackle this question the ReDa project coordinates the Research Centre on "Methodological foundations of the construction of Probabilistic Evidence in Rare Cancers" (MePeR), launched in late 2024 in collaboration with Istituto Nazionale Tumori in Milan and the Department of Oncology and Ematology-Oncology (DIPO) at the University of Milan.

MePeR aims to advance the state of the art in the methodological foundations of probabilistic reasoning in conditions of great uncertainty, which, paradigmatically, occurs in rare tumours, therefore used as a model of the lack of evidence in medicine . By their nature, in fact, rare tumours pose significant problems in the application of conventional statistical methods in clinical research. This has a negative impact on the formation of evidence, therefore on clinical decisions, and therefore on the quality of care.

The research objectives of the MePeR team is twofold 1) to develop methodologically rigorous approaches to a personalised formulation of probabilities in clinical decisions and in patient information; 2) to create (technological) solutions to share the clinical decision between clinician and patient in conditions of high uncertainty.

Details about the ReDa research team and output are available from the project website reda.unimi.it

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Gender Discrimination In Italian Academia within Logic and Philosophy of Science

:: **Mara Floris and Maria Raffa**

Abstract

This feature reports on the output of the World Café table on Gender Discrimination in Italian Academia which took place at first meeting of the Milano Logic and Philosophy of Science Network (12 March 2025).

Keywords

Gender Inequality; Italian Academic Institutions; Philosophy of Science

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Mara Floris and Maria Raffa. *Gender Discrimination In Italian Academia within Logic and Philosophy of Science* . The Reasoner 19(4) 2025. https://doi.org/10.54103/1757-0522/30079

The underrepresentation of women in academic philosophy is a well-documented and persistent problem in many countries (Tripodi, 2017: The value of diversity and inclusiveness in philosophy: An overview. *Rivista di Estetica, 64*, 64, 10.4000/estetica.2077, 3-17). Italy is no exception. Despite a broader movement towards gender equality in higher education, philosophy remains a strikingly male-dominated discipline, especially in its senior ranks and more formal subfields. Drawing on recent national data and insights from a World Café on gender and academia held at the first meeting of the *Milano Logic and Philosophy of Science Network*, at the Politecnico of Milan on 12 March 2025, this Feature offers a snapshot of the current situation in Italy and reflects on some of the underlying structural and cultural causes, including those discussed during the event.

According to the latest 2023 report by the Italian Ministry of University and Research (MUR: https://ustat.mur.gov.it/media/1244/focus_carrierefemminili_universit%C3%A0_marzo2023.pdf, last accessed 9/7/2025), women make up 41.1% of all university faculty and researchers in Italy. However, this aggregate figure conceals significant disparities across disciplines. In areas such as Medicine and Health Sciences, women hold 70.4% of research fellowships. In Engineering and Technology, by contrast, only 34.3% of research fellows are women. This reflects both horizontal segregation (women and men tending to cluster in different fields) and vertical segregation (a decline in female representation at higher levels of the academic hierarchy).

Philosophy lies somewhere in the middle of this spectrum, but the patterns are telling. Data from AlmaLaurea (2023) show that women represent 52.8% of students earning a bachelor's degree in philosophy (https://www2.almalaurea.it/cgi-asp/classi/Scheda.aspx?codiceAggr=10029&tipoCorso=L&lang=it, last accessed 9/7/2025), and 49.2% at the master's level (https://www2.almalaurea.it/cgi-asp/classi/scheda.aspx?codiceAggr=11200&lang=it, last accessed 9/7/2025). However, this early gender balance does not carry through into permanent academic positions.

According to MUR data, out of 332 full professors (professori ordinari) in philosophy (classified under macro-sector M-FIL), only 91 are women – approximately 27%. The distribution becomes even more skewed when broken down by sub-discipline. In Logic and Philosophy of Science (M-FIL/02-A), women account for only 9 out of 45 full professors (20%). In Theoretical Philosophy (M-FIL/01-A), the figure is 14 out of 56 (25%). Similar numbers are found in Moral Philosophy (13/48) and Philosophy of Language (17/43). These statistics point to a consistent and significant gender gap at the top levels of the discipline.

The pipeline problem in philosophy appears to begin after the master's degree and intensifies during the transition from temporary to permanent positions. Anecdotal and qualita-

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30079

tive evidence suggests that several factors contribute to this attrition.

One major issue is the timing of academic career progression, which often coincides with the years in which many women choose or feel social pressure to have children. The lack of robust parental leave policies and the challenges of balancing caregiving with precarious academic contracts can push women out of the academic track.

Moreover, there is growing recognition of a confidence gap (Herbst, 2020: Gender differences in self-perception accuracy: The confidence gap and women leaders' under-representation in academia, SA Journal of Industrial Psychology, 46, 1, 10.4102/sajip.v46i0.1704, 1-8), whereby women are less likely to apply for competitive positions or to self-promote within highly competitive and often male-dominated environments. This is exacerbated by what many describe as a toxic or aggressive intellectual climate, particularly in subfields such as analytic philosophy, where debate styles may discourage participation by those who experience the environment as confrontational rather than constructive (Garry, 2024: Analytic feminism. In E. N. Zalta & U. Nodelman Eds., The Stanford Encyclopedia of Philosophy, https://plato.stanford.edu/archives/sum2024/entries/femapproach-analytic/).

