# Chapter 18
# A Shannon-Like Solution for the Fundamental Equation of Information Science

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## ABSTRACT

*In a seminal paper published in the early 1980s titled "Information Technology and the Science of Information," Bertram C. Brookes theorized that a Shannon-Hartley's logarithmic-like measure could be applied to both information and recipient knowledge structure in order to satisfy his "Fundamental Equation of Information Science." To date, this idea has remained almost forgotten, but, in what follows, the authors introduce a novel quantitative approach that shows that a Shannon-Hartley's log-like model can represent a feasible solution for the cognitive process of retention of information described by Brookes. They also show that if, and only if, the amount of information approaches 1 bit, the "Fundamental Equation" can be considered an equality in stricto sensu, as Brookes required.*

## INTRODUCTION

In the last few years, several studies in the literature have addressed information and knowledge from the concepts proposed by Brookes (Brookes, 1981; Cole, 2011; Bawden, 2011; Castro, 2013a; Castro, 2013b). After more than three decades, Brookes' contributions to Information Science are indisputable. Numerous updates have been based on his equality for the information-knowledge duality, widely known as the Fundamental Equation of Information Science (Cole, 2011).

Brookes' contributions to foundations of information science are indisputable, and numerous works have been based on his representational model for the knowledge-information duality. This underlying equation to cognitive perceptual behavior is commonly defined as

DOI: 10.4018/978-1-4666-4936-1.ch018

$$K(S) + I = K(S + \Delta S)$$

where a knowledge framework, $K(S)$, is changed into an altered structure, $K(S + \Delta S)$, by an input of information, $I$, being $\Delta S$ an indicator of the effect of the modification (Brookes, 1981; Cole, 2011; Bawden, 2011).

Notably, Brookes' work provides a quantitative sharp bias, albeit a seldom examined from this viewpoint. Most of the works found in the literature refer to Equation Fundamental of Information Science merely how a pseudo-mathematical shorthand description of knowledge transformation. However, in a pioneering paper published in the early 1980's and entitled "Information technology and the science of information", Brookes suggested outright that his representational equation could be treated how a quantitative problem, so much so that he even probed, in field of what he called perspective space, a possible logarithmic solution similar to Shannon-Hartley's measure (Brookes,1981).

That nontrivial idea has been long forgotten, but in a recent paper, Bawden (2011) suggested that a model based on the Power Law (PL) (Newman, 2005; Clauset et al., 2009) could be used to account the $I$ input term in the Brookes equality. Bawden's hypothesis takes into account that the input, $I$, should not be treated as a number, but as a function (Bawden, 2011). This author maintains the following: "We do not know, a priori, what this function is; not even its general nature. But we may take an educated guess that the most likely form of such a function would be that of a Power Law. This seems likely, simply because Power Laws are very commonly found in many aspects of the biological and social domains; it is difficult to see any rationale for choosing any other form of function".

Inspired by Brookes' quest for an analytics solution that satisfies the $\Delta K = I$ equality, we show in this piece that a first-order ordinary differential equation based on premises of meaningful learning converges accurately to a Shannon-Hartley's log-like model for the $I$ input, as Brookes (1981) required. This continuous-time log-measure, once treated as an infinite sum of terms calculated from the values of the $I$ function's derivatives, exhibits a behavior how Power Law, according to Bawden's hypothesis.

## THEORETICAL BACKGROUND

Based on Brookes' premises, information (an outside stimulus) is considered as an element that provokes changes in the cognitive structure (framework) of an individual (Neill & Brookes, 1982; Todd, 1994; Todd, 1999; Cornelius, 2002; Capurro & Hjorland, 2003; Bawden, 2008). Information is received by an individual as a code that can be interpreted/assimilated according to an idiosyncratic affinity model (matching), i.e., an individual produces knowledge only when receiving stimuli that make sense to them (Cognitive-Meaningful Learning Theory) (Ausubel, 1963; Ausubel, 1978; Novak & Mosunda, 1991; Wadsworth, 2003; Wadsworth, 2004;Novak, 2010).

This matching can be mathematically translated using an approach based on the well-known Law of Mass Action (LMA), which is widely used by physicists, mathematicians, and theoretical biologists to quantitatively describe the relationships between biological entities (Jong, 1995;Knell et al.,1996; Devaney et al., 2004; Adleman et al. 2008; Bacaër, 2011).

The LMA originated in chemical equilibrium analysis, Guldberg-Waage Law (Adleman et al. 2008), where the reaction speed is proportional to the product of the concentrations of the reactants. The implementation of this approach in epidemiology, for example, is based on the assumption that infectious agents interact mathematically with susceptible populations by means of multiplica-