ISSN: 2349-7300
ISO 9001:2008 Certified
International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences (IJIRMPS)
Volume 2, Issue 5, October 2014

An Overview of Structural Information Processing Models in the Cognitive Domain

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Abstract*— The cognitive models of information processing represent a multidisciplinary phenomenon with potentially great practical application. They are of great importance for improving the process of education, training, ergonomics, design of man - machine interface, robotics, as well as for other scientific disciplines. In this paper, different structural models of information processing which are often cited are topic of consideration. Structural validity of Smith's model, as well as the validity of some other information processing models has been analyzed. As a result, it has been concluded that almost without exception these models have a certain disadvantage. Main disadvantages reflect in the absence of certain structural components, their positions in the models, as well as in the flow of information between components. This indicates the need for further work in this area, with the aim of creating a model of information processing that would be able to provide answers to certain questions and problems that people of different specialty have in practice.

Index Terms—**Information processing, models, ergonomics.**

I. INTRODUCTION

Models of information processing explain the process of transforming information that begins with the reception of signals, until giving the responses to the received stimuli. They are important for the explanation of the process of perception. From the practical point of view, these models are the basis for the design of work tasks in accordance with human mental capabilities, design of resources for education in accordance with the cognitive characteristics of students, ergonomic design of displays and controls for the interaction of man and machine. This knowledge is also the basis for an adequate transfer of human mental abilities from humans to the computer or a robot.

The basic purpose of information processing models is to provide the insight about the ways of processing of different information by human beings, by using the symbolic (schematic) presentation. Although these models are generally formed to explain some specific phenomena about processing of information, some researchers often try to explain almost all occurrences concerning information processing by using one complex model. However, it is not a rare case that some weaknesses of models become apparent by application of a detailed analysis [1]–[4].

One of the first structural models of information processing is Broadbent's single channel model. This model of information processing has suffered a lot of criticism. One of the modifications of the model was created by Treisman. However, this model has also been the subject of controversy. This situation, as well as the assumption that man can simultaneously process different types of information has led to the formation of the multi-channel model of information processing. The aim of this paper is to analyze the structural validity and applicability of the most commonly cited models of information processing, which are presented in textbooks and other contemporary scientific literature.

II. MODEL OF HABER AND HERSHENSON

Information processing model of Haber and Herhenson is the model that is used in some textbooks for the interpretation of human information processing. Information processing model according to Haber and Hershenson is presented in the Fig.1. Haber and Hershenson consider that in the short-term memory performs the processes of information coding. Information coding represents a preparation for the storage of information in the long-term memory, or for giving a response. Also, information retains in the short-term memory only few seconds, although with repetition, its stay can be extended. Accordingly, internal repetition of information on the individual stages of processing represents the sub phase process, i.e. processing that executes on the same location in the system (iconic memory, short-term memory some authors often call the phases of processing). For example, such

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kind of processing enables that some visual construction can be "refreshed" internally, without any additional information inputs from short-term or iconic memory.

