

## Chapter 2

# The Fundamental Properties of Information–Carrying Relations

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### ABSTRACT

*Philosophers have used information theoretic concepts and theorems for philosophical purposes since the publication of Shannon's seminal work, "The Mathematical Theory of Communication". The efforts of different philosophers led to the formation of Philosophy of Information as a subfield of philosophy in the late 1990s (Floridi, in press). Although a significant part of those efforts was devoted to the mathematical formalism of information and communication theory, a thorough analysis of the fundamental mathematical properties of information-carrying relations has not yet been done. The point here is that a thorough analysis of the fundamental properties of information-carrying relations will shed light on some important controversies. The overall aim of this chapter is to begin this process of elucidation. It therefore includes a detailed examination of three semantic theories of information: Dretske's entropy-based framework, Harms' theory of mutual information and Cohen and Meskin's counterfactual theory. These three theories are selected because they represent all lines of reasoning available in the literature in regard to the relevance of Shannon's mathematical theory of information for philosophical purposes. Thus, the immediate goal is to cover the entire landscape of the literature with respect to this criterion. Moreover, this chapter offers a novel analysis of the transitivity of information-carrying relations.*

### INTRODUCTION

Philosophers have used information theoretic concepts and theorems for philosophical purposes since the publication of Shannon's seminal work,

"The Mathematical Theory of Communication". The efforts of different philosophers led to the formation of Philosophy of Information as a subfield of philosophy in the late 1990s (Floridi, in press). Although a significant part of those efforts was devoted to the mathematical formalism of information and communication theory, a thor-

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ough analysis of the fundamental mathematical properties of information-carrying relations has not yet been done. This is an important gap in the literature because fundamental properties such as reflexivity, symmetry and transitivity are not only important for mathematical purposes, but also for philosophical purposes. For example, in almost all attempts to use information theoretic concepts for philosophical purposes, information-carrying relations are assumed to be transitive. This assumption fits our intuitive understanding of information. On the other hand, the transitivity assumption has some controversial consequences. For information theoretic concepts to be useful for philosophical purposes, the semantic informational content of a signal needs to be uniquely identified. In standard accounts, the informational content of a signal is defined by conditional probabilities. However, conditional probabilities obey transitivity only if when they are 1, and thus the informational content of a signal is fixed in an absolute manner. This leads to the denial of partial information and misinformation, which sounds implausible at first glance (Lehrer & Cohen 1983; Usher 2001). Some have preferred to accept the dichotomy and live with the ensuing seemingly implausible consequence (Dretske 1981). Others have tried to avoid the implausible consequence by using some other notions from the stock of mathematical theory of communication, such as mutual information (Usher 2001; Harms 1998). The point here is that a thorough analysis of the fundamental properties of information-carrying relations will shed light on some important controversies. The overall aim of this chapter is to begin this process of elucidation. It therefore includes a detailed examination of three semantic theories of information: Dretske's entropy-based framework, Harms' theory of mutual information and Cohen and Meskin's counterfactual theory. These three theories are selected because they represent all lines of reasoning available in the literature in regard to the relevance of Shannon's mathematical theory of information<sup>1</sup> for

philosophical purposes. Thus, the immediate goal is to cover the entire landscape of the literature with respect to this criterion. Moreover, this chapter offers a novel analysis of the transitivity of information-carrying relations. Until recently, transitivity has been assumed without question. Cohen and Meskin's work (2006) is the first in the literature that challenges this assumption. They claim that information-carrying relations need not be transitive; there are cases where this assumption fails. They state this claim, however, without giving any argument; they simply assert it, which is understandable given the scope of their article. This chapter provides a novel argument in support of their claim. The argument is based on the Data Processing Inequality theorem of the mathematical theory of information.

Given this framework, the chapter is organized as follows. Section 1 is a basic introduction to equivalence relations and may be bypassed by those who are already familiar with this topic. Section 2 is a brief historical survey of the literature. Section 3 analyzes the three semantic theories mentioned in the previous paragraph, in chronological order. Section 4 answers the following question: What are the desired properties of information-carrying relations for philosophical purposes? Lastly, Section 5 concludes the chapter with some suggestions for future research. There is also a short glossary of technical terms at the end.

## **EQUIVALENCE RELATIONS: A PRELIMINARY INTRODUCTION**

A relation could have any number of arguments: one, two, three, four and so on. For example, a 'being in between' relation requires three arguments, that  $a$  is in between  $b$  and  $c$ , and therefore is a 3-place relation. Similarly, 'being the father of' is an example of a 2-place relation with two arguments: the father and the child. These 2-place relations are also called binary relations. Our main focus in this chapter is binary relations, since an

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