Another factor is the unequal distribution of labour within academic departments. Women are more frequently tasked with administrative roles, student support, and teaching-

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30079

heavy assignments, leaving less time for research output, i.e. the primary criterion for promotion (e.g. Guarino & Borden, 2017: Faculty service loads and gender: Are women taking care of the academic family? Research in Higher Education, 58, 6, 10.1007/s11162-017-9454-2, 672-694).

The gender imbalance in philosophy is not just a matter of numbers. Indeed, it creates a climate in which women are more vulnerable to harassment and discrimination (cfr. Saul 2014: Stop thinking so much about 'sexual harassment'. Journal of Applied Philosophy, 31(3), 10.1111/japp.12046, 307-321). Several high-profile cases of harassment in Italian academia have prompted public reflection on how environments dominated by one gender can foster abuse of power and complicity through silence.

Moreover, women often face implicit biases in hiring and evaluation (e.g. Moss-Racusin et al. 2012: Science faculty's subtle gender biases favor male students. Proceedings of the National Academy of Sciences, 109, 41, 10.1073/pnas.1211286109, 16474-16479). Even when formal quotas or diversity initiatives are in place, women may be perceived as "diversity hires" or face higher standards of evaluation. Although gender quotas in hiring processes are legally encouraged and sometimes implemented, the overall effect remains limited without sustained institutional change and cultural shift.

The World Café tables held at the first meeting of the *Milano Logic and Philosophy of Science Network* gathered philoso-

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phers from various subfields to reflect on gender inequality in the discipline. Participants shared experiences, exchanged data, and discussed both problems and possible interventions.

Several themes emerged:

- The importance of mentorship: many attendees highlighted the lack of female mentors in senior positions as both a consequence and cause of gender disparity. Women often do not see themselves reflected in leadership roles, which may limit aspirations or reinforce imposter syndrome.
- The need for inclusive epistemic environments: the "style" of philosophical engagement especially in analytic circles was frequently criticized as unnecessarily adversarial. Participants called for a shift towards more collaborative and respectful discourse norms.
- Intersectionality and marginalization: some discussions focused on how gender inequality intersects with other axes of marginalization, including class, disability, race, and language. Migrant and non-Italian women, in particular, often face compounded disadvantages in navigating the Italian academic system.
- Institutional responses: while some universities have begun implementing gender-sensitive policies (e.g.,

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30079

awards for female scholars, family-friendly work arrangements, and gender equality offices), participants stressed the importance of moving beyond tokenistic gestures and fostering deep structural change.

- Data collection and transparency: there was consensus on the need for more systematic data collection on gender representation at all career stages and across subfields. Without transparency, it is difficult to track progress or identify where interventions are most needed.

On this basis, it can be argued that the academic philosophical environment in Italy, as in many other countries, faces a paradox: while the discipline teaches critical reflection and ethical reasoning, its institutional practices often fall short of these ideals when it comes to gender equity. Addressing the underrepresentation of women in philosophy requires both bottom-up and top-down efforts. Departments must cultivate inclusive environments, mentor underrepresented scholars, and challenge norms that valorize competitiveness over collaboration. Institutions must monitor data, ensure transparency in hiring and promotion, and design policies that support work-life balance.

The problem is not just that there are too few women in philosophy. It is also that the current structure of the discipline – its culture, incentives, and hidden hierarchies – often deters them from staying or thriving. The workshop concluded

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30079

with a shared commitment to continuing the conversation, amplifying marginalized voices, and holding the discipline accountable to its own normative standards. This Feature hopes to contribute to that effort.

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Mental Health in the Academic Profession

:: **Davide Serpico and Malvina Ongaro**

Abstract
This feature summarizes the outputs from the *World Cafe* table concerning mental health in the academic profession, which took place at first meeting of the Milano Logic and Philosophy of Science Network (12 March 2025).

Keywords

Mental Health; Italian Academic Institutions; Research Environment.

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Mental health concerns in academia have increasingly come to light over the past few years. In a 2019 *Nature* editorial, Skipper ("The mental health of PhD researchers demands urgent attention," *Nature, 575*, 257-58, https://doi.org/10.1038/d41586-019-03489-1) reported that over one-third of PhD students globally are at risk of developing mental disorders, with anxiety and depression being the most common. In a similar vein, Levy (2025, "Mind matters: investigating academia's 'mental health crisis'," *Nature Careers Podcast*, https://www.nature.com/articles/d41586-024-04240-1) reported that the prevalence of mental health conditions is estimated at about 37% among researchers, faculty, and teachers, nearly double the rate in the general population. Stress, overwork, and job insecurity are cited as key drivers of poor mental health among academics; poor relationships with supervisors, lack of inclusivity and belonging, and the competitive environment of academia are also leading predictors of negative mental health outcomes. Although mental health is often framed as a personal matter, the structure and culture of academia play a crucial role in shaping scholars' wellbeing.

At the networking event held in Milan, scholars from multiple universities gathered not only to exchange ideas about science and its methods but also to reflect on the professional conditions in which such inquiry takes place. One insightful moment was the World Café on mental health issues in the research environment, where early-career scholars, postdocs, and faculty members engaged in a conversation about the emotional costs of academic life. The World Café opened with a simple question: "How would you describe the current culture in your department regarding mental health awareness?" Responses varied, but many participants shared a sense of silence or neglect around the topic. From there, the conversation touched on several interrelated issues.

