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Measuring Knowledge and Other Cognitive Properties ; Consequences in Terms of Ethics

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Abstract

Information as a classical concept, and, as newly defined notions, knowledge, cognition and quantitative cognitics – automated cognition - are briefly reviewed here. An important result clearly points at the necessity to adopt another point of view, to reverse the causality chain as usually perceived, whereby the past seems to generate the present: in practice, it is some conveniently set goal in the future that can most effectively trigger the present cognitive processes and the course of actions that allows us to reach this goal, i.e. that makes ***this*** *future happen.*

1. Introduction

Humanity has progressed through ages, learning most successfully about nature by a systematic use of scientific approach. In particular, clear definitions of concepts and appropriate metrics have been defined in many fields. This has worked particularly well for physical entities, such as length, weight, or time.

Repeatedly, careful measurements, i.e. quantitative observations, have later led to powerful new theories, techniques and innovations.

Building on the theory of information, it is time to extend it to knowledge and cognition. And to see the consequences, which turn out to critically relate to ethics – setting up appropriate future goals.

2. Information

In recent times a revolution has occurred, by which information-related objects and activities have become extremely important. The central concept – information- presents a bizarre status. While firmly established, it is not really understood by most people

2.1 Firm background

On one hand the concept of information is very firm ; it has been scientifically defined more than 50 years ago.

In a few words: Information plays a crucial role in the shaping up of people's opinion. Quantities are related to surprise, i. e. to the inverse of message probabilities.

Nowadays everyone is aware of information related metric units, mostly in the context of computers and digital media: « bit », and associated forms such as megabit, byte, etc.

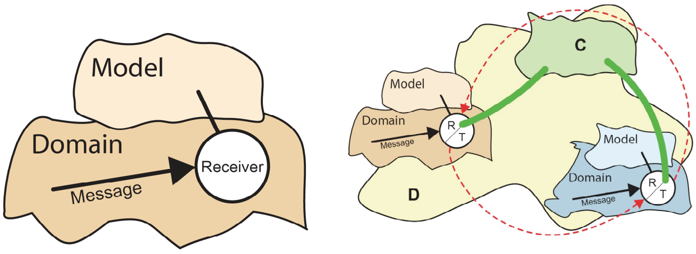


Fig. 1. *Information.* Information, conveyed by messages, allows the receiver to shape up his/her/its opinion, i.e. internal model, simplified representation of (some domains) of real world (*left*). At group level, a similar scheme may support the notion of culture: common aspects of multiple individual models (*right*).

2.2 Unfamiliar limits

On the other hand, general people are not familiar with estimating information quantities; the intangible nature of information, along with the fact that information is essentially subjective, and time-dependant make it difficult for many to estimate information quantities.

Model-based nature

Information is related to probabilities, and the latter need some appropriately simplified representational context, a model, in order to remain of finite, tractable size.

Subjective nature

By definition, the same message does not necessarily carry the same amount of information for all people receiving it.

Time-dependant nature

Information quantities vary with time: typically, the same message, repeated, does not bring any information any longer.

3. Knowledge and cognition

There is a general feeling in the 21st century that something else then information should be explored, yet beyond the concept of information, namely knowledge and, more generally, cognition. This becomes especially necessary as we are on the way to automate some cognitive processes (re. "cognitics"). We have therefore proposed definitions and new units for the notion of knowledge and for other cognitive properties; the "MCS" theory for cognition.

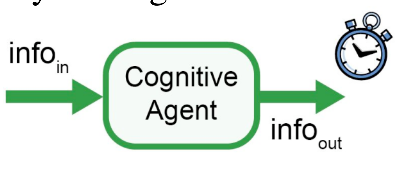


Fig. 2. *Framework for cognition.* The framework for cognition in MCS theory includes, in addition to cognitive agents or systems, information flows and time considerations.

3.1 Knowledge

The concept of information is tightly associated to the one of message, typically in a static fashion, as for a dictionary, a newspaper, a movie reel, or recorded news. While information tends to be static, knowledge is by nature dynamic. Knowledge relates to the *process* of *generating* information: writing a dictionary article, commenting an event on the fly, etc.

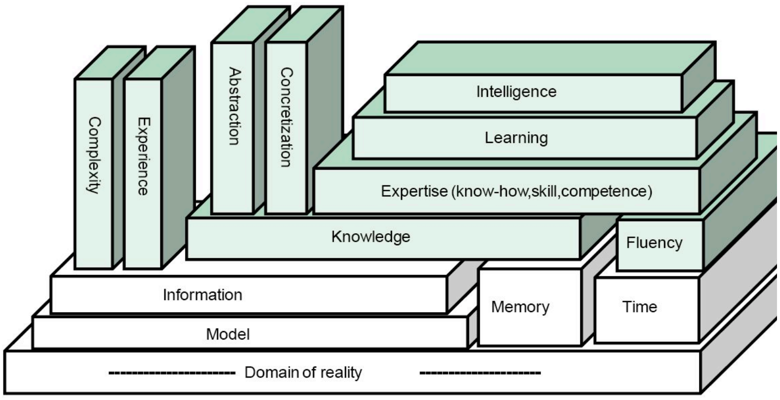
Notice that knowledge need to be *implemented* in a system in order to deploy its effects: this is a cognitive system.
In quantitative terms, the MCS theory estimates knowledge in a domain by analogy to the size a memory which would be required so as to store all the possible messages in that domain.

3.2 Cognition

Knowledge is the essential property of cognitive systems, i.e. of systems generating relevant information in a given domain.

Cognitive systems however can be characterized in many other aspects than just knowledge; in particular : abstraction, expertise, learning or complexity.

