Committee V
East-West Perspectives on Science
and Spirit: Time and Consciousness

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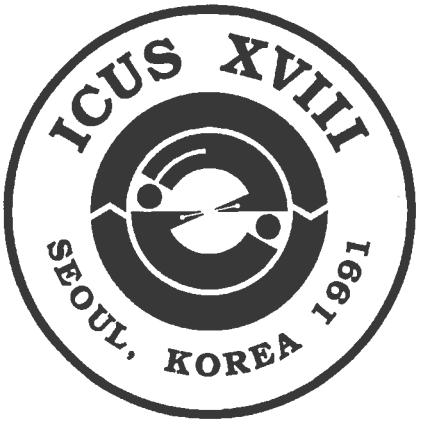

NEUROLOGICAL BASIS OF TIME AND CONSCIOUSNESS

by

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Contemplating, as a neurobiologist, of the subject Time and Consciousness, I faced with numerous dilemmas whose universal significance extends not only the framework of neurosciences as scientific disciplines but also the science as it is in its essence. Everyone of us who deals with the science is inclined to divergence, what has been appropriately formulated by von Weizsäcker (1985): "that the science is, if it thinks of itself as the whole truth, the greatest deceit in which the mankind has ever fallen into". Anyhow, much greater dilusion of people would be if they were tempted not to believe in science. The man, generally speaking, and especially a scientist, is inclined to divergence which includes implicitly that the issue he understands he considers as the whole truth. This particularly refers to contemplative means of abstraction; inner consistency of world abstraction is so great that it is very difficult to learn to what extent man herein moves in the system of delusion and deceit. However, very often, it is not possible to reject a priori the system of delusion, because it sometimes consists of the elements of profound truth, which we, led by existing scientific pragmatism, completely ignore. Thus, it is always necessary to approach to every notion with respect in order to discern between the truth and the delusion.

The human being with his consciousness as his innate essence is a part of nature which is much older than himself, but man is older than the science which studies that nature. Consequently, the goal of science is to explain natural phenomena with new insights and the knowledge with the history of nature, and all of that has been known to happen through dynamic changes over time.

The evolution of life and mankind, since the beginning, has been submerged into a sea of time. Human beings, like fish in water, have only slowly made themselves aware of the time-sea in which they live. Archeological data from Cro-Magnons caves in Southern France about 37.000 years ago indicated that these men, who were the first human beings, had recorded systemic observations of the moon phases, migration of game animals, the spawning of salmon and possibly even the position of the sun at different times of the year[11]. An ability of these early human beings to record and predict such events, and the possession of greatly enhanced potential for survival enabled them to plan for the first time in human history.

During the ensuing centuries, men made the instruments for measurement and classification of physical time, as an external standard for defining the "acceleration" or "retardation". The development of civilization led up to the extension of possibilities for progress and expression of new modalities of social and biological life in which the time consumation became the main goal and purpose. However, the extension is limited by specific biological and physiological functions. Extensions can be viewed as externalized manifestations of human drives, needs and knowledge, and they also reflect our unconscious drives. For example, the phone extending the human voice, television extending both the eye and ear, computers extending the memory, microscopes extending the lens of the eyes, automobiles extending our legs, etc. But every extension usually takes the place of the process which has been extended. Most frequently, it brings about the disorders of our biological clock, moves them outside ourselves and that is the moment when the extensions are treated as though they represent the only reality. And subsequently, the tension and colision

of internal clock and external physical clock occur what gives rise to numerous stress situations and discrepancies in contemporary world.

The time and consciousness have their roots in numerous disciplines relevant for comprehension of their relationships in the context of neurobiology; not going into details, I would point out metaphysics, physics, evolution and culture. Metaphysics, especially European metaphysics in a dialogue with certain Greek sources, emphasizes that the cognition of time presents the horizon of subsistence and that time has central significance for mathematics. Physics, being the fundamental discipline of natural sciences, is firmly linked to time logic, out of which the quantum logic is only one of its variants. Quantum theory as the theory of probability prognosis, seeks for the possibility of its application in psychological processes, including the consciousness, what will be the topic of other communications at this meeting. Evolution, both as science and philosophy presents the continuing succession of changes over time. Culture in the scientific premises context of transpassing through time barriers of milleniums of our civilization, enables our historical comprehension of man, what includes: the unity of observation and dynamics, the unification of target rationality, pointing out the trinity (theory, moral and art) and finally the unity of truth.

