Yuri I.Alexandrov. Systemic psychophysiology / In Chris Forsythe, Mikhail V. Zotov, Gabriel A. Radvansky, and Larisa Tsvetkova (Eds.) Russian Cognitive Neuroscience: Historical and Cultural Context. N.Y.: CreateSpace Independent Publishing, 2015. P.65-100

Chapter 3

SYSTEM PSYCHOPHYSIOLOGY

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SUMMARY

The objectives of this chapter are as follows: (1) provide a survey of systemic representations in psychophysiology rooted in the theory of functional systems (TFS); (2) compare dynamic representations at different stages of development of TFS with advancements in the world scientific community; (3) describe a systemic solution to the psychophysiological problem, and associated with it, of the consciousness and emotion problems; (4) compare systemic structures of subjective experience and culture; and (5) highlight features of Russian science and discuss their cultural specificity.

THEORY OF FUNCTIONAL SYSTEMS (TFS)

A considerable contribution to development of systemic representations in psychology and neuroscience has been made by the works of the V.B. Shvyrkov Laboratory of Neural Bases of Mind,Institute of Psychology of the Russian Academy of Sciences. This institute was created in 1972, with the active assistance of TFS founder, P.K.Anokhin, for research in fundamental problems of psychophysiology. TFS is the theoretical basis for laboratory research by specialists constituting the core of “Systemic Psychophysiology,” which has been acknowledged to be one of the leading scientific schools in Russia.

Why did P.K. Anohin's theory, which was originally formulated to solve problems in physiology, turn out to be such an effective theoretical basis (see in detail Alexandrov and Druzhinin 1998), and its founder – P. K. Anokhin – who was a recognized leader in physiology, become considered among the giants in psychology(Cole and Cole 1971, 43-99)? What is the difference between TFS and other variants of the systemic approach and what determines the special value of TFS for psychology?

The idea of a system-forming factor was developed in TFS and confines the degrees of freedom of the elements of a system, thereby creating order in their interactions. This concept is generalizable across systems and enables analysis of quite different objects and situations. The system-forming factor is a product of systems and has a beneficial effect in the adaptation of an organism to its environment. Furthermore, it is *not past events – or stimuli related to them, but future events and their results* that determine behavior, from a TFS point of view.

How can a result that will occur in the future determine current activity, and be its cause? P.K. Anokhin solved this "time paradox" using the future result model wherein an aim acts as the determinant, with a corresponding action result acceptor forming before the actual result and containing its predictable parameters. Therefore, Anokhin has eliminated the contradiction between causal and teleological descriptions of behavior and has made the latter acceptable even for "causalists." That is, those researchers who believe that science deals only with causality, and not explanation, and no law is possible that does not address causality (Bunge 1962).

TFS assumes that to understand an individual's activity, it is necessary to study not the "functions" of separate organs or brain structures as traditionally understood (i.e., as immediate functions of this or that substrate, including the nervous system: the sensory, motor, and motivational functions, etc.), but the organization of holistic individual-and-environment interrelations involved in obtaining a particular result. Considering *function* in regard to the achievement of a result, P. K. Anokhin provided the following definition of a *functional* system: The idea of "system" is applicable only to complexes of selectively engaged components whose interaction and mutual interrelations enables the mutual cooperation of components aimed at obtaining a beneficial result. This "systemic" function cannot be localized. It is apparent only with the organism as a whole.

According to TFS, associations between elements of an organism are structurally embedded within mechanisms such as afferent synthesis, decision-making, action result acceptors (the apparatus for predicting parameters of future results), and action programs. These mechanisms provide the organization and realizations of the system (for more detail, see Anokhin 1973).

SYSTEMIC PSYCHOPHYSIOLOGY

Long-term studies in the V.B. Shvyrkov Laboratory shaped a system-evolutionary approach (Shvyrkov 2006) and a new branch of learning: *systemic psychophysiology*. One of the most important landmark results was a systemic solution of the psychophysiological problem. Its essence is as follows. Mental processes characterizing an organism and its behavior act as a whole and neurophysiological processes operating as separate elements are comparable only through information systems processes. That is, processes by which elementary mechanisms are organized within a functional system. In other words, mental phenomena cannot be compared directly with the localized elementary physiological phenomena (as in traditional psychophysiology), but only with those underlying their organization. Thus *psychological and physiological descriptions of behavior and activity are descriptions of the same system processes*.

The proposed solution of the psychophysiological problem avoids: (1) decoupling of mental and physiological, as the mental appears as a product of the organization of physiological processes in the system; (2) parallelism, as system processes concern the organization of elementary physiological processes; and (3) interaction, as the mental and physiological are both aspects of uniform system processes.

The systemic solution of the psychophysiological problem can be compared with neutral monism by Hegel (Prist 2000), according to which the spiritual and physical are two aspects of underlying reality, and comparable to a two-aspect theory (Chalmers 1995, 200-219), according to which physical (brain processes) and mental are considered as two base aspects of "*some* information state." Prist (2000) claims that neutral monism and the two-aspects principle have one very important advantage: they are not subject to the disadvantages inherent to other solutions to the psychophysiological problem. However, they have one grave disadvantage in that the resulting conjectures tend to be vague. The systemic solution avoids this disadvantage. It is based upon definableinformation systems processes which may be studied through experimental studies (see, for example, Anokhin 1975; Shvyrkov 1990).

The proposed solution to the psychophysiological problem delivers psychology from the reduction of mental phenomena to the physiological that appears in traditional psychophysiology, which directly compares mental and physiological processes. The resulting emphasis within system psychophysiology is placed upon the study of patterns of systems formation and realization, their taxonomy, and the dynamics between system relations in behavior, as opposed to traditional psychophysiology which emphasizes study of the physiological correlates of mental processes and states.

Systemic psychophysiology rejects *the responsiveness paradigm* in favor of an*activityparadigm*,which focuses on future activity of not only single, but of multiple neuronal processes. Thus, it allows psychological processes based upon activity and purposefulness, discarding eclectic representations, e.g. use of the concept of reflex mechanisms in explaining purposeful action (see in detail Alexandrov et al. 1999). Since opposing activity and responsivenessis of particular importance for systemic representations, the following provides a detailed account.

Responsiveness Paradigm

Based on analogies to physical *mechanisms*, Descartes regarded *reflected action* as a universal law manifested both in mechanisms and in living beings. With *reflected action*, the primary cause of behavior is the inner environment, and the very action is regarded as an objective reflection of components ofthe *inner* environment that influence the organism. Descartes also put forward a provision concerning the *constancy of the reflected action* in response to stimuli, which may be interpreted as a claim for the unambiguity of behavior determination by the inner environment.

