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Hermann Haken
Juval Portugali

Information
Adaptation: The
Interplay Between
Shannon Information
and Semantic
Information in
Cognition



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Information Adaptation: The Interplay Between Shannon Information and Semantic Information in Cognition

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Prologue

Shannon's seminal information theory defines information as a quantity irrespective of the meaning it conveys. His theory was followed not only by studies that applied the theory to a variety of domains, but also by attempts to define notions of information with meaning, that is, *semantic information*. So far the two lines of thinking run in parallel; in that, they do not discuss the possible interaction between Shannon's and semantic notions of information. One exception was the chapter by Warren Weaver—Shannon's co-author in their seminal book from 1949: *The Mathematical Theory of Communication*. In that chapter, Weaver laid the foundations for incorporating semantic information within the overall framework of Shannon's theory of communication. Weaver's initiative was not followed, however.

Here, in this monograph, we follow Weaver's footsteps and show that Shannon's information acts as driving force for the formation of semantic information; and vice versa too, namely, that semantic information participates in the formation of Shannonian information. We further show that in cognition, Shannonian and semantic information are interrelated as two aspects of a cognitive process we term *information adaptation*. In the latter, the mind/brain adapts to the environment by the deflating and/or inflating of the information conveyed by the environment. In the process of information adaptation, quantitative variations in Shannon's information entail different meanings while different meanings affect the quantity of information. We illustrate the above conceptually and mathematically by reference to three cognitive processes: pattern recognition, face learning, and the recognition of a moving object.

We can trace the origin of this study to our collaborative paper some two decades ago (Haken and Portugali 1996) that introduced the notion of synergetic inter-representation networks (SIRN). The latter suggests that several cognitive processes that cannot be performed by a single cognitive act evolve as a sequential ongoing interaction between internal representations constructed in the mind/brain and external representations constructed in the world. In the above noted paper, the focus was mainly on cognitive mapping with some preliminary applications to collective cognitive processes; in subsequent studies (Haken 1996; Portugali 2000,

2002, 2011, 2014), the notion of SIRN was applied to art, human communication in general, urban dynamics, city planning, and design.

While the notion of SIRN added important insight to various cognitive phenomena, it still left us with a dilemma: how and by what means, do, internal and external representations interact? Inspired by Haken's (1998/2006) book *Information and Self-Organization*, our principle answer to this question was that internal and external representations interact by means of two forms of information they convey: the quantitative Shannonian information and the qualitative semantic information. This answer paved the way to our study (Haken and Portugali 2003), which started by applying information theory to "The face of the city ...". In this study we showed, firstly, that different urban elements (buildings, roads, parks, etc., of various forms and uses) convey different quantities of information that can be measured by means of Shannon's bits. Secondly, that urban elements convey different meanings, (i.e., semantic information) to different urban agents (i.e., different receivers). But here came a somewhat surprising finding, namely, that "semantic information enters in disguise": We have realized that in order to determine the Shannonian quantities of urban elements, some kind of grouping is required. For example, grouping of buildings according to their architectural style, size, function, or combination thereof; or of roads according to their topology and so on; and grouping implies meaning. In other words, meaningful semantic information is a prerequisite to the determination of the Shannonian information bits of the various urban elements. This latter finding motivated us to dig deeper into the relations between Shannonian and semantic information. The outcome of this intellectual archaeological excavation is the present monograph with its notion of information adaptation.

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