A first key topic was the sense of inadequacy and self-doubt often promoted by the competitive nature of research: participants noted that academia fosters a culture of constant comparison, which is particularly acute in philosophy, where the standards of excellence are often opaque, and failure feels deeply personal. The passion-driven rhetoric "we are lucky to be paid to think" often conceals a system where identity and professional achievement are deeply entangled. This leads to a tendency to overwork, accept precarious conditions, and internalize failures. Relatedly, the publish-or-perish dynamic and publication pressures represent a major concern: philosophers reported feeling torn between the desire to pursue meaningful research and the need to meet quantifiable performance metrics. This results in "strategic publication" behaviors, such as chasing trendy topics rather than addressing questions that matter most to them. Over time, this disconnect can erode one's motivation and sense of purpose.

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30083

Another point about individual-level difficulties concerned isolation and loneliness: unlike many other disciplines, philosophy is structurally solitary. With fewer research groups, labs, or collaborative frameworks, scholars often work in isolation. For early-career scholars in particular, short-term contracts and limited opportunities for long-term collaborations further deepen this sense of alienation. Participants also raised concerns about the difficulty of escaping toxic work environments, given the small size of the philosophical community and the pervasiveness of power asymmetries.

At a more systemic level, we witnessed considerations about career insecurity and structural uncertainty: the lack of long-term job prospects makes it nearly impossible to plan for the future. Choices about where to live, whether to start a family, or how to invest in personal and professional life are all shaped by short-term contracts and the constant need to relocate. Even for those who manage to "do everything right," the randomness of success – being "in the right place at the right time" – leads to a sense of unfairness and frustration. Many participants highlighted how deeply structural many of these issues are. The sense of injustice is not just about unequal treatment but about how the entire system seems to reward availability, mobility, and productivity in ways that often contradict a healthy life.

While the diagnosis was often critical, the discussion also produced a range of suggestions and practices that can promote healthier academic environments.

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Participants stressed the importance of creating daily routines and protecting personal time – avoiding emails on weekends or holidays, for instance. Focusing on long-term, value-driven research, rather than immediate performance goals, was also seen as vital to reclaiming scholarly integrity. A recurring proposal was the development of practices alleviating the sense of loneliness and enhancing the relationship between scholars of different career levels. First, working in shared offices or coworking environments can counter isolation and foster informal exchange and mutual support. Second, young scholars could benefit from having multiple mentors to whom they can turn for different kinds of support: despite the persistent stigma, asking for help was described as a critical and often underutilized resource. Relatedly, participants proposed structured forums for mutual education between senior and junior scholars – spaces where experiences, struggles, and coping strategies can be shared across career levels. However, this idea was also met with caution, as we must consider that expressing vulnerability in a context that remains hierarchical and characterized by power structures can lead to distortions and manipulation.

Finally, many participants emphasized that mental health challenges in academia are not simply matters of individual resilience. Structural injustices – precarity, competition, metric-based evaluation – must be addressed at the institutional and policy level. While personal strategies can offer short-term relief, long-term wellbeing requires some sort of

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systemic reform. More established academics have a crucial role in modelling sustainable practices, offering support, and helping to enhance departmental norms. This includes being transparent about the realities of academic life and actively working to reduce the pressure on younger colleagues.

This World Café was a rare and valuable opportunity to reflect collectively on the costs of academic life and the possibilities for making it more humane. Philosophy, perhaps more than other disciplines, seems to us an ideal context to develop the conceptual and ethical tools to lead this cultural change.

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Epistemology, Reasoning, and Logic

:: Vita Saitta, Silvia Larghi, Giorgia Adorno, Antoine Brandelet and John Michael

Abstract
This feature reports on the Epistemology, Reasoning, and Logic session of the first Milan Logic and Philosophy of Science Network workshop (12th March 2025). The session brought together six contributions addressing diverse aspects of scientific reasoning: the psychology of extreme beliefs, analogical reasoning in contemporary physics, joint commitment across species, the epistemology of pseudoscience and disinformation, logical reasoning with data, and modal logic for truth-maker semantics.

Keywords

Psychology of Belief Formation; Analogical Reasoning; Joint Commitment; Epistemology of Pseudoscience; Epistemology of Disinformation; Modal Logic; Data-Driven Inference.

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The first meeting of the *Milano Logic and Philosophy of Science Network* convened scholars from the Milan area engaged in research at the crossroads of logic and philosophy of science. The meeting was hosted by Politecnico di Milano (PoliMi) on 12 March 2025. The network aims to strengthen collaboration among researchers based at institutions located in Milan, fostering exchanges across disciplinary boundaries and encouraging dialogue between formal, empirical, and conceptual approaches to scientific inquiry.

Contributions in Epistemology, Reasoning, and Logic explored the diverse ways in which reasoning processes, ranging from the psychological and social to the formal and computational, inform the production and justification of scientific knowledge.