Drawing upon the ideas expressed by Descartes, the *reflex theory* was developed(Pavlov 1949). We assert that the essence of the reflex theory may be expressed by the following formulation: *the individual in his action and state objectively reflects the precedent inner signal*(Alexandrov and Krylov 2005, 2007; Krylov 2007).This statement can be represented by the following formula:

$$Y(t + \tau) = f(S(t)), \ \tau > 0 \qquad (1)$$

where:

$S(t)$ - an inner signal perceived by the individual;
$Y(t)$ - action of the individual at the moment t;
f - a function.

This formula indicates that there is *a functional dependency* between the perceived inner signal and subsequent behavior (Alekseev, Panin 1998). The formula (1) can be read as: a certain function f is applied to input signal $S(t)$, and, with the delay τ, the result is output. Descartes' *reflex objectivity* and its *constancy*, is consistent with the definition *of functional dependency*. Thus, the structure of the reflex arch and forward dynamics of the reflex follow from presence of the delay τ between the input signal S and the consequence Y caused by it, and from the condition $\tau > 0$, which means that the consequence comes later than the cause.

Despite wide acceptance of the reflex theory, it has been the subject of serious criticism (Anokhin 1978; Shvyrkov 2006; Sudakov 1997; Alexandrov et al. 1999; Leshly 1933). This has prompted repeated modifications to the theory (see, for example, Petrovskiy and Yaroshevskiy 1996; Yaroshevskiy 1996; Batuev 1991; Sudakov 1997). For instance, the Cartesian reflex initially considered a single determinant - the inner signal producing an effect. Then, additionally, *secondary* behavior determinants, or the state of the individual and their experience, were also considered. Claims regarding the importance of internal variables for behavior served to expand the set of determinants – recognizing these variables as inner determinants. However, the inner state and experience of the individual are both determined by an inner signal (Kruglikov 1982). It should be noted that in relying on this modification of the initial reflex theory, one may appeal to experience, to state of the individual, and their needs etc., but they are not obligated to do so. In contrast, consideration of an individual's inner state as an essential behavior determinant occurred long ago with TFS, but did not occur, and was fundamentally problematic for reflex theory.

If it is assumed that there are inner determinants, which are not conducive to reduction, Descartes's fundamentals are challenged: both the concept of the *reflected action* and his postulate concerning *constancy of the reflected action* in response to application of certain stimuli. The essence of modern concepts concerning the role of “inner states” can be formulated by the following equation (Krylov 2007):

$$Y(t + \tau) = f(S(t), Q(t)) = f^*(S(t), S(t-1), S(t-2), \dots), \quad \tau > 0 \qquad (2)$$

Here the inner state is designated as Q and f* represents a functional dependency. Therefore, it follows that action reflects a functional dependency between the previous inner signal and the previous inner state. Consequently, since the inner state reflects previous inner signals and their history, action arises from the background of inner influences. In other words, both behavior and inner states are determined by a sequence of inner influences (Kruglikov 1982). Application of the "reflex" concept to phenomena means that causes may be found in *the past* and extend *beyond* the phenomenon. Thus, a phenomenon may be invoked by another inner phenomenon from the past. However, inclusion of the notion of inner states within the reflex theory does not provide a completely satisfactory solution.

The Activity Paradigm

Considering behavior and activity in reference to the future requires an understanding of *activity* as a basic property of a living entity; with the specific form of activity that is manifested depending on the nature of the entity (Anokhin 1978). The core ideas within this paradigm originated in attempts to overcome mechanistic response schemes (see Alexandrov and Jarvilehto 1993, 85-103), providing broader homogeneity (Gibson 1988; Tolman 1932; Koffka 1935; Bernstein 1966; Dewey 1969; von Uexkull 1957. 5-80; and many others). The central point of the activity theory, as advanced in Russia, is the notion of the active subject (Petrovskiy and Yaroshevskiy, 1998; Petrenko 1999).

The activity principle asserts that the action of any individual occurs in reference to the future, is purposeful and is conditioned by the individual. Action determination relies on the inner nature of the individual and is connected with the future event. The concept of activity and purposefulness is connected with the concept of advance reflection (Anokhin 1978). *Advance reflection appeared with the nascence of lifeon the Earth* and is a distinct property of the latter. Non-living matter (or deceased organisms) reflect in a "delayed" manner. That is, it exhibits responses to past events-stimuli. The living reflect the world in an advanced manner: their activity at each given moment is preparation to ensure the future.

Advance reflection is inseparably connected with subjectivity because planning the future (aim formation) depends on the contents of individual memory and motivations. Furthermore, aims create an individual-specific division of the world, which was neutral beforehand, into "good" and "bad "objects and phenomena: contributing and interfering with achievement of individual aims.

The distinction between principles of determination on the basis of living and nonliving is, surely, an oversimplification. All reality cannot be reduced to a single-type determination (Bunge 1962). Thus, nonliving matter obeys not just stimulus causality, but also holistic determination (of parts to the whole) and self-determination (see, for example, the principle of inertia in mechanics). At the same time, *to consider the livingorganism not as a livingindividual*, *but as a physical body, determination by inner cause can be a convenient approximation*, appropriate within the structure of this limited domain. However, teleological determination of aims applies only for description of the living. Therefore, it is didactically justified to contrast teleological and stimulus determination.

Classical TFS included the *notion of "trigger stimulus."* It was supposed that all organization of processes in the system was determined by results attained by the given system. The stimulus initiates this integration and its significance goes no further. The seeming necessity for the central role of the “stimulus” falls awayif the behavioral act is seen not separately, but as a component of a behavioral continuum, a sequence of acts performed by the individual throughout their life. The following act in the continuum is realized after achievement and assessment of the result of the previous act. This assessment is an essential part of the organization processes (afferent synthesis and decision-making) which, in such a way, can be considered as transition processes from one act to another.

The activity principle not only addresses functioning of an individual organism, but also the individual cells of a multicellular organism. From the position of the responsiveness paradigm, a response is based on the activation of a reflex arch. Thus, the neuron is an element within the reflex arch, and its function ensures the transmission of activation. Accordingly, it is logical to treat neuron impulses as follows: the response to a stimulus upon a part of the nerve cell surface can spread across the cell and act as a stimulus on other nerve cells.

The view that determination of neuron activity conforms with requirements of the system paradigm was reached though refusal to treat neuron activity as merely a response to synaptic inflow and by acceptance of the claim that a neuron, as any living cell, is genetically programmed to need metabolites coming from other cells (Shvyrkov 2006). Accordingly, the sequence of events in neuron activity is analogous to that characterizing an active aim-oriented organism and its activation is analogous to action of the individual (Alexandrov et al. 1999; Alexandrov 2008). Activity of the neuron from this position is seen as a means of changing its relations with the environment, as the “action” references the future in eliminating unbalance between “requirements” of the cell and its microenvironment. The neuron itself acts not as a “conductor” or a “summator,” but as an organism in ensuring its “needs” at the expense of metabolites from other elements.