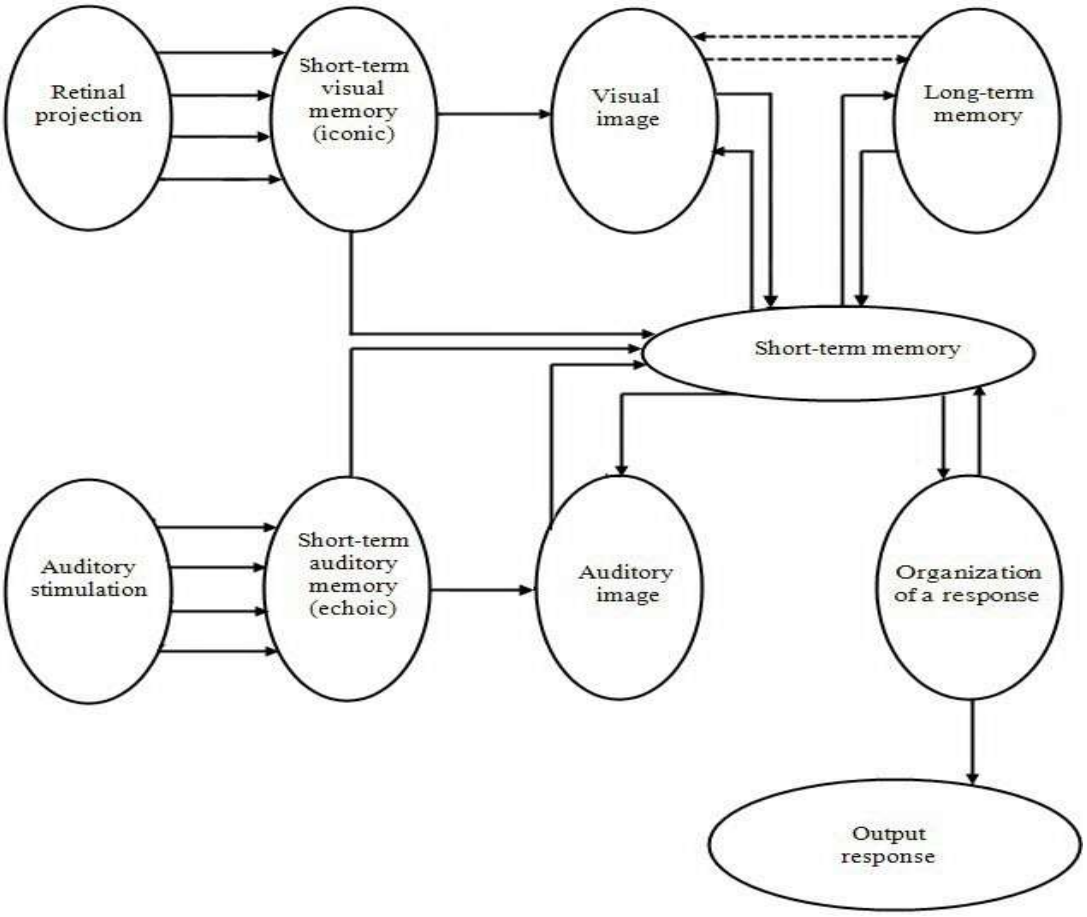

Fig.1. Information processing model for the visual and auditory input information, according to Haber and Hershenson [5].

Globally considered, the model of Haber and Hershenson differentiates from the single-channel Broadbent model therein the short-term memory undertakes the function of the Broadbent's p - system, i.e. the role of the channel of limited capacity [6]. Haber and Hershenson consider that their model mainly corresponds to the information processing models of other authors. However, primary item that separates their model from the other information processing models is the block of a visual image presentation. According to these authors, in this block performs a creation of a complex visual image, based on a determined number of visual sense fixation (i.e. in that way forms an image of the world that surround us). Because of that, it is necessary to make the difference between this block and the block of iconic memory, which content is determined with retinal projection in the extent of one visual sense fixation. In the visual image block, information retains longer than in the iconic memory, i.e. longer than 250 ms, although it is not known precisely how long [5].

According to the type of components that are in the content of the structure, the model of Haber and Hershenson does not differ much from the majority of other information processing models. In addition to the block of visual image, the characteristic that this model separates from the other models is the character of the connections between the structural components.

In the Fig.1, it is shown that the data flow between individual segments can be accomplished in the both directions. Thus, it is punctuated the information exchange interdependency between the elements that participate in the processing of information [2].

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However, certain details that relate to the information flow between structural elements offer some questions, although the model of Haber and Hershenson does not offer an answer. When we observe the connection between long-term memory and visual image, we can see that it is mutual. So, if exists the analogy in the way of processing of auditory and visual information (which perceives in the conception of the model), then we can notice that mutual connection between long-term memory and auditory image does not exist. In addition, the link between long-term memory and the visual image is not clearly defined. For that connection, Haber and Hershenson cite that it has conceptual or ideological character. They punctuate that it is not known is it possible to construct the visual image direct from long-term memory, or it is necessary that information firstly passes from long-term memory to the short-term memory, and then in the block of visual image. Therefore, the connection between the long-term memory and the visual image is presented with a broken line. Nevertheless, Haber and Hershenson did not explain what presents the visual image. Understanding of occurrences in this block can be useful for a revelation of the connection between long-term memory and auditory image and its adequacy.

III. MODEL OF BOWER

Bower's model of Information processing is shown in Fig. 2. This model of information processing is an example of a cumbersome model, whose complicated structure leads to the situation where loses to a great extent the use-value of the model, because the function of explanation of information processing in such a way becomes virtually impossible [7]. Such a cumbersome structure is the result of the aspirations of the author to integrate in a single model as many different phenomena related to information processing, in order to get the universal character of the model. A feature that distinguishes this model from other models is the differentiation on short-term and working memory. The basic functions of long-term, short-term and working memory are shown in the figure.