Let us back to the basic phenomena of this paper - consciousness and time. According to the Encyclopedia of Neuroscience[2], consciousness as a neuroscientific concept has been loosely employed to encompass several different meanings or aspects of cerebral function in humans and non-human animals. The term is often applied to the states of responsiveness to the environment - being conscious or in coma, awake or asleep, and

being alert or aroused within the awaking state. These conditions can be described behaviourally by observing the human or the animal. Conscious or subjective experience or awareness is clearly accessible only introspectively to the subject having the experience. The role of neurosciences is to understand the neural basis of conscious experience, i.e. the mind-brain relationship; also, to provide necessary conditions for an explanation of this phenomenon on the cellular level. The experiments of Maruzzi & Magoun (1949), Penfield (1975), Jasper (1966) and others on the role of reticular formation in arousal indicate that there are areas of the brain outside the cortex that are necessary for consciousness. On the other hand, the experiments of Sperry (1970) demonstrate that there are separate and specific hemispheric locations of different brain functions related to consciousness. Additionally, there is an evidence that the hippocampal and limbic system (Vinogradova, 1975) and striatum as well (Rakić, 1966) can function to distinguish the novelty and read out the short term memory in a fashion that might modulate input to the conscious brain.

Perhaps the main impact of this and related work is that the consciousness is not a privilege of the entire brain, but rather the result of processes occurring in certain defined areas, for example, two cortical hemishperes, the thalamocortical relation (Mountcastle, 1974), the striatum and limbic and reticular systems. The recent studies on humans, using non-invasive methods of local cerebral circulation and metabolism, effects of pharmacological agents as well as direct cortical stimulation and recording by intracranical electrophysiological methods, in awake and responsive subjects, greatly contribute to better comprehension of the

matter, especially the balance and relationships between conscious and unconscious mental events (Libet, 1982).

In searching for objective biophysical and molecular biological parameters, one should always be enough critical, cautious and above all, all these data should be observed integrally with the whole behavioural expression, especially in differentiating the conscious and unconscious. We have previously emphasized that the certain degree of cortical activation presents a prerequisite for consciousness. Libet et al (1983) found that many of conscious experiences required a substantial minimal period of cortical activation and that shorter periods of such cortical activations might elicit unconscious mental operations. Subsequently, the difference between conscious and unconscious mental events could be the duration of appropriate neuronal activities. This provides an opportunity for unconscious modification of the content of a subjective experience during the time in which the conscious event is developing. This also represents one of the possibilities of real and probable interactions of time and consciousness.

In search for neurobiological correlates of time and consciousness, the processes of learning and memory occupy a special place, about which both affirmative and negligible attitudes exist. Learning connotes acquisition of information or acquisition of new skills and behaviours, whereas memory implies the retention over periods of time of acquired knowledge or previously experienced events, together with the retrieval of such knowledge or conscious remembering of such events.

The question arises - what role has consciousness in the systems responsible for learning and memory? The current knowledge concerning the problem points out the existence of numerous different forms of memory in a wide range of various situations as well as necessity to differentiate them among several kinds of consciousness. Both are closely related to mind - the central problem of man. It is well known that a prerequisite for the phenomena of mind is consciousness which may be described as a state that implies an ability for awareness of sensation - that is, a state in which perception may take place. Consequently, consciousness is a state of awareness in which the subject is capable of perception; the state of activity in the brain which enables it to exert any of its functions as "mind". One´s own mind is a subjective experience, a personal world which can be explored, within limits, by introspection. The mind of other men can be inferred from their speech, writing and actions, while the mind of animals from their actions alone. (We shall discuss later on the mind and consciousness in the early stage of evolutionary scale).

Consciousness is a condition sine qua non for mind but the components of mind may be considered as perception, memory, emotion, propositional thought and response. Perception is the transfer of information into its physicochemical equivalent to the appropriate part of the brain by propagation from sensory organs to the cerebral sensory cortex. The information may be described as sense data which are part of the perceptional world of the subject in distinction from the physical world of the perceived object. The nerve cells responsible for the act of perception are maintained in a state of readiness as a part of consciousness by neural mechanisms previously described. When the system is in a state