The difference between a neuron and a single cell organism lies in the fact that the neuron fulfills the “requirements “of its metabolism, joining with other elements of the organism to form a functional system. Formation of such aggregations enables the metabolic cooperation of neurons. Satisfaction of the whole spectrum of metabolic cell “requirements” is ensured by diversity of the realized acts. There are arguments in favor of the neuron being active not only throughout its normal lifespan, but also during the scheduled cell death –apoptosis.

Neuron activity is a component in achievement by the organism of desired results, which involves acts essential to obtain required metabolites from the microenvironment. This new approach to understanding neuron functioning requires new analysis methods, for example, plotting pre- (or peri-) result histograms (Figure 3.1), instead of post-stimulus depictions (Figure 3.2), and a new approach to research concerning the neural mechanisms of learning and memory (see below; more details in Alexandrov 2006).

HISTORY OF INDIVIDUAL EXPERIENCE FORMATION AND ITS ACTUALIZATION

In addition to ideas of systemacity, at its core, TFS advanced the idea of development as systemogenesis. Accordingly, it is claimed that heterochrony in laying the foundation and pace of development of separate morphological components of an organism at early stages of individual development are connected with the formation of “organism-wide” integrated functional systems, which require involvement of many elements from different organs and tissues (Anokhin 1975).

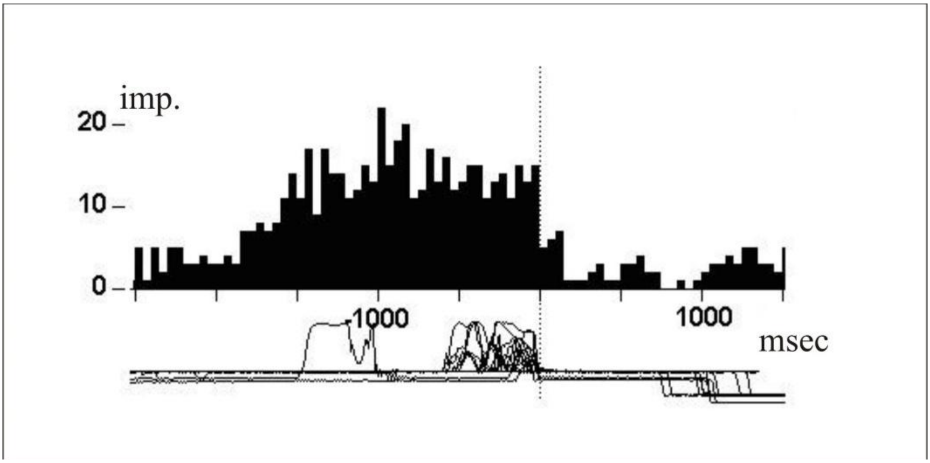

Figure 3.1. Post-stimulus histogram of neuron activity of the visual cortex in rabbits. The neuron is activated after presentation of a light flash. The moment of flash presentation is designated by the arrow.

Within the TFS structure, rather long ago (Sudakov 1979; Shadrikov 1982; Shvyrkov 1978), it was shown that systemogenesis also occurs in adults through acquisition of new behavioral acts and the accompanying formation of a new system, and also, that understanding the separate roles of neurons in ensuring behavior must takeinto account *the history of its systems formation* (Alexandrov 1989). That is, it must take into account the histories of consecutive systemogeneses, and the system-evolutionary theory and the system-selection conception of learning (Shvyrkov 1986, 599-611; Shvyrkov 2006).

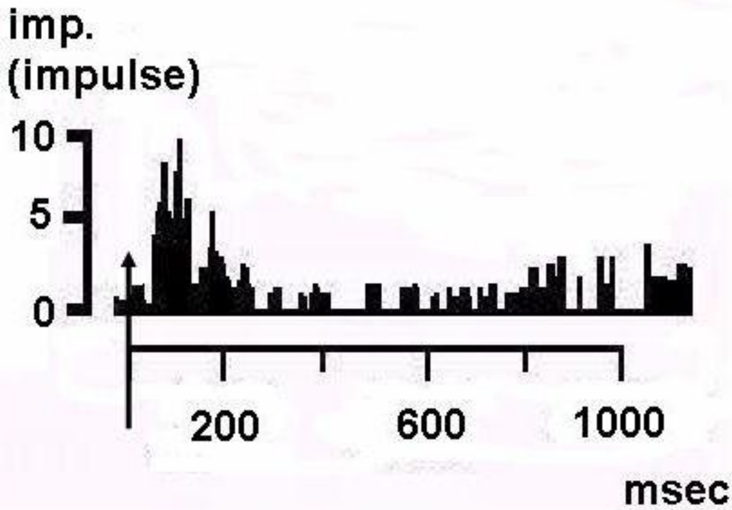

Figure 3.2. Pre-result histogram of neuron activity cingulate cortex in rabbits The neuron is activated at the approach of the animal to the pedal or the ring, then pushing the pedal or pulling the ring trigger the feeder to dispense food. Activation persists till completion of pushing or pulling. Top: the histogram shows the moment of completion for pushing the pedal or pulling the ring. Bottom: Actograms of summarized realizations of behavior; deviations upwards - pressing a pedal or pulling the ring; downwards – muzzle dipping in the feeder.

From this view, formation of a new system involves fixation upon a stage of individual development - formation of a new *element of individual experience* in the process of learning. The basis for a new element is not "re-specialization" of the prior specialized neurons, but establishment of permanent specialization in a newly-formed system composed of "reserve" cells that were "silent" before, and also of neurons emerging through the process of neoneurogenesis. Specialization of neurons within newly-formed systems - *system specialization* - is permanent, i.e. *the neuron is systemospecific*. Thus, in the process of individual experience, the newly-formed systems *do not replace the preceding, but* "*lay in layers*" on them, being "additive" with respect to the ones formed before.

It has been shown that realization of distinctbehavior occurs through realization of new systems formed during activities associated with learning, as well as the *simultaneous* realization of a set of older systems formed at previous stages of individual development (Alexandrov 1989; Shvyrkov 2006; Alexandrov et al., 2000). Hence, *realization of behavior is*, so to say, *realization of one's behavior formation history (phylo-* as well as *ontogenetic).* In contrast to prevalent ideas within neuroscience whereby the neural mechanisms of learning and memory involve consolidation and increased efficacy of synaptic transfer to chains of connected neurons, in systemic psychophysiology, new systems of neuron specializations are not necessarily bound synaptically (see in detail Alexandrov, 2006, 969-985).

Neuron specialization occurring through individual experience does not reflect the outer world, but rather the individual's relation to it. Therefore, a description of system neuron specializations is simultaneously a description of the subjective world, and studying the activity of these neurons is the study of subjective reflection.

