COGITATIONES

'Passive' Thinking, a Hypothesis

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Summary. Based on observations and on analogical deductions from the organization of the cerebellum, a hypothesis of a 'passive' process of thinking is described. According to it, we try to program the cerebrum for the handling of an idea, regarding its solution we are, however, exposed passively to the brain.

Since the advent of computers, whether of the analogue or digital type, it was inescapable that explanations of the brain would be tried by applying the concepts governing computers. This was promoted by some resemblance between computers and the brain. It is, therefore, not surprizing that many models of the brain suffer from 'computeritis'. A computer is, however, passive; its individual parts develop no life. On the other hand, the brain is a living system with spontaneous activities developing everywhere.

In view of this it may surprise us that thinking – which is that part of brain activity considered in this paper – is described as a passive process. This position is adopted here not because of any credo confronting an 'ego' with the brain, but better to explain in which way the model suggested here deviates from a computerlike or governorlike interpretation.

POWER wrote that the factor distinguishing man from animal or machine is visible in his model only as a ghost. Whereas the writer does not differentiate in this context between man and animal, it will be tried to show the difference which separates man from the machine called computer.

The biological 'machine' called brain is at no time entirely switched off, its activity varies only by degree, as a whole or from area to area. As this system is practically totally interconnected, the above requires a ceaseless activity of differing magnitude, which may normally not be perceived, in areas, orders, levels, loops or circuits, as one may like to call them. This is not so in a computer. The term loop or circuit is used here in a very loose sense, the literal meaning is too computeristic and not appropriate for brain structure where energy may be generated everywhere and where currents may not be as well confined as in a man-made machine. Also the general propagation of stimuli is handled in a way which is in several aspects quite different from that of an 'inorganic' apparatus.

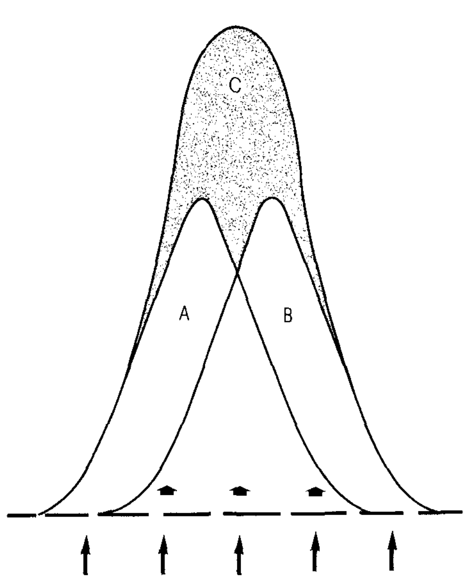

Fig. 1. Schematic illustration showing a tendency towards the center of 'meaderin' currents in neural networks. As the central path experiences a stronger and more probable excitation, i.e. in the region where A overlaps B, the flow of signals is enhanced there. This is indicated by the peak C. Therefore, impulses coming over a wide path represented by the 5 long arrows will have a tendency towards a central region indicated by the 3 short arrows.

Some selected observations are presented which advocate a model of the process of thinking quite different from an approach coined by computer philosophy. There are some 10^{12} neurons or more in the brain (the granular layer of the cerebellum alone accounts for some 10^{11} cells), each of which establishes some 10,000 synaptic connections. This system would represent a waste of material and construction detail contrary to the standard design-economy of nature if we were able to use the brain in an active and aimed way. A passive method of functioning would, however, require a considerable redundancy in 'equipment', and therefore explain the extreme number of parts. We mull over problems hoping to have an idea, try to remember a name, matter, or thought we considered minutes ago. Quite frequently we are not successful as long as we try; however, the idea, name, or matter may appear spontaneously after we have given up the hunt. Our brain may refuse obedience for quite a while if we wish to eliminate repetitions of words in spoken or written language. When working on one subject, our brain may suddenly supply us with ideas on a different one. If we hunt for a reference in a book we are distracted by a different subject. As we try to concentrate on something we read, our brain takes an excursion to a different subject, and so on. We try to fall asleep but our brain refuses to be 'switched off'. When, during falling asleep, our center(s) of wakefulness reduce the level of activity we suddenly have an idea which failed to come when we were working on it. A similar process may act when brainstorming reduces intentionally the effectiveness of such centers. The brain continues to 'think' during the D-phase of sleep, sometimes quite long logical sequences occur and may even be registered in memory.

