Geometry and Information: Dimensions, Metrics, and Constraints on Conventions

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Abstract

Constructing empirically testable spacetime theories remains a critical challenge in contemporary physics. To assess the feasibility of measuring and testing different spacetimes, a scientific realist has to consider the nature of at least three interrelated types of spaces: physical space, abstract measurement spaces, and quantity spaces. Physical space refers to the four-dimensional spacetime continuum where physical objects exist and events occur. Abstract measurement spaces serve as conceptual frameworks for representing and interpreting data from physical measurements. Quantity spaces, on the other hand, are the dimensions assigned to physical quantities, such as length, time, and mass, used in dimensional analysis and the articulation of physical laws. Wolff[9] has recently advocated for quantity substantivalism, an ontological standpoint that is analogous to spacetime substantivalism, claiming that the best way to understand quantitative attributes is as relationally structured spaces. However, the explanation of this analogy between spacetime and quantities remains a significant metaphysical challenge, and the incorporation of measurement into the discussion remains an even deeper question. The hole argument further complicates the issue by demonstrating that different, observationally indistinguishable spacetimes can exist, challenging the substantivalist view that spacetime points have independent existence[2].

A conventionalist about the geometry of different kinds of spaces might be skeptical of the claims of a spacetime substantivalist or a measurement realist, given that the same set of experimental data can be represented using various geometries and measured with different metric conventions. These differing conventions can lead to empirically incomparable theories and measurement outcomes. Poincaré[7] famously argued that geometry is a product of our conventions and definitions rather than a reflection of an underlying reality. However, Poincaré also noted that physicists define time in ways that simplify our dynamical theories, making certain conventions more 'convenient' than others [6].

This paper aims to examine the constraints on conventional choices regarding two fundamental properties of representational spaces: the number of dimensions and metric scaling or topology. By employing information-based and pattern recognition-inspired terminology, it seeks to elucidate how Poincaré's criteria of simplicity can

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have realist implications. Dennett [1] famously argued that a pattern in data is real if it is compressible. As demonstrated by information theorists [4, 8], data is compressible if and only if it displays patterns. Data compression plays a crucial role in reducing noise and uncertainty in measurement outcomes, thereby enhancing the accuracy and reliability of data analysis [5]. However, different methods of data compression can reveal different patterns within the same dataset. Some approaches to dimensional reduction, projection, and metric conventions can result in information loss, while others can preserve and efficiently deliver the information encoded in the pattern.

This paper argues that the limitations of representing information using different conventions regarding the geometry of spaces lead to a nuanced and weaker form of realism compared to spacetime and quantity substantivalism or measurement realism. Inspired by Isaac's Fixed Point Realism [3], this form of realism acknowledges the constraints imposed by the number of dimensions in representation spaces and the metric or scaling conventions used, thus revealing the limitations and advantages of representing information while asserting the reality of patterns discerned through compressibility.

Keywords: *Spacetime; metric conventions; dimensions; conventionalism; information; measurement; compressibility.*

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