DECISION MAKING IN MAN-MACHINE SYSTEMS: FUZZY CATEGORIES AND THE FUNCTIONAL ASYMMETRY OF THE BRAIN

Part II

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4. Memory and Brain Asymmetry

Decision making heavily relies on memory as a decision must be supported by all past experience available to the decision maker.

The above approach can help understand the distinction between image memory and verbal logical memory. The latter type of memory (associated with the left hemisphere) can be modeled by a set of closed or open chains; each link typically connects to at most two links (the ones next to it up and down the chain); the chains are only coupled to each other via a few interlinks. Any missing link (due to an organic lesion) will thus cause the entire chain to be interrupted, the sequence of the stored events to be disrupted, and some stored information lost. Yet, the effect of such a gap can be partially offset by other interlinks that may make up a bypass using somewhat dissimilar though logically relevant information in other parts of memory.

By contrast, image memory rests on a large number of intertwining and interconnecting links set in a multidimensional space. Each link may interplay with many others at a time, and a complex network of intertwining and partly overlapping links is thus generated. Naturally, the more reference points there are the less significant each of them becomes. Here one or even several missing links will not make the whole structure collapse and fall apart in disarray because the system uses other links and a myriad of their relations to survive. Image memory thus gains important advantages in terms of 'costs' required to absorb and store information as well as of effective memory capacity and data loss probability. Luriya's 'A Small Book about Large Memory' describes a testee endowed with incredible mnestic capabilities. The testee could memorize a very long series of figures or words at a glance. To do so, he would visualize a real picture, for example, the arrangement of houses along Gorky Street in Moscow, and then attach the figures read to him to the houses just as beads are threaded on a string. When asked to repeat the series, even a long time later, he would make a mental trip along the same route and "take the figures off" the houses so vivid in his mind. This trick appears to require an involved mental picture of the street as a whole, if only not to get confused over the sequence of figures. Investigations or public demonstrations of this extraordinary capability required that the testee remember a lot of diverse facts or, what is more, of rather uniform items. Bearing this in mind, we have to assume that each image he employed displayed a unique distinction, specifically, due to a great number of various relations between its components and between the image and his perception of the rest of the world. It is noteworthy that not only did S. have no subjective problems in putting facts into memory but he actually suffered from memorizing involuntarily everything he encountered.

In light of our concept that polysemantic relations are an essential element of image thinking and image memory, we see as very remarkable the results of tests where the subject is hypnotized and instructed to reproduce specific information. The tests tend to be more successful when the subject is told to create a mental picture of interacting images rather than of individual ones.[5] Subjects who exhibit higher mnestic capabilities in a hypnotic state report discerning a greater number of inner and often queer relations between image elements. They more frequently make up stories to facilitate the retention process. Many researchers note that such subjects do not have to make an effort to relate images: the process seems to go by itself.[6] Only highly hypnotizable subjects report an increased share of spontaneous fantasies in stories dreamed up in a hypnotic state.[7] It is these integral images emerging with no effort that pertain to the right hemisphere. Experiments put short-term memory to a specific strain. A higher level of cerebral activity was observed when the left rather than the right hemisphere dominated data processing. Empirical evidence thus proves image memory as well as image thinking to be both richer and less "costly" to the body.

It has also been demonstrated that the intensity of the alpha rhythm remains unchanged when one tries to remember music whereas a similar test with letters or figures results in a significantly decreased intensity in the left hemisphere. Our findings also agree with the studies of memory functions which involved persons with either hemisphere injured.[8] The interference was shown to play a secondary role in recalling an earlier imprinted item if the right hemisphere was injured. The success of imprinting seems to depend on whether new data can be incorporated into the image context. Once the process succeeds, the new engram coupled to many others is rather persistent. However, the process that fetches an engram from memory largely relies on the functional capabilities of the unimpaired left hemisphere. A severe organic lesion of the right hemisphere, though, may impede the 'coupling' proper. A lesion of the left hemisphere primarily impairs the function of engram retrieval. Probably the most evident effect of such impairment is interference observed if the period between imprinting and retrieval is taken up by intellectual activities. Here the process of retrieving the desired data is in effect that of detecting a signal in a noisy environment and interfering data represent 'noise'. The latter process calls for the ability to arrange data in a logical manner as well as to focus on a definite goal, to develop and maintain a rigorously ordered system. All these functions are discharged by the left hemisphere.