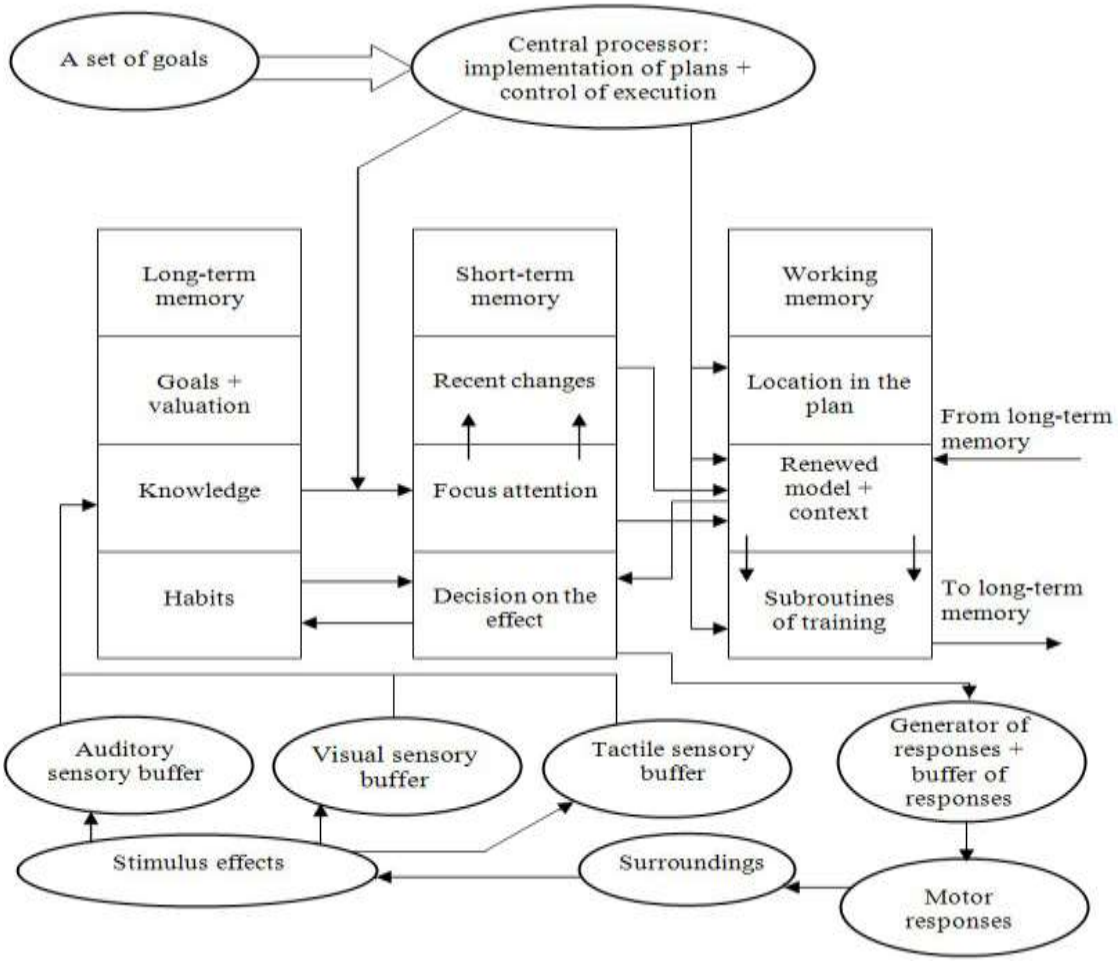

Fig. 2. Model of information processing according to Bower [7].

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Although the complexity characterizes this model (perhaps excessive), however, by careful observation, can be noticed the basic structural components that also contain other models [4]. Thus, we can notice the central processing segment whose function is virtually identical to the function of the block that relates to the control processes, in the model of Atkinson and Shiffrin. However, the Bower's central processing unit does not have a decision-making function, like it, for instance, has the central mechanism for decision-making in the Luczak's model. The function of decision-making is taken over by the short-term memory in the Bower's model, based on the data that is processed in the working memory. It can also be noted that auditory, visual and tactile buffer act as sensory registry, in the previously mentioned models of information processing. Generator of responses in the Bower's model also exists under the similar name in the most models of information processing (such as, for example, the block of organization of responses, in Schneider's and Shiffrin's model).

Bower's model is not without shortcomings, despite the complexity that it possesses. From Fig. 2, we notice that the information from the sensory register goes first to the long term, and only later to the short-term memory. This concept is in contrast in relation to most models of information processing, which explicitly show the memory components (as it is the case with the models of Atkinson and Shiffrin, Wickens, Haber and Hershenson). In addition, it is well known that upon the receipt of the stimulus information retains only a few seconds. If the long-term memory is responsible for this process, then its name certainly should be changed. From Fig. 2 also can be noted that there is no flow of information from any memory (or other components within the model) to the central processor, so it is not clear how information is processed in that block, when it previously not arrived for processing.

IV. MODEL OF MAZUR

Mazur's model of Information processing is shown in Fig. 3. After registering, the information is sent from the receptor to the correlator, which has multiple functions. Generally speaking, in this block, incoming information compares with already memorized information, whereby after the registration and processing of such information, it incorporates in the memory, for a longer or shorter time. Homeostat is a block whose function consists in determining the usefulness of the received information, for the person who participates in the process of information exchange with the environment.