Specifically, concerning the psychology of belief formation, Giorgia Adorno (Università Vita-Salute San Raffaele) presented her work on the psychology of extreme beliefs. Pseudoscientific theories can be understood as a distinct form of

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extreme belief: coherent yet rigid systems of thought that promise clarity in the face of uncertainty. Far from being mere products of ignorance, these beliefs fulfil profound psychological needs for meaning, stability, and control. At their core lies the interplay between two motivational forces: the need for understanding – the human drive to construct coherent explanations of reality – and the need for cognitive closure – the desire for definitive answers that resolve ambiguity and restore a sense of order. When these needs become particularly salient, they can give rise to an illusion of causality, fostering the perception of patterns and causal links where none objectively exist. In this light, pseudoscience functions as a psychological mechanism of closure: it offers immediate, emotionally satisfying explanations that reduce cognitive tension, even at the cost of accuracy. Adorno's project explores these underlying dynamics to illuminate why, for many, pseudoscientific worldviews remain not only plausible but psychologically indispensable.

Turning to the role of conceptual tools in the sciences, Antoine Brandelet (Politecnico di Milano) presented his project concerning analogical reasoning in contemporary physics. The role of analogies in physics is a long standing philosophical debate. Generally speaking, an analogical reasoning is a mapping that links two distinct domains (source and target) which are supposed to present a form of resemblance allowing us, from a series of known shared properties, to infer the existence of an additional similarity. Looking at the history of physics, one can find many examples of successful analogies, but while in most concrete cases a common causal structure is shown to support the similarity justifying the inference, the success of more formal analogies in theoretical physics remains mysterious. "Analogical Reasoning in Contemporary Physics" is a PRIN 2022 collaborative research project between Politecnico di Milano and Università degli Studi di Urbino Carlo Bo that aims at exploring the role of analogies in contemporary physics, particularly quantum field theories and black hole physics. It also incorporates an educational focus (in collaboration with the Effediesse Lab at PoliMi) which seeks to shed light on the contribution of analogies in science learning.

On the topic of social cognition and cooperation, John Michael (Università degli Studi di Milano) presented his work on joint commitment across species. It has been argued that the capacity to form joint commitments is crucial for stabilising joint action in humans, and may be foundational for social norms and institutions. But humans are not the only animals to engage in joint actions for which joint commitment may be important. To structure research on the phylogeny of joint commitment, we propose a behavioural definition of joint commitment which does not presuppose characteristically human forms of cognition, communication, or awareness. It is sufficiently broad to include paradigmatic cases of joint action in humans as well as cases of joint commitment in non-human animals. This will enable

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us to identify mechanisms which humans share with other animals, as well as to home in on uniquely human mechanisms, as well as differences across species.

Carlo Martini (Università Vita-Salute San Raffaele) explored the epistemology of pseudoscience and disinformation, highlighting how the two are connected in the theory and in practice. There are various rational explanations for why people believe disinformation. Among the drivers of disinformation are motivated reasoning, political polarization, cognitive biases, fake news. But can motivated reasoning, polarization, and cognitive biases really explain all or even most cases of disinformation? And are people genuinely looking for high-quality information? The focus of the presentation was on scientific disinformation. Scientific disinformation has a solid evidential basis in pseudoscience, that is, pseudoscience provides the (false) evidence that allows scientific disinformation to thrive. Debunking pseudoscience is essential, and it requires establishing criteria to identify, for example, pseudo-experts and pseudoscientists. These can be recognized by examining citations, authors' credentials, and acknowledgements in papers. The talk introduced the research project 'Demarcation for Dummies', which investigates pseudoscience and disinformation and develops strategies to counter them by promoting media, science, and health literacy through randomized online and field experiments testing cognitive, behavioural, and AI-based interventions.

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The session then turned to formal and logical methods for scientific reasoning. Hykel Hosni (Università degli Studi di Milano) presented the research activities of the Logic, Uncertainty, Computation, and Information (LUCI) Lab at the University of Milan, focusing on the Reasoning with Data (ReDa) project. The project interrogates how logic can contribute to understanding and structuring reasoning in data-intensive and AI-driven science, which is inherently stochastic. Challenging the traditional probabilistic interpretation of scientific inference, ReDa reframes the problem as one of logical validity rather than probabilistic ideology. By developing formal frameworks for data-driven inference, the group explores how logical methods can enhance the construction, evaluation, and application of scientific knowledge, from epidemiological modelling to clinical decision-making. Ongoing collaborations include projects with the Istituto Tumori of Milan and interdisciplinary teams addressing topics such as e-values, policy reasoning, and inductive inference.

Vita Saitta (Università Cattolica del Sacro Cuore) presented ongoing work by the Logic Group at the Department of Philosophy on Modal Logic for Truthmaker Semantics. This presentation introduced the research carried out by the Logic Group at the Department of Philosophy of the Università Cattolica del Sacro Cuore in Milan, featuring Vita Saitta and Alessandro Giordani. The group's work focuses on applying modal logic to truthmaker semantics, an approach grounded in the notion of an exact truthmaker – a state that brings about the truth of a formula and is wholly relevant to it. Truthmaker semantics is emerging as a major framework in philosophical logic and the philosophy of language, offering alternatives to the traditional Possible Worlds Semantics. It reshapes the analysis of meaning, subject matter, and content in linguistic expressions, provides new semantics for non-classical logics, and offers refined accounts of conditional and counterfactual reasoning. Although its application to modal operators is still in its early stages, this line of research has already advanced the study of metaphysical and deontic modalities, shedding new light on the nature of necessity, possibility, obligation, and permission.