In summary, each type of memory has its advantages and limitations. The right hemispheric image memory is more flexible and spontaneous, it can retain an engram for a longer period. However, in a normal mind, left hemispheric processes must be strongly involved if the engram is to be properly and consciously retrieved. These processes are also dominant when a person is to memorize ordered and well arranged material.

Image memory is largely identical to the so called episodic memory that registers events of the subject's private life rather than learned formal knowledge unrelated to his experiences.

5. Applications of the Functional Asymmetry of the Brain

The above discussion suggests a modal and rather schematic definition of the left and right hemispheric functions. The left hemisphere controls analysis, evaluation of quantitative parameters, statistical prediction, as well as combinatorial and logical procedures. The right gives a qualitative evaluation for a complicated image and contributes to prediction that goes beyond the probabilistic approach. The two hemispheres operate as mutually complementary systems. The left hemispheric functions can be rigorously defined in a fairly straightforward manner. The case of the right hemisphere is much more complicated but we believe that the formalism of fuzzy sets and the theory of categories may provide an effective approach to this problem.

Functional asymmetry may be examined with advantage in such areas as interpersonal communication, development of interactive user interfaces and man-machine decision-making systems, procedures to formalize fuzzy categories, select an operator to deal with a given type of problems or provide him with a comfortable and friendly environment. When selecting experts to formalize fuzzy categories preference should be given to right-handers. The design of a terminal console for a 'unique' expert must be matched to his specific features. The results of such studies along with various means to explicate implicit ideas may be helpful in constructing techniques for such formalization which are adopted to a particular occupational group of experts or a particular class of application problems.

The advent of PCs has given rise to a new approach to uncertainty formalization, i.e. self-formalization of fuzzy categories.

This approach applied to decision making problems can take advantage of the above description method based on multi-element quality scales, membership surfaces, and two-level selection procedures. What follows is an excerpt of a human-computer dialog that seeks to formalize elements in the space of evaluated parameters.

Computer: Let's see how you evaluate the qualitative uncertainties inherent in the environment and in your system.

C: How many elements are there in the set of situational data? The decision maker's answer.

C: The number of the quantitative and the qualitative parameters? The DM's answer.

C: The name of the quantitative parameter? Scale type? (1 - a curve; 2 - a set of fuzzy points). The DM's answer.

C: What does the scale look like (monotonically increasing, monotonically decreasing, unimodal, or multi-modal)? The DM's answer.

C: How many elements does the scale comprise? ( ) (for a scale of the second type) - The DM's answer.

C: Reference points? Lower boundary point. Upper boundary point. First typical point. Second typical point. Third typical point. The DM's answer.

C: Intermediate fuzzy points? The DM's answer.

C: What does the parameter scale look like? The DM's answer. Similar questions about the other quantitative parameters follow.

C: The name of the qualitative parameter? How many elements does the associated term set contain? The DM's answer.

C: Does the parameter vary monotonically? The DM's answer.

C: What are the highest and the lowest degree of attribute intensity? The DM's answer.

C: What are the elements of the ordered term sets? The DM's answer. Similar questions about the other qualitative parameters follow.

Definition of Criteria

C: The number of criteria in the problem? The DM's answer.

C: Name the quantitative criteria. The DM's answer.

C: List the parameters they depend on. The DM's answer.

C: Name the qualitative criteria. The DM's answer.

C: List the parameters they depend on. The DM's answer.

The above fragment of the self-formalization procedure relies on such macroblocks as 'representation', 'teaching', and 'control'. Answers to questions similar to those of the fragment help derive appropriate quality scales and surfaces. The process of self-formalization is largely dependent on the specifics of the processes in the cerebral hemispheres. It draws on generalized past experience, actual conditions, particular image features, the ability to bring to mind a desired or a similar image and to imitate it as well as on the evaluations of various objects with respect to the elements of the selection procedure scale.

It may be inferred from the analysis of the above dialog in terms of the functional asymmetry of the brain that the computer seems to assist 'left hemispheric' thinking to translate into its discrete and unambiguous language those fuzzy categories that do not readily lend themselves to formal description and always fall within the scope of right hemispheric thinking. Obviously, no absolutely adequate translation is feasible, and yet DM often finds even such translation complete enough to accomplish his goals. The questions are presented in a very lucid manner to restrict the answers to a deliberately rigid format, and the subject just has to put his somewhat indistinct notions to a consistent analysis as dictated by the procedure discussed. The questions the computer asks are essentially those of highly developed verbal logical thinking.

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