THE SCIENCE OF SYSTEM PSYCHOPHYSIOLOGY IN WORLD SCIENCE

Based on recent theoretical and experimental articles, the following assertions may be made. Neuroscience and psychophysiology are transitioning to a new phase from Cartesian determinism to ideas of antireductionism (Petrenko 1999; Shishkin 2006; Alexandrov and Järvilehto 1993; Ellis 1999, 237-250; Engel et al. 2001, 704-716; Fisher and Bidell 2006, 313-399; Freeman 1997, 1175-1183; Jordan 1998, 165-187; Schall 2001, 33-42; Thompson and Varela 2001, 418-425; Vandervert 1998, 159-164; de Waal 1996; Webb 2004, 278-282; Wilson 1998; Woese 2004, 173-186). This transition is not yet in the mainstream (though, for example, in neuroscience journals and molecular biology the number of articles in which the term "systemic" is used has increased by a factor of a hundred*)*, but it is gaining strength and support from authoritative authors.

The present stage, as is usual during a transition from one paradigm to another, is characterized by eclectic expression. The methodological basis of the overwhelming majority of papers reflects "activistic" and "responsive" determinism (see Alexandrov et al. 1999).

Systemic psychophysiology, having become less eclectic, *has essentially outstripped neuroscience and traditional psychophysiology*. Empirical regularities that were discovered in systemic psychophysiology many years ago have become a subject of close attention of mainstream science only recently (see, for example, Alexandrov, 2008, 419–457). Conceptual transitions which have already been made or are being made by neuroscience and psychophysiology, largely repeat those undergone by systemic psychophysiology. One may attempt to predict development within traditional science as this new paradigm progresses toward the mainstream.

(1) Traditionally, behavior mechanisms have been thought of as sensory-motor. In the future, it will be understood that “functions” of these kind (as well as motivational, activational, etc.) are fictitious. Transition from the concept of strict “function” localization to the concept of “dynamic localization” and “distributed system” has already occurred. In the future there will be a transition to understanding that because function is systemic, and systems are not sensory or motor (nor sensory-motor), but organism-wide, function cannot be localized in any structure of the brain (neither strictly nor dynamically), not even localized in the brain; it is organism-wide.

(2) In contrast to understanding the mechanism of behavior as reflex response, there will be a transition to regarding the individual as “reacting actively” or even “reacting purposefully.” An understanding will follow that reflection is a primary characteristic of living organisms.

(3) There has been a transition from viewing the neuron as summarizing input on its membrane to the view of the neuron as a complex integrator of input that depends on the dynamics of intraneural metabolic processes, its history and presynaptic activity, etc. In the future, these views will be replaced by the view of the neuron which is not a microcircuit transforming input, but a living “organism within the organism” which discharges not “*in response to,*”but to receive the metabolites essential for its vital activity.

(4) In contrast to the view of learning as a top-down process of closing the circuit of local reflex arches, neuroscience has moved to an understanding of cerebral mechanisms of learning as complex, with memory modified through consolidation of the mosaic of neuromorphology, synaptic “conductivenes,” and gene expression in many “associated” brain structures. There will be a transition to the view of learning as systemogenesis: formation of a set of neurons not necessarily directly bound, but specialized in their relation to the newly-formed system by modification of cells pre-specialized in early ontogenesis and neurons formed in the process of neoneurogenesis.

(5) In contrast to a view of neurons specialized as to sensory, motor, etc. “functions” (see item 1), neuroscience and psychophysiology, not rejecting these views completely, will move to the perspective of “clever” neurons,

specialized for various cognitive “functions”, emotions, consciousness, imagination etc. Furthermore, it will become clear that neurons may be similarly specialized in systems aimed at achievement of different results.

(6) In contrast to the view of sensory stimuli coded as consecutive stages of processing information from receptors to cortical centers, there is a shift of attention to *top-down* regulation mechanisms. Within science, there will be increased incorporation of ideas of activity wherein anticipation is key, as well as intensification of studies of efferent influences on peripheral elements. In the future it will turn out that the view of “aim” determination and system specialization is applicable both to the level of central, and to level of peripheral elements.

(7) In contrast to the view consistent with the reflex theory concerning the consecutive inclusion of “afferent” and “efferent,” central and peripheral structures in the evolution of behavior, there will be a transition to representations emphasizing synchronization of brain structures operating as the mechanism to underlying perception, memory, consciousness, etc. In the future, an understanding will arise that “afferent” and “efferent,” central and peripheral structures work synchronously, not because it is merely a means of achieving greater efficiency between neural structures or to bind together different parameters of the stimulus (binding theory), but because elements of these structures are simultaneously involved in ensuring evolving organism-wide system mechanisms of behavior. It will also become evident that perception, attention, consciousness, emotions etc.are *not special processes* realized by special structures and mechanisms and co-operating with each other, but *special ways* of describing *various aspects of the uniform* system.

With respect to the above, it may be asserted that the present of modern psychophysiology and neuroscience is in the past of systemic psychophysiology. From where did these original ideas emerge? I believe that one of essential conditions was specifically the culture in which TFS and system psychophysiology were formed.

WORLD SCIENCE AND ITS CULTURE-SPECIFIC COMPONENTS

Science is a part of culture and along with invariant characteristics reflecting its global character, possess certain local, national features (Abelev 2006; Allahveryan et al. 1998; Astafiev 1996; Grehem 1991; Rous 1995; Slobin 2004; Uorf 1960; Shishkin 2006; Yurevich 2000; Alexandrov 2009; Gavin and Blakeley 1976; Graham and Kantor 2006, 56-74; Lewontin and Levins 1980, 47-78; Nosulenko et al. 2005, 359-383; Peng et al. 2001, 243-263; de Waal

1996; and others). Certain features characterize not only fundamental, but applied areas, such as medicine (e.g. radical differences between western and officially recognized Indian medicine see in Singh 2007, 27-46).

With respect to cultural influences, we focus upon the specificity of sciences practiced within different cultures, and do not claim a linear causal connection between culture and science, which may be impossible to establish (Graham and Kantor 2006, 56-74). The true experiment revealing this connection would be difficult. Borders separating science from other components of culture are vague, in particular, because scientific knowledge includes significant volumes of everyday knowledge (Polani 1998).

The diffusion of western science, having its origin in ancient Greece, into western countries was connected with its merging with non-western mentalities, traditions, and language (Crombie 1995, 225-238), which modified science. Thus it has been shown that in one culture, people can be more inclined to a convergent, and in others, to a divergent style of thinking (Peng et. al. 2001, 243-263); e.g. in Asian and western countries the nature of "probabilistic thinking" differs (Wright and Phillips 1980, 239-257; Whitcomb et al. 1995, 51-67).

As to language, different languages, within cultures, do not reflect *different designations of the same phenomenon, but different visions* (Gumbolt 1985; Slobin 2004; Uorf 1960; and others). Recently cross-cultural features of thinking and perception have been demonstrated by a larger number of works. Thus, native speakers of different languages distinguish different (also in number) fragments during description of the same visual scenes (Stutterheim and Nüse 2003, 851-881; Stutterheim et al. 2002, 89-105). We will add that subjects speaking two languages reveal those features of scene subdivision and their description which are inherent to their native, to the first language(s) they learned (Carroll and Stutterheim 2003, 365-402).