A brain which worked like a computer, executing orders according to a programmed sequence and in an aimed way, would operate much too slow to permit, e.g. fast speaking on a difficult subject, because of intrinsic delays at nerves, synapses, etc. Even without considering the all-or-nothing character of nerves, low velocity of transmission and frequency limitations of nerves determining manageable volume of information per unit of time result in an efficiency which is about the one hundred-millionth part of that of a modern electronic system. Speed does not present a problem if many simultaneously existing thinking currents are assumed, which are raised to a conscious level in a more or less orderly sequence.

The cerebellum manages to control simultaneously the kinetics of, e.g. walking, chewing, humming a tune, looking, and hearing. The cerebrum copes, for instance, with simultaneous reading, thinking about it, and listening to music. There is, therefore, good reason to believe that the brain may at the same time handle many thought patterns at a subconscious level. We are passively exposed to the visual impressions and their evaluation as produced by the brain. If, for instance, on a photograph of a vase the highlights are removed by retouching, the entire surface changes its appearance from glossy to mat. The correlation of illumination and perception of colour has been explained by a hypothesis stipulating an unconscious computation operating in the visual system. It would seem to be logical to admit unconscious, in our context passive, processes not only for one part of the central nervous system but for others, like thinking, as well. The impression of differences in illumination of experimental objects may cease if one starts to employ the brain for a critical evaluation. Until then one is passively exposed to the impression generated by the visual and the evaluating systems. We cannot control Necker cube reversals, switching staircases, hollow molds of human faces from appearing to project outward, monocular Ames room inspection looking rectangular although it is not rectangular at all, but we are surrendered to the unconscious processing of information. Auditory illusions resulting from tones of different pitch being presented simultaneously to each ear show that the selection of the high tone place and reversal of high and low tone position cannot be influenced by our will. Phylogenetic reasons advocate similar process characteristics whether a 'non-thinking' primitive mammal, or primates, or man are involved. Also this suggests a passive exposure to the thinking process within the central nervous system. Much of what we do takes place although we have not actively engaged our brain. We pocket something and later search for it, we whistle a tune with our brain busy with something else, drive a car only realizing it when our brain tells us that there is an obstacle ahead, etc.

From such and further observations, one is tempted to construct a hypothesis of 'passive' thinking, with a large number of patterns of thought operating simultaneously at the subconscious level. We shall now try to correlate very tentatively thinking with the structure of the brain, starting with parts which co-ordinate patterns specific for certain areas.

Neuropsychological and neurosurgical evidence shows that certain regions in the brain have special tasks. Damage in the primary zone of the 2nd block causes, for instance, a sensory defect, if it is in the tertiary zone of the same block it may cause visual disorientation in space. If the injury is in the 3rd block the formation of intentions and programs may be seriously impaired and such disturbance may not be corrected by logical and aimed thinking. This does not only mean that we are passively delivered also in the sphere of co-ordination to the functioning of the individual sections of the brain, but it suggests how this part of the process of thinking might be organized. As the process of thinking involves stimuli from various locations in the brain, it may be assumed that 'currents of thought' of identical nature utilize parts of the neural wiring diagram which are identical as well, to reach circumscribed target areas. Even if the neural pathways involved are not precisely followed when an identical impression is conveyed the next time, a lateral deviation will still lead to an enhanced probability of excitation of the central path (cf. Figure 1). This will lead to facilitation, which together with inhibitory processes (also influenced by facilitation) will enhance sharpness of the signal.