of awareness, the percept is registered, and by complex neural connections is committed to memory. These sense data are stored to be retrieved at will in temporal sequences. Percepts may then be correlated with pre-existing memory patterns and with the stored emotional contents of those patterns. Emotion may be considered as having a sustained "tonic" component and a "phasic" component, linked closely with autonomic activity. The tonic aspect of emotion sets the bias for reaction pattern, so the person is said to be of happy, amiable, irritable or gloomy disposition. The phasic aspect of emotion is a response to a percieved stimulus, and its nature depends upon memory of events associated with a similar percept - it is a learned response. The emotional reaction influences the selection of an appropriate motor response - grasping or avoiding, accepting or rejecting, advancing or retreating. The important form of intelectual endeavor, logical or propositional thought, proceeds from a given premise to a conclusion. In this system memory may provide the premise which thereupon acts as an internal stimulus, taking the place of a perceived stimulus, to initiate a chain of events. Propositional thought is the basis of what we term intelligence, intellectual ability comprising an aggregation of special skills, out of which each may be developed to a different degree in a single person. Then, effector or motor neurons ensure that activity, whether it be speech or movement (response), which can be initiated in a fashion appropriate to received information[7]. What I wish to stress here is the importance of systematic occurrence of conscious awareness in remembering and in other mental activities. Clinical example of an essential impairment of consciousness together with the deficits of learning and memory is amnesia. Amnestic patients can learn new skills and acquire new knowledge but they do not remember such

learning and therefore are not aware of the facts they now possess. Within this general picture, some neurobiological evidences favor that conscious experience may be dissociated from the memory. Sleep research indicates that a person awakened during so called rapid eye movement (REM) sleep, usually can report dream experience. If the person is awakened later, he cannot recall any dream. Animal experiments report that in REM sleep a subject responds to previously conditioned stimuli and learns poorly new tasks during the REM sleep. This confirms that dream experiences are clearly conscious but that the memory consolidation is so week unless the memory process is activated by awaking. Dreaming represents a good example that conscious experience is not necessarily tied to memory. All mentioned phenomena emerge from the physical-chemical brain activity and its anatomo-physiological organization, what we are not able to discuss within this limited paper.

The time is very difficult to bend to simple linear description. It is not a definite constant, but a cluster of concepts, events and rhythms covering a wide range of phenomena. Not going into details, I am pointing out that one may talk about different types of times[3]: Existential time (physical, biological), physiological and conscious time (metaphysical, sacred), unconscious emergent time (personal, synchronized) and situational cultural time (profane, micro). We shall deal, in this paper, with that time which includes neurobiological aspects.

Biological action and human experience is indivisibly tightened to time. There is no action or experience without an appropriate timing and duration. Contributions from classical neurosciences emphasized the importance of temporal integration in the physiology of brain and so called higher nervous activities (Lashley, 1951). The establishment of conditioned

reflexes depends on close association in time of conditioned and unconditioned stimuli. The duration of time base has theimportance in different expressions of adaptive learning system functions - cognitive or affective ones. During classical conditioning animals are subjected to conditioned stimulus (tone) emanating from external sources, paired with biologically significant external unconditioned stimulus (food). Both stimuli effect cognitive system (i.e. animal learned that tone paired in short period of time with food is a signal for feeding) and affective system. When animal consumed food (after longer time period) the affective values of that food in the internal milieu appeared. The cognitive and affective processes have a great impact on consciousness, and they are qualitatively distinct and subserved by different neural systems, both essential for associate learning. In general organization of behaviour, temporal order of planned and deliberate behaviour depends on cerebral organization (frontal lobes) which has ready access to the store of the past and present experience, capable of representing action in the form of general schemes. The execution of the behavioural act must be followed by the reference of those schemes. Following these facts I wish to mention the Ingvar's[4] data on the cerebral processes involved in integration of conscious experiences related to past, present and future events, based on clinical and cerebral blood flow studies. The neuronal substrate for the past - responsible for storing information of events (memories of motor-behavioural reactions, sensory percepts, sounds, cognitive structures, etc.) - constitutes the structures in postcentral cortical areas and temporal lobes. The present means the experience of actual events in the now-situations and in a given sensory situation. We are conscious of the fact that we see, hear and feel things

in the present with the aid of our sensory inputs. The basic type of awareness of the present is mediated by the sensory inputs pertaining to the present moment. Electrical stimulation of primary sensory projection field in the cortex induces functions of now experiences represented by activated sensory modality. The future or "memory of the future" provides us to be aware of, to be conscious of, to anticipate, to expect, to plan for, and to remember events in the future which have not yet taken place. This function has stressed the fundamental capacity of the central nervous system - to deal with the future, to make up action plans and to program anticipatory goal-directed behaviour and cognition. This capacity of the brain is especially pronounced in man and it is closely related to his language ability. Using the most advanced non-invasive techniques to measure the distribution of function in different brain structures in conscious unanesthetized human subjects at rest or performing various types of mental activity, Dr.Ingvar found that future behaviour and cognition were evidently handled by the prefrontal cortex.