Together, these contributions highlighted the richness of ongoing research in the Milan area on the epistemological and logical dimensions of scientific reasoning. The session demonstrated how interdisciplinary collaboration, bridging cognitive science, formal logic, and philosophy of science, can advance our understanding of how knowledge is formed, justified, and represented.

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Science Meets the Human Condition – Values and Uncertainties in Science

:: **Hernán Bobadilla, Francesco Nappo, Davide Serpico**

Abstract

This feature reports on the first meeting of the Milano Logic and Philosophy of Science Network, held at Politecnico di Milano (12 March 2025). It focuses on the contributions investigating the roles of values and uncertainty in contemporary scientific practice. The five contributions presented by the authors are summarized, spanning climate science, medicine, measurement theory, and scientific classification.

Keywords

Philosophy of science; Uncertainty; Epistemic values; Non-epistemic values.

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We are living in complex and uncertain times. We experience this most of the time, across the globe. Our concerns and emotions are deeply affected by these conditions, but also serve as resources that help us endure. Complexity and uncertainty also pervade the realm of scientific research. Alongside limitations in providing certainty and control, scientists are progressively recognising the standpoint-relativity and value-ladenness of their tasks and practices. In light of this, it seems inevitable that uncertainty and values would become central themes in the philosophy of science. Nowadays, scientific practices are examined through the lens of both individual and collective values. The hope is that, by acknowledging science's entanglement with uncertainty and values, we might better navigate the forms of uncertainty we face from various perspectives, allowing us to move toward wiser evidence-based decisions.

During the first meeting of the *Milano Logic and Philosophy of Science Network*, several scholars presented aspects of their philosophical research dealing with values and uncertainties. Their work spanned fields as diverse as climate science, civil engineering, medicine, and economics. In this feature article, we briefly review and reflect on five of these presentations, which illustrate how philosophical inquiry can enrich science in uncertain times.

Malvina Ongaro (Politecnico di Milano) addressed how decisions are made under conditions of uncertainty. Her research focuses on contexts of natural risks, but her talk extended to risks in medicine, climate change, and AI. Ongaro distinguished different types of uncertainty: aleatoric (related to the randomness of the world), epistemic (related to our representations of the world), and normative (related to our values). She outlined two main approaches to treating uncertainties: models, which seek to quantify and predict outcomes, and storylines, which explore plausible narratives without relying on probabilistic forecasting. For decision-making, she discussed cost-benefit analysis and multi-criteria analysis, each with its strengths and limitations. She finally called for more responsible and inclusive decision-making, one that accounts for the plurality of needs, values, and forms of knowledge across disciplines. Fairness, particularly in terms of recognition and participation, emerged as a key ethical dimension of managing uncertainty.

Davide Serpico and Francesco Guala (Università di Milano) introduced their project on normative kinds. Their central thesis is that classification schemes in science are never entirely neutral, but are rather influenced by the values of those who construct and apply them. Thus, what counts as a 'natural kind' in science typically depends on whose interests are being served. These categories are not merely descriptive, but also carry normative force: They can evoke positive or negative connotations and thereby influence how individuals perceive the world and behave, as well as how institutions

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respond. As part of their project, Serpico and Guala are investigating several case studies, particularly in the medical domain, such as diagnostic categories related to addiction and eating disorders, as well as social categories like money, casts, and human races.

Mara Floris (Università Vita-Salute San Raffaele) presented ongoing research at the intersection of philosophy and medical practice, with a focus on epistemic injustice: a form of harm that occurs when individuals are wronged in their capacity as knowers. In clinical contexts, such injustices often affect patients, particularly women, who may be disbelieved, dismissed, or excluded from knowledge production. Floris and her collaborators are developing three interconnected projects to address these issues. The first project investigates obstetric violence, focusing on how information can be distorted or withheld during childbirth, often through over-medicalisation. The second project examines the diagnostic delay in endometriosis, attributing it partly to cognitive biases in clinical reasoning and systemic underestimation of women's suffering. Finally, a broader initiative identifies and classifies instances of epistemic injustice in doctor–patient interactions, to foster more equitable, trust-based clinical relationships.

Alessandro Giordani (Università Cattolica di Milano) explored the topic of measurement in science. Far from being a simple, objective act, measurement is influenced by uncertainty, which does not simply mean technical flaws but also

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inherent limitations in our knowledge. Giordani emphasised that every measurement results from a particular standpoint, meaning our perspectives and interests shape the outcome. Hence, there is no 'true' measurement, but only measurements relative to specific conditions and assumptions. The talk also explored how values may infiltrate the measurement process, from deciding what to measure and how, to interpreting the results. Understanding these interwoven roles of uncertainty, standpoint, and values allows for more critical engagement with data and a deeper appreciation of the human element in scientific research.