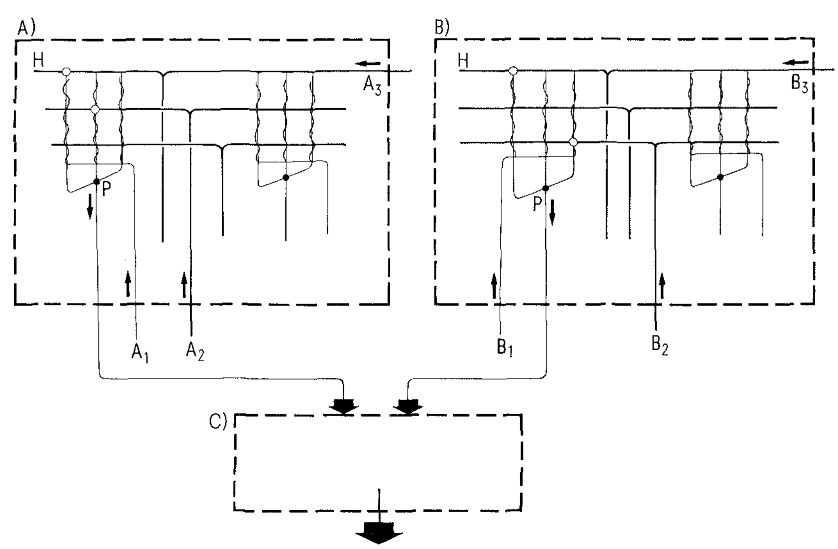

Fig. 2. A wiring diagram of a functional model of a micro-region of the cortex is shown in a rather simplified way. Several components of the system have been omitted, in particular inhibitory neurons and interneurons. The cortical area marked A receives signals via the climbing fibres (A_1). These inputs could be regarded as aimed commands exciting the Purkinje cells (P). Further signals reach the area through the mossy fibres (A_2), and from the granular cells not shown here. They travel in the parallel fibres (H). As these parallel fibres contact a considerable number of Purkinje cells, establishing as a rule only 1 contact with a given cell, a 'large' area is interconnected and fed with signals through the parallel fibres (A_3). In view of contacts between any one Purkinje cell and about 100,000 parallel fibres, an extremely large number of combinations of afferent and background signals is possible. Such patterns may have been subject to prior 'screening' by numerous filters. The output of the areas A and B reaches other processors in a further level of organization. There a further processing of signal patterns takes place and desirable ones may be passed on to successive integrators. A more real picture could be visualized as interconnection and cooperation of an exceedingly large number of 'similar' system elements, with other systems arranged before or after them, or in parallel, supplying, inhibiting, receiving, augmenting, or filtering signal patterns.

Turning now to the individual cortical area where an incoming pattern is processed or an indigenous one is generated, we will utilize certain similarities between types of cells of the cortex of the cerebellum and of the cerebrum. It is appreciated that there is, however, no point-to-point correspondence. Some better known elements of the cerebellar cortex will be used to venture a correlation of mind and structural detail in our model of thinking. Figure 2 renders a rather simplified wiring diagram in which many parts and details have been left out.

The Purkinje cells, probably represented by the pyramidal cells in the cerebral cortex, seem to be designed for maximum signal catching efficiency. Each Purkinje cell may be in contact with as many as 100,000 parallel fibres and therefore receive inputs from a large area. The parallel fibres run perpendicular to the plane of dendrites of the Purkinje cells, and they are connected to the granule cells which are exitatory and exceedingly numerous. We could assume that the intrinsic (local) latent currents of our thinking brain flow in these parallel fibres.

One type of input signal comes via the mossy fibres (fusiform or polymorphe cells in the cerebral cortex ?), activating large areas of the cortex. Due to interconnections with other cells which are inhibitory, the mossy fibres may not only detect signals but modify them. The parallel fibres into which the mossy fibres are feeding via the intermediary granule cells, as well as the latter may quench stimuli in the parallel fibres. This arrangement could represent 'filter systems' controlling the continuous background 'thinking currents'.

Each Purkinje cell is reached by only one climbing fibre which is afferent, like the mossy fibres. As the climbing fibres establish several hundred synaptic connections with the corresponding Purkinje cells, the latter respond promptly with an intense action potential to a signal arriving in the former. Similar to the Purkinje cells which are inhibitory, equivalent cells in the cerebral cortex may serve to produce pattern adjustments suppressing undesired 'currents of thought' in areas controlled by them upon receipt of a corresponding aimed order.

The Golgi cells do not only switch off parallel fibres via the granular cells but may select signals which are to reach the Purkinje cells by means of contacts with the climbing and mossy fibres. There are also inhibitory neurons in the cerebellar cortex, like stellate and basket cells which tend to sharpen the boundary and contrast between activated and undesired areas. By the above elements, a mutually perpendicular three-axial network is formed.

In the cortex of the cerebrum, there are parallel fibres and further cells which seem to be analogies of corresponding elements in the cerebellar cortex. They are afferent, efferent, or intracortical, and have exitatory or inhibitory tasks. Responsibility for individual tasks, therefore, does not stop at the functional level of blocks, zones, or areas but extends to elements of construction. Also this suggests our passive exposure and stresses need for redundancy.