Cross-cultural covariance of differences has been demonstrated in language and in cognitive strategies concerning (1) spatial orientation (Haun et al. 2006, 17568-17573), (2) discrimination of object characteristics, including colors (Tan et al. 2008, 4004-4009; Winawer et al. 2007, 7780-7785; Skotnikova 2008; Baranski and Petrusic 1999, 1369-1383), (3) perception of mimiced emotion expressions (Barrett et al. 2007, 327-332), (4) risk assessment (Hsee and Weber 1999, 165-179), and (5) confidence in the correctness of choices (Yates et al. 1996, 138-147). English and Chinese supposedly think of time differently and use different regional metaphors to represent the flow of time: the former use horizontal (for example, “the best days are behind”), and the latter use vertical (for example, the “top” month in meaning “last”) (Boroditsky 2001, 1-22; see objections to Boroditsky, 2001 in Chen 2007, 427-436; Kako 2007, 417-426 and also additional arguments made out by Boroditsky including data about opposite horizontal “time orientation” in Hebrew speakers, in contrast to English speakers: Boroditsky 2008, 16). It has been shown that native English or Chinese speakers solve arithmetic problems using different cognitive strategies enabled by different patterns of brain activation (Cantlon and Brannon 2007, 1-4; Campbell and Xue 2001, 299-315; Tang et al. 2006, 10775-10780). Erroneous conclusions are connected with temporoparietal activity in English-speaking Americans and German-speaking Europeans, but not in other English-speaking children and English-speaking bilinguals (Kobayashi et al. 2006, 210-222; 2007, 95-107). Perner and Aichorn (2008, 123-126) consider these data as arguments in favor of culture or language influencing “brain functional localization” and object to assertions attributing these functions to maturation of congenitally-specified cerebral substrates.

Recently, arguments have been presented in favor of a connection between national features of thinking, culture and politics with local features of different areas of science: natural sciences in general (Paló 2008, 6), cosmology (Kragh, 2006), statistics (Stamhuis 2008, 4), neuroscience (Debru 2008, 5), geology and geography (Klemun 2008, 9; Yusupova 2008, 11). For purposes of our discussion, it is important to underline that a number of authors highlight features of the Russian science (Astafiev 1996; Grehem 1991: Mironenko 2007; Rous 1995; Shishkin 2006; Yurevich 2000; Yaroshevskiy 1996; Gavin and Blakeley 1976; Graham and Kantor 2006, 56-74; Nosulenko et al. 2005, 359-383). I believe “systematicity”and “anti-reductionism”are key among them (Alexandrov 2005, 387-405; 2009, 3-4). Apparently, a detailed substantiation of systeology in “Tectology”by A.A. Bogdanov (1913-1917) appeared at the time when the founder of the general theory of systems Ludwig von Bertalanffy was only 12 years of age. Similar advances can be noted for TFS. For good reason, The origins of TFS may be linked with formation of the systemic approach, which “released biological thinking from the deadlock of Cartesian mechanicism,” and emphasized that “development of the concept of functional systems by Anokhin and his collaborators dated 1935 anticipated development of both neurocybernetics by Norbert Wiener in 1948 and the general theory of systems by Bertalanffi in 1960” (Corson 1981, 222).

At the same time, Cartesian mechanicism in the natural sciences and social sciences are considered especially characteristic of western science (Lewontin and Levins 1980, 47-78; de Waal 1996; Graham and Kantor 2006, 56-74; and others). Certainly, anti-reductionism can be found not only in Russia:

Eager to study a living subject,
And to receive a clear view of it, —
The scientist first drives away the soul,
Then divides the object into parts
And observes them, but what a shame:
their spiritual bond
In the meantime has vanished,
it was carried away!

One cannot attribute these lines to a Russian mentality - they belong to Goethe. More likely, they can be connected with ideas of German philosophy whose creators included Goethe's friends and correspondents who, as well as Spinosa before ("nature of the part is determined by its role in the whole system"; Edwards 1967, 531), considered systematicity the primary characteristic of cognition and viewed knowledge as a system. These ideas, undoubtedly, influenced Russian science greatly. Probably, features of the Russian culture and mentality had an influence as "German thought and literature of that time had nowhere such a deep and powerful response, as in Russia" (Kozginov 2002, 128).

The protest against mechanicism which "exclusively captivated thought of the West" (Astafiev 1996, 101), "the revolt against Cartesianism - the foundation and symbol of western thinking — took place namely in Russia" (Gavin and Blakeley 1976, 101). And in L.R. Graham's opinion, the "anti-reductionist approach roots deeply in the history of Russian and Soviet thought" (Graham 1991, 102). S. Rose notes: "I have opposed … reductionism of the Anglo-American school … to much more perspective traditions … especially to those originated … in the Soviet Union, {and have caused development of views that} behavior cannot be reduced to a simple chain of combinations of various responses; it reflects aim-oriented activity, hypotheses formulation and many other things" (Rose 1995, 264-265). And, to the greatest degree in the Soviet psychology and physiology, there exists a special Russian tradition of research interpretation" (Graham 1991, 163). For instance, a connection to the national style of thinking in Russia with features of mathematics development has been highlighted (progress in theory of sets development; Graham and Kantor 2006, 56-74).

The above noted intercultural differences become more evident when taking into account the presence of a significant Eastern component in Russian culture and thinking (see in Alexandrov and Alexandrova 2009, 109-124) and research results. Nisbett et al. (2001, 291-310), after comparison of cognitive processes in people belonging to Eastern (Asian) and Western cultures, arrived at the following conclusion: in the former cultures, *continuality* is regarded as the basic property of the world, in the latter, the world is represented as discrete, consisting of *isolated objects*. In the former, formal logic is scarcely applied, but *the holistic approach and "dialectic" argumentation are used*. In the latter, *analytic* thinking is used, *a greater attention is drawn to a separate object rather than to integrity*. In Eastern cultures, it is considered that nothing in nature is isolated but everything is interconnected, therefore isolation of elements from the whole can result only in delusions. These differences appear in comparison of ancient China to Greece (8th - 3rd centuries B.C.) and still persist, characterizing features of modern China and other Asian countries in comparison with the North America and Europe.

In discussing “western” science, I do not imply a homogeneity of the West. Consider, for example, comparison of features of German and American psychologies, which led (Watson 1934, 755-776) and is leading (Toomela 2007, 6-20) authors to greater expressions of holicism and systemasity with the former, and reductionism with the latter. It may be noted that A. Toomela (2007, 6-20) attributes Russia for the holistic direction, as well.