Hernán Bobadilla and Francesco Nappo (Politecnico di Milano) explored the epistemic and ethical dimensions of climate research. Bobadilla examined a methodological controversy surrounding the storyline approach, a recent method in the attribution of extreme climate events. Bobadilla argued that this approach leads to a genuine scientific understanding of climate phenomena, although qualitatively distinct from traditional probabilistic approaches. He suggested that philosophers of science are well-positioned to clarify emerging controversies. Nappo focused on Integrated Assessment Models (IAMs), which aim to generate long-term climate policy scenarios by combining data and assumptions from economics, environmental science, and engineering. He discussed the epistemic status of IAM-based scenarios and examined how convergence across them should be interpreted. Nappo also addressed the ethical di-

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mensions of IAMs, raising important questions about where in the modelling process value judgments occur, who should be responsible for managing them, and how ethical oversight can be improved.

The collective upshot of these presentations carries both descriptive and normative implications. On the one hand, philosophical research on various branches of science and engineering highlights how deeply entangled scientific research is with societal concerns and ethical norms. On the other hand, social sciences and philosophical perspectives do not undermine the possibility of achieving objective scientific knowledge. Rather, the presentations collectively emphasise how recognising and critically examining the interplay between science, ethics, and society is essential for fostering a more responsible, inclusive, and reliable scientific research, one that can legitimately offer guidance in a complex and uncertain world.

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Philosophy of the Physical Sciences, Biology and Health in Milan

:: **Maria Raffa, Thomas Bonnin, Maurizio Esposito, Luca Guzzardi, and Sahar Tavakoli**

Abstract

This feature reports on the philosophy of the Physical Science, Biology and Health session of the first Milan Logic and Philosophy of Science Network workshop (12th March 2025). The six contributions presented by the authors are summarized, spanning epistemic cohesion, temporality, food, cognition, medical practice and the relationship between organisms and machines.

Keywords

Philosophy of the Physical Sciences; Philosophy of Biology; Philosophy of Medicine.

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The inaugural meeting of the Milano Logic and Philosophy of Science Network brought together scholars working in the Milan area at the intersection of logic, philosophy of science and the life and health sciences. Hosted at Politecnico, the event showcased the breadth and depth of contemporary research within, among the other areas, philosophy of the physical and biological sciences. From the dynamics of epistemic cohesion in nuclear fusion research, to the historical entanglements of organisms and machines, to the epistemological implications of food, the contributions shared during this first meeting reflect the growing importance of interdisciplinary perspectives in philosophical inquiry. Together, they invite us to rethink how knowledge is shaped – not only through formal reasoning and theoretical constructs but also through collaborative practices, historical metaphors, and cultural forms of life.

Concerning physical sciences, Luca Guzzardi (Università degli Studi di Milano) presented FusEUrope, a PRIN PNRR interdisciplinary project investigating the historical, epistemic, scientific, and political dimensions of European cooperation in (peaceful) nuclear fusion energy research. Within this context, the project's social-epistemological strand seeks to develop an operational approach to the joint commitment model in scientific communities. Drawing on Margaret Gilbert's theory of collective belief, alongside critiques by Brad Wray and others, Guzzardi proposes a reframing of the model around shared goals rather than be-

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liefs. This goal-based interpretation better captures the formal and informal structures that shape scientific collaboration – from contractual arrangements to tacit knowledge and institutional constraints – and more accurately reflects the dynamics of large-scale research projects. To test this framework, the project employs a mixed-method approach combining social network analysis and keyword analysis of co-authorship data in nuclear fusion research from 1979 to 2001. Preliminary results reveal both the continuity and internal differentiation of the field over time, and suggest that small but persistent groups of researchers may have played a key role in shaping long-term epistemic agendas. More broadly, the project aims to show how co-authorship clusters and their evolving thematic profiles can be interpreted as instantiations of joint commitments to specific research goals. In doing so, it provides a method for making joint commitments empirically tractable and offers a concrete framework for analyzing the formation and evolution of collective epistemic agents in science.

A second contribution by Giuliano Torrengo (Università degli Studi di Milano) described the research activities carried out by the Lab LEMMings (Language, Epistemology, Mind, Metaphysics) at the State University of Milan, coordinated by Daniel Dohrn. LEMMings integrates resources from *Center for Philosophy of Time*, currently coordinated by Giuliano Torrengo himself, and *Culinary Mind: Center for the Philosophy of Food*, directed by Andrea Borghini.

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The *Center for Philosophy of Time* (CPT) deals with the metaphysical discussion about the nature of time, within the fields of Philosophy of Science, Mind and Language. Past projects at PCT included *Timemethod*s, concerning the definition of common methodology in various areas of philosophy; *Timeframe*, that addresses common currency of conceptual resources in various disciplines; *Chrono*s, that deals with the common core of shared competences. Currently, the focus is on Temporal Experience and Social Cognition, whose Principal Investigators are Giuliano Torrengo and J. Michael. This project investigates the nature of temporal experience by combining philosophical analysis with experimental methods. It examines different interpretations of the belief that "time passes," ranging from metaphysically rich claims about the world's constant updating to more modest views centered on the continuous updating of conscious experience. Central questions include whether the feeling that time passes corresponds to a specific phenomenological content, or whether it reflects how we tend to describe our sensory experience. The project also draws on experimental philosophy to explore how people interpret temporal concepts and how cognitive biases, such as sunk cost effects and future bias, shape our experience and understanding of time.