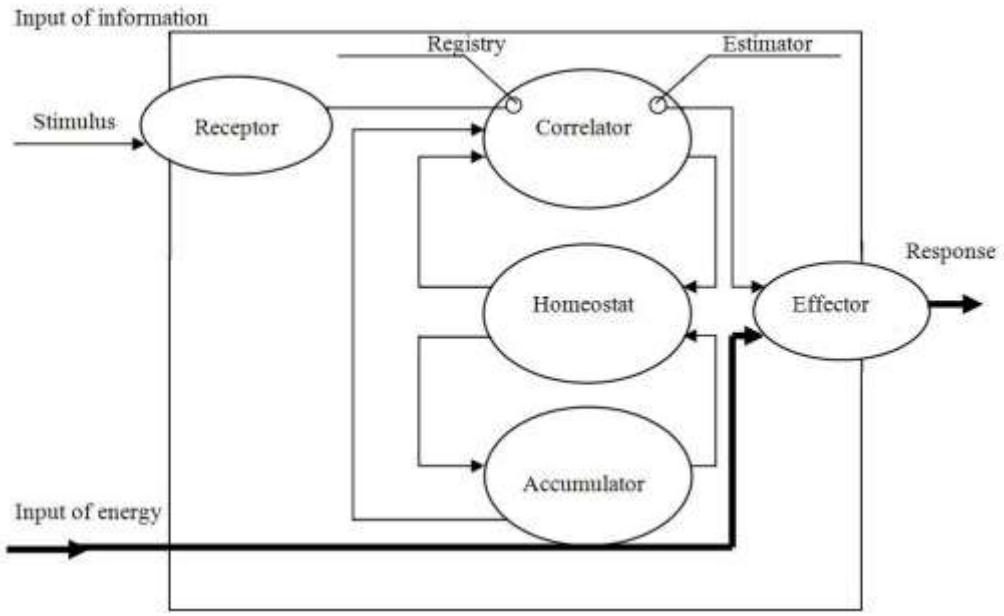

Fig. 3. Model of information processing according to Mazur [8].

In terms of structure, Mazur's model is quite different from all other models of information processing. We note three completely new structural segments (correlator, homeostat and accumulator), whose functions also appear at the first time in any of information-processing models. One of the novelties of this model is also presented through the function of estimation in the correlator, where the decision-making process performs, depending on

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the achieved energy value of the impulse in the relation to the decision making threshold. In this model, also for the first time we meet with the notion of the importance of information, for whose assessment the homeostat is responsible. The function of accumulator in terms of obtaining of energy for the execution of mental processes is a novelty compared to previous models. All in all, Mazur's approach with regard to the presentation of the structure and flow of information processing is different from the approaches that are represented in the models of other researchers [4].

As a possible disadvantage to this model can be pointed out that is to a single structural segment (correlator) attributed almost the entire function of information processing. What the correlator symbolizes in Mazur's model, in other models of information processing is separated through functions of a greater number of structural segments, which essentially constitute the very core of these models. Thus, for example, Mazur's model does not provide the insight into the information flow between different memory segments, and also is omitted the block that relates to organization of responses.

V. MODEL OF SMITH

In the Fig. 4 is shown Smith's structural model of information processing [9]. Smith's model does not contain significant novelties in comparison to the previously presented models. It may be noted that Smith's model includes structural components that are analogous to the previously seen. Thus, the block of stimulus preprocessing is analogous to the sensory registering of information, the block of categorization of stimuli is largely consistent with the perception, segment of selection of response correspond to the decision-making, whereas almost all models contain the block of execution of response. The characteristic of this model is that it explicitly does not show memory components, which in some sense is a drawback. The structure of this model and interconnectedness of the blocks indicate that this is a single-channel model of information processing.

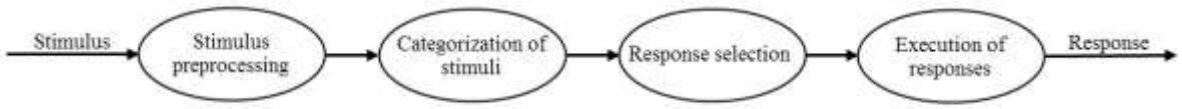

Fig. 4. Model of information processing according to Smith [9].

VI. CONCLUSION

In this paper, structural models that have frequent use for explaining of various phenomena related to the information processing have been considered. Their structural validity and functionality were analyzed. Certain disadvantages of these models are identified, indicating their limited applicability. Bearing this in mind, there is the need of performing experiments that would primarily enable the elimination of the dilemma about giving the priority to the single-channel or multichannel model of information processing. Such experiments could provide a significant contribution to the creation of new, improved models of information processing.

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ISO 9001:2008 Certified
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Volume 2, Issue 5, October 2014

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