There is an increasing number of evidencies supporting the statement that human being exhibits some pragmatic organization of time in his daily life, shows the capacities for elaboration of cognitive treatment of temporal information, builds conceptual constructs about time and also experiences time with various affective connotation. It is worth stressing the possibilities that the aforementioned emerges from more basic and more general forms of adjustments to time in all living organisms, known as "biological clocks" or "biological rhythms". Biological clocks have evolved as adaptations to periodic fluctuations in the environment. The role of such clocks, as innate temporal substrates,

for physiological and behavioural programmes forming an adaptive match to predictable variations in the outside world, is well established (Aschoff, 1984). Without going into details, because this question will be discussed more in other contributions of this meeting, I wish, following the main task of this paper, to emphasize the importance of the circadian periodicities in learning behaviour. Our data have shown that circadian rhythm plays an important role in the formation of conditioned reflexes. Desynchronization of the circadian oscillator by subjecting the experimental animals to permanent darkness or permanent light produces a significant disruption of the circadian variations in learning processes and the learning process itself (Kovačević & Rakić, 1971). The discrepancies between the internal (biological) and external (physical) clocks cause a lot of stresses in our everyday life. Edward Hall (1984) introduced the term - time "drags" - in the case when the body clock and the clock on the wall are out of synchrony. Time dragging is expressed as a synonim for not having a good time. Accordingly, the message that time is dragging can be used to alert individuals to find out what it is that makes them feel that way. Be aware of time dragging is important, because it is increasingly clear that our unconsciousness is where the organizing, synthetizing core of our personality is located. Many persons attempt to reduce alienation and try to bring together the conscious part of ourselves with the unconscious one. The gap between the unconscious and the conscious is not inconsiderable. When this gap is too wide, people´s lives are diminished. The strain of trying to bring the two parts together makes people less productive and less satisfied. The phenomenon of time dragging has to be more often and more thoroughly considered in the context of individual psyche,

psychological status and conditions. Regulation of time does not mean control of time. The general feeling must have been that time can be adapted to, but that it cannot be controlled and therefore even "the Gods followed time as given" (Toda, 1978).

The question arises - what structures and what systems represent the possible common neurobiological basis of time and consciousness. The data here presented indicate that it would be cognitive brain structures and systems. Talking about the neural structure of consciousness we have pointed out that property of consciousness includes: (1) the ability to appreciate or distinguish different events; (2) the capacity to react critically to inward or outward conditions and to update information; (3) the ability to accummulate memories and to recall them associatively in temporal sequences, and (4) the capacity to distinguish self from nonself (self-awareness). On the other hand, the cognitive functions are closely related to temporal organization of behaviour - both temporal regulation and rhythmic periodicities. The main dynamic function of the brain is mediating between experience and action. In doing so, one must be able to account for updating of past storage and for temporal properties of recall. Among other things, specially important are the continuity of perception, temporal succession and detection of novelty. According to that, consciousness can be considered as a form of associative recollection with updating, based on present reentrant input. The cognitive structures occupy different brain regions and may be experimental or genetic or, more likely, the result of an interaction of both. They integrate present events with the representation and generation of past history and also create the action plans for the future (anticipation, prediction). But time cannot be treated simply

as a homogeneous artificial parameter describing input-output relations. Before all, time means information for man - temporal information which persists in humans throughout their lives. Time is an independent property of the information flow, same as the other properties of information patterns such as size, color, sound or spatial locations (Michon , 1972).

The consciousness appears gradually during the evolution of life. Only on the level of man develops the human consciousness capable of relation towards itself, of arising critical questions about the objects and living beings in the environment; likewise, capable of searching for answers to these questions within exact scientific and philosophical solutions. Together time and consciousness, besides other dimensions, have cultural dimension as well, and all of them depend upon neurobiological basis which is again under the influence of time and consciousness

Summarizing up the whole idea I would like to point out once again that the consideration of neurobiological basis of time and consciousness includes as an obligatory prerequisite the cognitive functions which are then in dynamic interaction with them.

The data presented in this paper serve mostly for guiding the future research rather than to be an adequate response for filling the gap of the existing knowledge.

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