M. Popovsky (1978) remarked that when in the USSR and they speak about *Soviet* science, “foreigners ironically smile” because for them, it is a “maxim” that there is only one science. This irony is not an indicator of knowledge of the corresponding literature, but on the contrary – a proof of superficiality and use of stock phrases. Misunderstanding that the differences between the national origins of sciences are basic characteristics and values of the world science, and treating concepts of global and local knowledge, national and world science as mutually exclusive is wrong (Jackunas 2006). In other words, it is the situation that “theorists working in different traditions and in different countries, will come to theories, which corresponding to all known facts, nevertheless, are mutually incompatible” (Feirabend 1986, 54-55). Finally, I assert that differences of views in the development of world science is positive. G. I. Abelev (2006) also remarks that diversity of national sciences is a major value of the world science.

Obviously, N. A. Berdyayeva (1991) was right when she claimed that *truth is not national*, it is universal, but *different nationalities disclose its different aspects*.

The world sciencecan be described *as a system consisting of diverse components, in which local culturally-specific components are complementary and cooperate in producing useful results: development of global scientific knowledge.* This mutual assistance can be appropriately seen as a "division of labor" in the world science, connected with national features of cultures (Alexandrov 2009, 3-4): systemacity and holicism predetermine a greater affinity for working out new directions in science, to "chipping off blocks," and Cartesian reductionism - to the matter of breaking "blocks" into pieces, to the detailed elaboration of knowledge and to seeking its practical application. This approach conforms with the carefully justified position of E. S. Kulpina (2007), according to whom in the Western (European) civilization, knowledge is connected with practical aims, with market needs, and in the Russian, connection with momentary practical benefit is considerably less important; not applied, but fundamental knowledge is much more significant.

Thus, it seems counterproductive to wish for unification of culture-specific sciences, as well as, for example, to desire that cultural specificity, which is an obstacle on the way to creation of "the world literature," should be overcome. The world literature "will arise mostly when distinctive features of one nation will be balanced via acquaintance with other [nations]" (Goethe, 1827).

N. Bor applied the complementarity principle, originally formulated in physics, in discussing relations between cultures. This is interesting because obvious parallels with the above discussed "cultural complementarity" can be seen here. "We can truly say, - N. Bor writes, - that different human cultures are complementary to each other". However, unlike physics, he emphasizes, no mutual exclusion of features belonging to different cultures is observed (1961, 49, 128).

Following this logic and bearing in mind the above-mentioned connection between features of language and styles of thinking, it is possible to conclude that confusion between languages of the builders of the Tower of Babel allowed them to reach two results simultaneously: not just the one, which due to authoritativeness of the source, is accepted— building termination, but not less significant - enrichment of the culture of the world as a whole. Thus, confusion between languages is not a punishment of mankind for pride, but the award given to it.

THE UNIFORM CONCEPT OF CONSCIOUSNESS AND EMOTIONS

Regarding the systemic solution of the psychophysiological problem, we remarked that physiological and psychological are two different descriptions of uniform system processes. And, they were described "from below" - via organization of brain activity. Let's consider the way the system processes can be described "from above," using the example of consciousness and emotions.

In the solution of this problem, a disjunctive approach prevails, which includes the following provisions:

a) there exist heterogeneous cognitive and affective mental processes;
b) these processes are the product of different structures of the brain;
c) being separate mechanisms, cognitive and affective processes can "influence" each other, "conform" with each other, etc.

These provisions fit into Aristotelian logic, operating by oppositional pairs, such as "normal – pathological," "cognitive – affective," etc. K. Levin (1990) insisted on greater consideration of the Galilean conceptual structure within which grouping into oppositional pairs is substituted by grouping using serial concepts, and S.L. Rubinstein (1973) claimed the possibility of discrimination of intellectual and emotional processes, not supposing a disjunctive division.

In system psychophysiology, *a uniform conception of consciousness and emotions* has been formulated (Alexandrov 1995; 1999a, b, 201-219, 220-235), which uses a non-disjunctive approach to understanding consciousness and emotions. It addresses the problem of the affective and cognitive in the context of phylo- and ontogenetic development. The central idea is that a non-disjunctive transition occurs in the development process, transition from formation of systems having *characteristics of "emotions,"* to formation of systems *characterized by "consciousness."* Moreover, the former *do not substitute* the latter. Therefore the behavior always possesses *both these characteristics*.

Analysis of works by many authors (Ivanitskiy 2001; Edelman 1989; Gray 1995, 659-722; John et al. 1997, 3-39; and others) suggests a connection between processes of consciousness, and attention to current environment changes, characteristics of the organism, and expected and real stimuli. An understanding of consciousness from the perspective presented here does not contradict this conclusion.

However, the majority of authors rely on provisions of a more modern approach of "stimulus-response" in the development of their views. And this approach invariably leads them to an understanding of consciousness emphasizing the main idea defined by D.C. Dennett (1993) as the idea of "Cartesian theatre." According to this idea, "perceptive systems send "input" to the central thinking arena which sends "orders" to peripheral systems controlling body movements. Similar models … are based on the assumption, that …there exists the Cartesian theatre – a place in which "all information is summarized and consciousness emerges." "Though this idea is incorrect, - Dennett concludes, - the Cartesian theatre will persist unless an alternative is presented that has a strong experimental scientific foundation" (Dennett 1993,39, 227). From my point of view, the uniform concept of consciousness and emotions, rooted in the experimental foundations of TFS and system psychophysiology, can be considered as an alternative.

Given the above statements concerning the systemic structure of the behavioral continuum, one can suppose that processes of "monitoring expected and real parameters," considered in the literature as mechanisms of consciousness, occur *across the extent of the behavioral continuum*: both during realization of the behavioral act and at its end. Accordingly, *not stimulus parameters, but the results parameters are expected and compared*: both final and intermediate. This analysis enables comparison of development stages of the behavioral continuum with the stream of consciousness (James, 1890) and leads to the following *definition of consciousness*,

> "*Consciousness involves the assessment of intermediate and final behavior results obtained by the subject, accordingly, in the process of behavior realization (both "outer "and "inner") and at its end; this assessment is defined by the contents of subjective experience and leads to its reorganization."*

Within the limits of such understanding and considering the argued position of many authors about the necessity of levels of consciousness (Damasio 2000; Dennett 1993; Tulving 1985, 1-12; and many others), the following *description of the "stream of consciousness"* can be cited, *Comparison of real parameters of intermediate results with the expected ones (with the aim) during realization of the behavioral act corresponds to the First level of consciousness. Comparison of real parameters of the final result of the behavioral act with the ones expected (with the aim) during transient processes (from one act to another) corresponds to a Second (higher) level of consciousness***.**

A review of the literature (see in Alexandrov 1999a, 201-219) reveals the importance of the resemblance between consciousness and emotions for behavior organization. Emotions, as well as consciousness:

- take part in *activity regulation;*
- have a significant *communicative value;*
- are connected with *processes of comparison of expected and real results* during realization and completion of an action.