Expertise is of special relevance, taking into account not only generated information but also the time to perform cognitive tasks; changing expertise levels defines learning, and such an ability denotes intelligence; at least within MCS theory definitions.



Information:	$n = \sum p_i \log_2(1/p_i)$ [bit]
Knowledge:	$K = \log_2(n_{out}\, 2^{n_{in}} + 1)$ [lin]
Expertise:	$E = K/\Delta t$ [lin/s]
Learning:	$\Delta E = E(t_1) - E(t_0)$; >0 [lin/s]
Experience:	$R = r(n_{in} + n_{out}) = \Delta n$ [bit]
Intelligence:	$I = \Delta E/\Delta n$ [lin/s/bit]

Fig. 3. *Main cognitive entities in MCS theory*. Important cognitive concepts, defined in MCS theory, are colored in green(*left*). They are based on a few classic entities. Information, model and memory, though classic, need a discussion from a cognitive perspective; which follows.

4. Results of early works in quantitative cognitics

A rigorous, metric approach in the field of cognitive sciences brings many benefits, even though serious limits are encountered. And in fact this latter state of affairs may even be the cause for additional benefits.

4.1 First benefits of the MCS theory and a quantitative approach

The MCS theory defines an ontology for cognitive sciences which allows for unambiguous definition and comparison of concepts. Equations provided for quantitative estimation of essential cognitive entities allow for a clear assessment of current solutions and new task requirements.

4.2 Limits inherited from information nature

It turns out that we inherit here from the benefits and as well from the shortcomings of the concept of information. On one hand key cognitive concepts can be defined and in principle estimated rather simply; but the practical difficulties mentioned above, in estimating information quantities have similar consequences for cognitive entities.

A quantitative approach shows that reality is not upon reach. Infinite amounts of information would be required to fully describe any domain of reality, no matter how focused. As stated above, information is model-based, and models can only retain an infinitesimal part of reality.

Pushing very far the consequences of the subjective nature of information would blur the difference between reading the New York Times and performing the Rorschach inkblot test!

4.3 Limits relating to cognition context

Surprisingly, equations show that some common cognitive processes, performed as well by humans as by machines, can generate information as well as if they could rely on very huge memory capacities indeed, far beyond what can physically be achieved. The question still remains of how many, and which of those huge domains can validly be so strongly reduced by knowledge, i.e. correctly managed by cognitive systems.

4.4 Additional benefits and new directions

We have seen that the quantitative approach definitely shows that humans and machines can deal with information quantities, i.e. complexities, and knowledge quantities which, even looking large in absolute terms, remain infinitesimal with respect to reality.

That's a fact. Now two interesting questions are the following ones: Should we worry about it? Can we cope with it?

Cognitive quantities may not need to be that large!

But this quantitative approach, along with experience, also shows that fortunately large cognitive quantities may not be necessary for life (e.g. bacteria survive without much information nor knowledge). It is usually enough to have much simplified, incomplete views of reality – models. Models are too incomplete to be qualified of true, but they may be good enough to help reaching a certain goal.

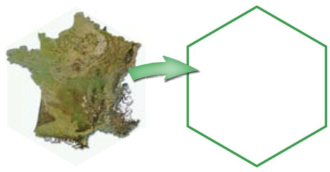


Fig. 5.. *Good and false*. A goal is a prerequisite for elaborating good models. For example France is often called after its shape: hexagon (*right*). This may help discriminate France from the Italian "boot" on a map, but retains very little information about the French nation indeed.

Reverse the causality sense!

The quantitative cognitive approach shows that is impossible to know where the current state of reality may lead. It is however most often possible to freely select goals for the future. Then hopefully good models may be elaborated, and a quantitative, scientific approach can be performed in their contexts.

5. WKD and Ethics

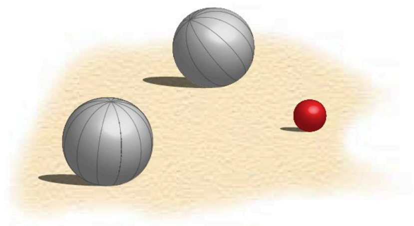
Addressing knowledge issues at world level, in a multilateral fashion, is surely a very good way to reach optimal solutions.

It has been shown above that in the world of knowledge, or more generally speaking, cognition, it all starts with setting goals. Ethics. Only then, hopefully, good models may be elaborated, and quantitative, scientific approaches can be performed in their contexts, so as to eventually reach those goals.

Consequently, boosting factors for WKD would be at least to make goals explicit. Preferably, the process should develop in order that respective goals of world-level partners, probably different for historical reasons, be adjusted so as to reduce negative interferences.

The principle of "reversing the causal direction", as shown as best approach in §4.4, suggest further that we should first dream that selecting common goals become possible at world level. Then cognition and dedicated work have a good chance to turn some of those dreams into reality.

Fig. 6. *Set appropriate goals!* Let's sketch together an enthusiastic, visionary future for our world, then we can be confident that knowledge and more generally cognition will lead us there.



6. Conclusion

Information, knowledge, cognition and quantitative cognitics, all this clearly points at the necessity to reverse the usual causality chain: in practice, it is some goal set in a convenient future that can most effectively trigger the cognitive processes and the course of actions that allows us to reach this goal, i.e. that makes *this* future happen. In a surprising way, this appears to somehow converge with many irrational yet culturally well-established paradigms, such as betting on placebo effects, betting on brain storming, on chance, or on fortune tellers!

Let's sketch together an enthusiastic, visionary future for our world, then we can be confident that knowledge and more generally cognition will lead us there.

More information:

"La Cognitique- Définitions et métrique pour les sciences cognitives et la cognition automatisée", Jean-Daniel Dessimoz, ISBN 978-2-9700629-0-5, Aug. 2008, http://cognitique.populus.ch.