Reasoning with Data (ReDa)

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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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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

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 Ev-

idence 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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