Taking into account this resemblance, one may see the similarity between consciousness and emotions, with respect to the assessment by the subject of his behavior results in the process of behavior realization (both "outer" and "inner") and at its completion.

Formation of new systems in the course of individual development causes progressive *differentiation* in the relationship of the organism with the environment (Alexandrov 1989; Chuprikova 1997; Tononi and Edelman 1998, 1846-1851; Werner and Kaplan 1956, 866-880; and others). Systems formed at *the earliest stages of ontogenesis* provide *a minimum level of differentiation*: good - bad, approach – withdrawal. Relationships with the environment at this level of differentiation can be described in terms *of "emotions"* (see also Anokhin 1978; Shvyrkov 1984; Alexandrov 1995; 1999a, 201-219; Berntson et al. 1993, 75-102 ; Davidson et al. 1990, 330-341 ; Pankseepp 2000; Schneirla 1959, 1-42; Zajonc 1980, 151-175). These early systems are neither “positive” nor “negative.” All systems are oriented to achievement of positive adaptive results.

Considering the system structure of behavior as a stable formation, it is possible to formulate the *key provisionfor the uniform concept of consciousness and emotions*: *consciousness and emotions are characteristics of different, simultaneously actualized levels of the system organization of behavior, represented as transformed stages of development and corresponding to various levels of system differentiation.* There is no critical moment at which consciousness emerges or emotions disappear during development. At each stage of development, at each level of systemic differentiation, behavior can be described using both characteristics. However, at each level, the ratio of these characteristics varies (see the right section of Figure3.3).

Emotions characterize systems at the earliest stages of ontogenesis and provide *a minimum level of differentiation*. *Consciousness* characterizes systems at later stages of development with there being a progressive *increase of differentiation* in the correlation of the organism and the environment. It becomes obvious that the definition of emotions provided above and the linking of emotions with an assessment of results should be more accurate: *results provide the means for correlating the individual with the environment at a low level of differentiation*.

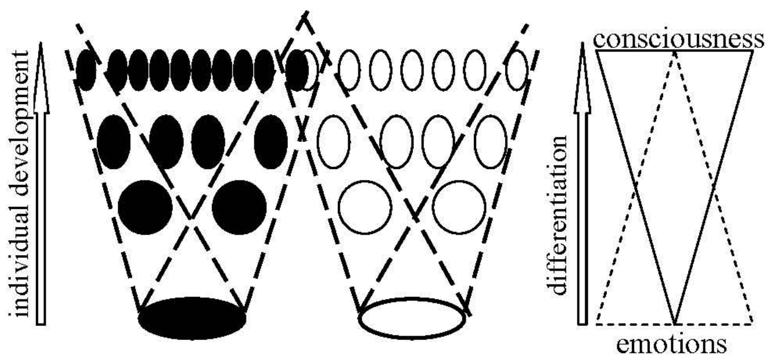

Figure 3.3. Consciousness and emotions at consecutive stages of behavior differentiation Large ovals at the bottom designate systems of the least differentiation providing realization of behavioral acts of "approach" (positive emotions, white ovals) and "withdrawal" (negative emotions, black ovals) at the earliest stage of ontogenesis. In the process of development, differentiation increases and behavioral acts occur through actualization of an increasing number of systems. Dashed lines indicate systems of different age and differentiation which are simultaneously actualized in achievement of behavioral results. The larger number of black ovals illustrates the empirically supported idea concerning greater differentiation of the withdrawal domain in comparison with the approach domain, and overlapping of black and white ovals – the idea that

externally identical acts aimed at achievement of different aims (approach or withdrawal) are supplied with activity though partially overlapping, but essentially different sets of neurons (Alexandrov et al., 2007; Alexandrov, Sams, 2005). Triangles illustrate the idea that consciousness (the triangle is turned with the apex downwards) and emotion (the triangle is turned with the apex upwards) are different characteristics of the same multilevel systemic organization.

Distinctions between the uniform conception of consciousness and emotions, and conceptions of other authors are presented below. The most important and original features are highlighted. We note that the uniform conception of consciousness and emotions, in contrast to conceptions of other authors whom I have supported, are not completely different. This fact can be explained by the fact that they are not just separate proposals, but necessarily connected with each other as products of TFS and systemic psychophysiology.

- Currently, a perspective focused upon a systemic approach, as opposed to the Cartesian approach, has been applied in developing conceptualizations of consciousness and emotions (Ellis 1999, 237-250; Freeman 1997, 1175-1183; Jordan 1998, 165-187; Thompson and Varela 2001, 418-425; Vandervert 1998, 159-164). In the proposed uniform concept, TFS and system psychophysiology are applied – in particular, that variant of the systemic approach in which the idea of activity is central, and seems to be *theleasteclectic*. In interpreting experimental data, *it allows one to completely avoid descriptions in terms of the Cartesian paradigm*.
- Being based on a systemic solution of the psychophysiological problem, the proposed concept *allows one to avoid reductionism and eliminativism*in solving the consciousness and emotions problems.
- The proposed concept uses *system understanding of function* and consequently *excludes* the following fairly criticized approaches to understanding of consciousness and emotions: “boxology” (Thompson and Varela 2001, 418-425), positions that consciousness and emotions occur as separate “localized entities” (Damasio 1994, 2000) or independent “modular” processes (Ellis and Newton 2000, 1-10).
- *The contents of consciousness* are assessed, not with respect to stimuli or “sensory-motor binding” as is done in the overwhelming majority of concepts (see, however, Jordan 1998, 165-187; Vandervert 1998, 159-164), but *with construction of resultsmodels* (of both “outer” and

"inner" behaviors) *and monitoring the parameters of actually reached results*. This is especially important in that *consciousness* is assessed with respect to *the behavior described, not as isolated behavioral acts, and as an uninterrupted continuum of intermediate and final results* of continually developing behavioral acts. This allows a depiction centering on the *dynamics of consciousness* corresponding to achievement and assessment of results, and also the elimination of the problem of "delayed consciousness."

- The proposed *concept of consciousness and emotions is based on Gallilean*, instead of the usual Aristotelian *logic*. In accordance with the latter, consciousness and emotions are treated non-disjunctively. Aristotelian logic leads to conclusions such as the *impossibility of "influence," "objectivity of action" and other effects of emotions on consciousness, or their "interaction"* that allow for behavior without an emotional "basis."
- In the proposed concept, *the similarity of consciousness and emotions as characteristics of systems having an identical architecture* is underlined. Though systems also differ at the level of differentiation, *all of them are oriented toward achievement of positive results*. The existence of special "systems" or "mechanisms" producing consciousness and emotions is denied.
- Consciousness and emotions are viewed as products of experience derived from memory acquired throughout a lifetime: from the oldest to the newest, and not as the characteristics of information associated with immediate stimulus action. Accordingly, *the proposed concept does not use "the metaphor of the light spot," inseparably connected with the fairly criticized ideology of the "Cartesian theatre."* This metaphor is based on the "false idea of spatial localization" and characterizes the majority of consciousness theories, even if not mentioned explicitly (Shanon 2001, 77-84).

