Human Information Processing in Man-Machine Interaction

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ABSTRACT: Information and information processing is one of the most important aspects of dynamic systems. The term 'information', that is used in various contexts, might better be replaced with one which incorporates novelty and related concepts. Many important communications of learning systems are non-ergodic. The ergodicity assumption of Shannon's communication theory restricts his concept to systems that can not learn. For learning systems that interact with their environments the more primitive concept of 'variety' will have to be used, instead of probability. A suitable concept to information processing of learning systems is presented.

INTRODUCTION

We can find in the literature different interpretations of the term 'information'. Several approaches from different point of views are done to clarify 'information' (e.g., [8] , [11], [12]): (1) information as a message (syntax); (2) information as the meaning of a message (semantic); (3) information as the effect of a message (pragmatic); (4) information as a process; (5) information as knowledge; (6) information as an entity of the world.

Table 1. Several terms to describe the amount of information of a message before and after reception.

before reception	after reception	Author
degree of freedom of the decision	content of the decision	HARTLEY 1928
uncertainty	certainty	SHANNON 1949
uncertainty	information	BRILLOUIN 1964
potential information	actual information	ZUCKER 1974
entropy	amount of information	TOPSØE 1974

If we try to apply information theory to human behavior, then we have to integrate activity, perception, and learning. In this proposal we are looking for an interpretation of 'information', which is compatible with concepts of activity and learning. Going this way, we hope to avoid the paradox of 'new' information. Information before and after the reception of a message is not the same! Different concepts are introduced in the literature to 'solve' this paradox (see Table 1).

ACTIVITY AND INCONGRUITY

Weizsäcker [14] differentiated the concept of 'information' into two dimensions: 1.) 'Singularity of the first time', and 2.) confirmation and redundancy. For both aspects we can find two different research

traditions in psychology: (1) novelty and curiosity ([1], [6], [13]), and (2) dissonance theory ([3], [4]). Both research tracks are only loose coupled till today.

Investigators of novelty assume, that living systems (like mammals, especially humans) are motivated by an information seeking behavior. In situations, which are characterized by sensory deprivation, mammals and humans are intrinsically looking for stimulation. They increase the complexity of the context or the perception of it. On the other side, mammals try to avoid situations with a high amount of stimulation, dissonance, or stress. Hunt [6] designated this amount of increased complexity as 'incongruity'.
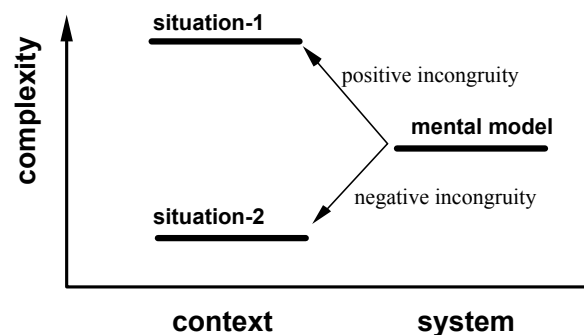

Figure 1. The difference between the complexity of the mental model and the complexity of the context is called incongruity.

If the complexity of the mental model is less complex than the complexity of the context, then mammals try to optimize this positive incongruity. Seeking behavior starts, when the positive incongruity sinks below an individual threshold or changes to negative incongruity (deprivation). Behavior of avoidance can be observed, when the positive incongruity exceeds an individual threshold (dissonance, stimulation overflow). Most of daily situations can be characterized by positive incongruity.

ACTIVITY AND LEARNING

Neisser [7] was one of the first researcher, who tried to integrate activity, perception, and learning. He emphasized that human experience depends on the stored mental schema, which guide explorative behavior and the perception of external context. Learning increases the complexity of the mental model [9]. This is an irreversible process. One consequence is, that the contextual complexity must increase appropriately to fit the human needs for variety.

We are able to measure the complexity of human behavior (e.g., explorative activities; [9]). The next step is to look for a good measure for the complexity of the perceived context. This problem is difficult, because we have to differentiate between the pre-structured part of perception based on learned mental schema (available information, [7]) and the unstructured and not predictable part, which enable the human to integrate new aspects into the stored knowledge (potential available information, [7]) .

ACTIVITY AND INFORMATION

A context with sensory deprivation has not enough positive incongruity or even negative incongruity. On one side, a human will leave a context with very low incongruity (to little difference to context complexity), and on the other side with very high incongruity (to much context complexity; see Figure 2). In between we have the range of positive emotions with behavior, which increase novelty on one side, and on the other side that increase confirmation and redundancy, or reduce dissonance, resp.
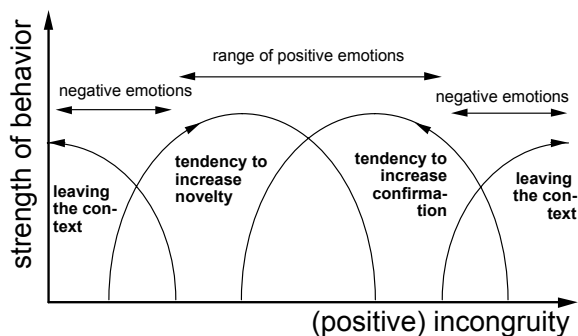

Figure 2. The coherence between positive incongruity, emotions and observable behavior.
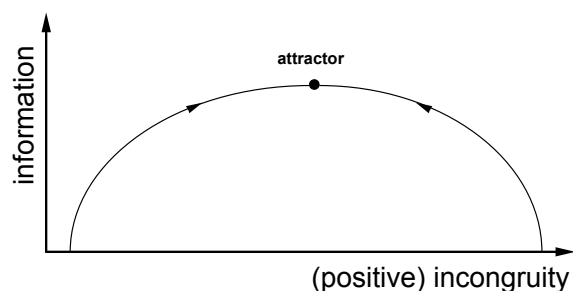

Figure 3. The summarized coherence between positive incongruity and information.

Overall we assume a reverse u-curve as the summarized coherence between incongruity and information (see Figure 3). If a human has to behave for a while in a total fixed and stabile context and he has a normal learning rate, then he must start to increase the incongruity. This can be done on two different ways: (1) increasing the complexity of the context or the perception of it, and/or (2) reducing the complexity of the mental model. Way (2) implies the possibility of "forgetting" (decrease learning rate) or

the manipulation of the perception mechanisms (suppression).

Different authors describe very clearly the problems arising when an operator has to take over a complex process during a monitoring task (the vigilance problem). To take-over process control is especially problematic when the system runs into an unknown state. Training in a simulator is one possible consequence, better is permanent on-line control in the real process. High skilled operators tend to lose the potential to be aware of the whole process. They need a special qualification to get open minded. In inescapable situations with information under-load we can interpret human failures as a subconscious strategy to increase external complexity.

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