Summarizing, a model of thinking is proposed according to which patterns of stimulation correlate certain areas of the cortex with various sources outside and inside of the central nervous system (optical, acoustical, kinesthetic stimuli, signals from parts of the brain involved in orientation, speech, writing, goal-linked intentions, etc. considering spontaneous intrinsic patterns). This will create case-specific stimulation patterns, and a later recognition of a pattern if it reappears and reaches adequate levels. This process is enhanced by facilitation comprizing inhibitory elements as well, if a pattern appears for a longer time (learning, in particular if repetitive, memory), or during the seconds when directing the brain at an aim, i.e. when it is fed with a search 'program' for a subject or idea. (The velocity of neural transmission in the short pathways permits many unconscious repetitions of the order within a few seconds.) Unconscious repetition of stimulation patterns, proved by spontaneous supply of ideas, etc., by the brain to the conscious mind, supports their refreshment, i.e. the maintenance of the memory store. Concentration on one subject tends to suppress activity of undesired patterns (this may also hold for retroactive inhibition), and enhances the probability of a desired one reaching the various filters which have been set to enhance their passage.

Correlated stimuli (cf. mnemonic techniques) enhance retrival probability, e.g. reappearance of patterns in the

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originally learned composition (optical, acoustical, scenic, etc. components) inter alia due to the higher probability of appearance of one element which promotes the retrival of the other components. Addition of new or deviating pattern elements leads to new 'ideas', weakening, distortion or suppression of original impressions, or repressions if the filters are set to block passage of patterns of unpleasant experience. It is seen that neither RNA modification nor loops are required to explain the various phenomena.

In simple language, our thinking may amount to stimulating a 'probability filter system' which then sees to it that the patterns passed on to the conscious mind correspond to our world of experience. We 'tap' the system, feeding in this and that stimulus which we believe is relevant. If the brain has been properly fed with information and was well maintained in the past, it may then supply us with the desired flow of thought, related trains of ideas may be triggered, and when we ultimately try to go to sleep, the brain may refuse to be silenced.

STUDIORUM PROGRESSUS

Timing of Single Daily Meal Influences Relations Among Human Circadian Rhythms in Urinary Cyclic AMP and Hemic Glucagon, Insulin and Iron[1]

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Summary. Relations among circadian rhythms in serum iron, glucagon and insulin and urinary cyclic AMP excretion differ drastically when diurnally active, nocturnally resting human adults consume all daily food for one week as breakfast only and for another week as dinner only – a finding of interest to diverse fields, e.g., for optimizing certain kinds of therapy or for a better utilization of calories.

Introduction. Variables at several levels of biological organization in pigeons and mice have been documented to exhibit a circadian rhythm persisting in the absence of all food and water, until death from starvation and dehydration[2–6]. This circadian rhythm persistence also has been demonstrated by Apfelbaum et al.[6] and Reinberg[7] for obese human subjects on a hypocaloric diet. In the latter studies, relatively minor if not negligible alterations were found in the rhythms' timing when a single 250 calorie meal was consumed at different times.

By contrast, time relations among circadian rhythms in mice could be shown to differ according to the location along the 24-hour scale of a 4-hour span of access to food, a span designed to simulate a substantial yet single daily meal[8].

Moreover, when daily food consumption was restricted to the start of the usual span of activity – 'breakfast only' – nocturnally active mice on a schedule of light alternating with darkness at 12-hour intervals, had a lower body weight than was the case when food was consumed as 'dinner only'; i.e., when mice were allowed access to food only during early light, presumably the equivalent of a very late supper or sleep-interrupting snack. The same finding also applied to human beings. Diurnally active volunteers had a relative body weight loss when they ate 2000 calories per day only in the morning, as compared to a span when they ate the same amount only in the evening[9]. Statistically significant differences in internal relations of human circadian rhythms dependent upon meal-timing were also observed and will be described herein.

Materials and methods. For 2 consecutive 1-week spans, 5 male and 2 female presumably healty human volunteers followed a more or less sedentary routine of wakefulness from 06.30 h to 23.30 h and rest (mostly sleep) during the remainder of each 24-hour span.

All subjects were given a complete physical examination, which did not uncover organic disease; they were interviewed to estimate usual caloric intake, food preferences, and eating times before establishing a meal plan. An average daily level of 2000 calories was determined and used as the basis for a catecholamine-free controlled-nutrient plan. The 2000 calories were distributed as 50% carbohydrate, 15% protein and 35% fat. Although the calculated protein intake remained constant from day to day, amino acid content and food composition did vary. Iron intake was fixed at 13 mg. The total fluid intake from the diets (milk, fruit juice, soft drinks and water) was set at 3,000 ml/day to ensure adequate urine output. The intake of non-caloric drinks was not restricted in time. For 3 subjects breakfast and dinner menus differed in kind, though not in total calories; for the other 4 subjects (including the 3 described in the Figure and Table II), menus were the same during the week on breakfast and that on dinner. The subjects were monitored by the staff of the General Clinical Research Center at the University of Minnesota.

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