SYSTEMIC PERSPECTIVE ON CULTURE

Culture, from a systemic perspective, may be seen *as structure, represented as a set of elements (systems) and culture units which symbolize means of achieving collective results within a given society at a particular stage of its development* (see in more detail Alexandrov and Alexandrova 2007, 85-103). Within the systemic structures of subjective experience and culture, analogies can be found. For example, after being formed, new and more differentiated elements of culture and subjective experience do not replace the previous ones, but stratify them (Figure 3.4). Actualization of units of culture and subjective experience occur at the expense of simultaneous activation of other elements formed at different stages of development of the society/individual. The formation of elements of subjective experience depends on cultural learning and the individual neural substrate arising from individual genomic features. But also, to a certain degree, the genome depends on culture. The culture not only defines the character of elements of subjective experience (even such basic skills as walking are culturally-dependent), but influences genome selection (“gene-cultural coevolution”), causing, in particular, “cultural genome complementarity” in the society.

CONCLUSION

In the framework of the above stated views of systemic psychophysiology (Krylov and Alexandrov 2008), it may be asserted that psychology, molecular biology, physiology, psychophysiology, sociology, cultural science and other disciplines address tendencies characterizing different links and aspects of a uniform cycle: from subjective experience to society; then through joint activity and achievement of joint results – to culture; from culture through genomes and individual genomes to neural specializations, and from neural specializations to subjective experience. Accordingly, an interdisciplinary methodology and interdisciplinary language for these interconnected and interdependent disciplines of systemic psychophysiology can be applied, and in particular, a system-evolutionary approach (See Figure 3.5).

ACKNOWLEDGMENT

This work has been supported by RFBR grant #08-04-00100 and by The Grants Council of the President of the Russian Federation of the Major Scientific Schools of Russia # NSh-602.2008.6.

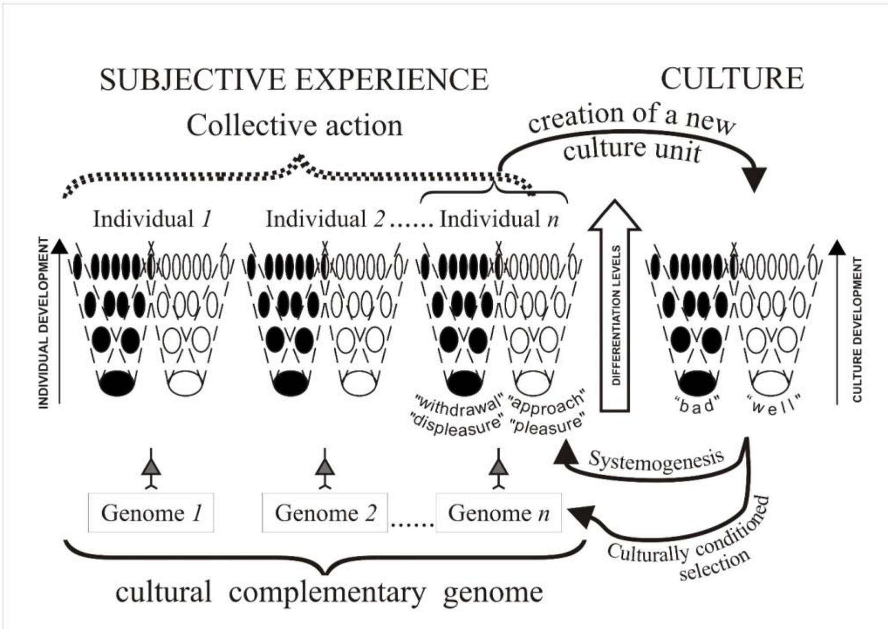

Figure 3.4. Structures of subjective experience (at the left) and culture (at the right).The arrow, "differentiation levels," designates the increase of differentiation of structures in their development. Large ovals at the bottom designate systems of subjective experience and culture of the least differentiation. As development progresses, the number of systems and level of their differentiation increase. "White systems" of subjective experience provide realization of behavioral acts of approach (positive emotions), black – of withdrawal (negative emotions). In the culture structure, white and black ovals symbolize culture elements. Dashed lines on the left show differentiated systems whose simultaneous actualization ensures achievement of behavioral results. Overlapping of black and white ovals designate identical acts of behavior oriented at achievement of different aims (approach, withdrawal). Arrows illustrate the idea gene-cultural coevolution, and "systemogenesis." Between the rectangle "genome" and the ovals symbolizing systems of subjective experience, a schematic image of the neuron specifies that genome realization in a given cultural environment is mediated by selection and specialization of neurons associated with newly formed systems.

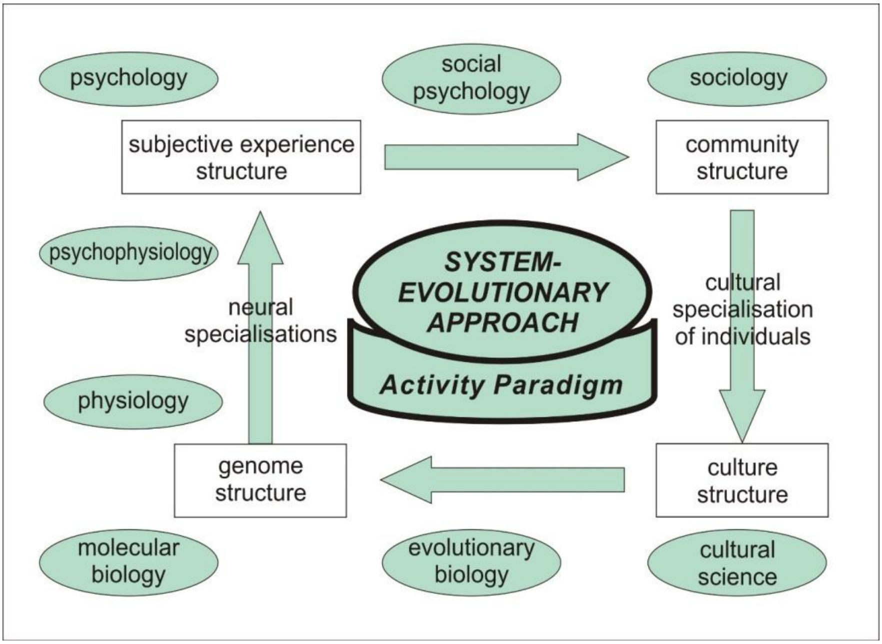

Figure 3.5. Relationship of subject areas of some disciplines.

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