Culinary Mind: Center for the Philosophy of Food was then presented by Sahar Tavakoli (Università degli Studi di Milano). Blending philosophical inquiry with cultural analy-

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sis, *Culinary Mind* explores food not merely as a matter of taste or nutrition, but as a site of knowledge production, aesthetic judgment, and cultural meaning. Tavakoli outlined the group's evolving role in the Horizon Europe-funded RELISH project, which seeks to reframe European culinary heritage through new philosophical and epistemological lenses. Culinary Mind has emerged as a dynamic platform for public engagement and interdisciplinary research, hosting workshops, lectures, and events that foreground food as a boundary object connecting the sciences, humanities, and everyday life. Through initiatives like the *Half Baked* colloquium and the *Crumble* newsletter, the group extends the reach of philosophical discourse beyond the academy, bridging logic, epistemology, and the philosophy of science.

Dealing with philosophy of biology and health, Maria Raffa (IULM University Milan) presented research conducted with Luisa Damiano, Antonio Fleres, and Sergio Rubin on the philosophy of cognitive biology, adopting a transdisciplinary perspective that integrates philosophical analysis, theoretical modeling, and computational simulations. Their work conceptualizes cognition as a biological phenomenon emerging from the dynamic interaction between brain, organism, and environment. Key research directions include modeling minimal cognition, exploring theoretical and computational models of the cognitive mind, simulating sustainable cognitive processes using the Free Energy Principle (particularly in AI systems), and advancing third-order cybernetics to understand human-technology-environment interactions and adaptive agency in complex systems. The research benefits from international collaborations (e.g., with Paul Dumouchel) and national projects such as PRIN 2022 (Org-SB-AI) and IULM's "Third-Order Cybernetics" initiative.

Thomas Bonnin (Politecnico di Milano) presented the research projects about contemporary approaches to health promotion held by Stefano Canali, Daniele Chiffi, Viola Schiaffonati, Giovanni Valente and himself, within the META research group. The core of their research is exploring and improving the basic building blocks of medical and clinical practice, whose epistemological underpinnings are often unexplored. Their works examine core practices like diagnosis, prognosis, and clinical reasoning, alongside emerging developments in medical datafication – from omics and AI to predictive models and synthetic data. These trends raise key questions about scientific change, reductionism, predictability and reliability and the philosophical reorientation of health concepts. Moreover, they also explore the rise of digital health as both an epistemic and ethical innovation, with attention to inclusivity, data ambiguity, and compatibility with evidence-based frameworks. Further areas of focus include exposome research, which integrates biological and social factors in public health, and evidence-based design, seen as a case of scientific expansion of evidence-based medicine into architecture and urban

The Reasoner 19(4), 2005. https://doi.org/10.54103/1757-0522/30080

planning.

In conclusion, Maurizio Esposito (Università degli Studi di Milano) revisited the long-standing analogy between machines and organisms. Indeed, since the early modern period, philosophers, naturalists, and physicians have speculated on the extent to which the organic body might be identified with, or meaningfully compared to, machines such as automata, clocks, and other mechanical artefacts. Esposito examined some of the assumptions underlying these comparisons, exploring the origins and historical development of the perceived relationships between organisms and artificial constructs. He briefly explored when, why, and how people began linking human-made devices to the living world. He argued that the debate has been shaped by two dominant conceptions of technological artefacts: anthropocentric and non-anthropocentric conceptions. By tracing their historical emergence, he suggested that this distinction is key to understanding possible continuities and differences between organic life and machines.

The first meeting of the Milan Logic and Philosophy of Science Network highlighted the diverse ways in which philosophical research can illuminate, and be transformed by, its engagement with scientific practice, historical inquiry, and cultural critique. Whether rethinking the epistemic foundations of scientific collaboration, challenging inherited metaphors in biology, or redefining what counts as an object of philosophical reflection, the contributions shared a com-

The Reasoner 19(4) , 2005. https://doi.org/10.54103/1757-0522/30080

mitment to critical interdisciplinarity. This event offered not only a snapshot of current research in Milan, but also a compelling vision for how philosophy can remain relevant in a rapidly changing intellectual and technological landscape.

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Perspectives in Philosophy of Artificial Intelligence, Robotics and Cognition

:: **Ilaria Alfieri and Silvia Larghi**

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Abstract

This feature reports on the Philosophical Perspectives on Artificial Intelligence (AI), Robotics and Cognition session of the first Milan Logic and Philosophy of Science Network workshop (12th March 2025). Giuseppe Primiero introduced PhilTech's agenda. Giacomo Zanotti presented the multidisciplinary approach to AI adopted by philosophers at Politecnico di Milano; Silvia Larghi discussed research on mental states attribution to robots conducted at the RobotiCSS Lab, University of Milano-Bicocca; and Ilaria Alfieri presented IULM's lines on synthetic modeling, the sustainability of social robotics, and the robosphere.

Keywords
Philosophy of Artificial Intelligence; Philosophy of Social Robotics; Philosophy of Cognition

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Recent advancements in robotics and AI are reshaping the way we conceive, interpret and interact with artificial agents. Interdisciplinary research in AI, robotics and cognition, encompasses both the design and development of artificial agents capable of learning, perceiving and acting in the world, as well as the cognitive and philosophical implications of replicating or emulating mind and intelligence. Emerging technologies are opening up new perspectives in understanding cognition and in the development of increasingly adaptive, responsive and collaborative intelligent systems. At the inaugural meeting of Milan Logic and Philosophy of Science Network, scholars working on these issues presented their research reflecting on crucial challenges, recent developments, future potential and related ethical and epistemological issues.

Giuseppe Primiero (Università degli Studi di Milano) presented the work of the Research Centre for the Philosophy of Technology (PhilTech). This is a leading interdisciplinary hub committed to the philosophical investigation of technology and its multifaceted impacts on knowledge, society, and

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human agency. Hosted within the Department of Philosophy "Piero Martinetti" and supported by the 2023-2028 Excellence Project *Techne*, PhilTech brings together expertise in logic, epistemology, ethics, political philosophy, media theory, and education. The Centre's research is structured around three thematic areas: Knowledge and Language, Society and Values, and Interaction and Education, reflecting a comprehensive approach to the philosophical study of technological systems and their environments.

PhilTech serves as the coordinating entity for major research projects such as BRIO – Bias, Risk and Opacity in AI, SMARTEST, and ISL360 – Immersive Synchronous Learning (philtech.unimi.it/projects), as well as for politically engaged initiatives like *Towards a Decolonized Artificial Intelligence Seminar Series*. The Centre addresses pressing issues like algorithmic opacity, formal logic and AI, normative machine learning, temporal perception, digital responsibility, language usage on technological platforms and the post-colonial imagination to name a few. PhilTech also partners with academic and industry institutions including IDSIA, Fondazione Bassetti, META, the CSS Lab, and the International Commission on the Philosophy of Technology and Engineering Sciences, the Commission for the History and Philosophy of Computing.

Giacomo Zanotti's presentation outlined the main features of the research in the philosophy of AI that is pursued at Politecnico di Milano. Here, philosophical issues revolv-

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ing around AI are tackled from a multi-disciplinary perspective that combines the philosophy of science and technology with conceptual and methodological tools from ethics, logic, and social sciences. Different philosophers from Politecnico are involved, including Stefano Canali, Daniele Chiffi, Fabio Fossa, Camilla Quaresmini, and Viola Schiaffonati. While they have different areas of specialization, a common denominator of their research is an understanding of AI systems as socio-technical ones, encompassing AI technologies but also the involved human actors and institutions.

Philosophers working on AI at Politecnico are active on multiple fronts. The relevant research topics include (but are not limited to) risk and uncertainty in AI, trust and trustworthiness in AI, medical AI and personalization, AI and the ethics of transportation, as well as algorithmic fairness. As an example, Giacomo Zanotti presented the work titled "AI-Related Risk: An Epistemological Approach" (10.1007/s13347-024-00755-7) that he has been doing with Daniele Chiffi and Viola Schiaffonati on AI-related risk, showing how a multi-component analysis of risk can fruitfully be applied to risk stemming from the use of AI systems.

Silvia Larghi (University of Milano-Bicocca) explored the epistemology of the attribution of mental states to robots, based on research conducted at the RobotiCSS Lab (Laboratory of Robotics for the Cognitive and Social Sciences, University of Milano-Bicocca). Under the scientific direction of Edoardo Datteri, the RobotiCSS Lab brings together multidisciplinary expertise from philosophy of science, psychology, education, computer science and engineering, anthropology, encompassing research on the role of robots in understanding cognition and on how cognition can be enhanced by using robots. The RobotiCSS Lab is actively involved in several research projects in the field of human-robot interaction and the understanding of robots, particularly in relation to the attribution of mental states to artificial systems. Larghi concluded the presentation with insights from a philosophical analysis of possible styles people may adopt to model the minds of robots, supported by findings from an exploratory empirical study on how children involved in roboethological activities explain robotic behavior.

Ilaria Alfieri (IULM University, Milan) presented the research work developed with Luisa Damiano, Antonio Fleres, Hagen Lehmann, Rebecca Mannocci, and Maria Raffa. Their work applies the synthetic method in scientific modeling of biological and cognitive processes and related technological developments.

Adopting a transdisciplinary approach that combines philosophical reflection, theoretical modeling, and ethical analysis, the main research lines developed at IULM are: 1) The epistemology of synthetic modeling, defining criteria and taxonomies for biological and cognitive models; 2) Software and wetware synthetic modeling of minimal cognition, addressing the thresholds between life, cognition, and sense-

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making with applications in healthcare, environmental care and related ethical issues; 3) Social robotics, focusing on the social and environmental sustainability of social robots, robot ethics, social robots in education, applications of the synthetic method in social robotics, and novel dimensions of social presence and sensory interaction (e.g., olfactory social robotics); 4) Modeling of the robosphere, studying the self-organization of robotic ecosystems and their sustainable integration with human and natural systems.

Their research group actively collaborates with academic partners (e.g., Leticia Dubouq, Paul Dumouchel, Raquel Ros) and industrial ones such as Pal Robotics and Oversonic Robotics. Their research activities are part of two major projects: IULM's departmental project *Third-Order Cybernetics: Towards a Systemic Vision of Sustainability* and PRIN 2022 titled "An organizational approach to the synthetic modeling of cognition based on synthetic biology and Embodied AI Org (SB-AI)".

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