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COMPARATIVE ANALYSIS OF THE RUSSIAN PHYSIOLOGICAL AND PSYCHOLOGICAL APPROACHES AS A HISTORICAL FOUNDATION FOR MODERN EXPERIMENTAL STUDIES OF INTER-ANALYZER INTERACTION

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A comparative analysis of the physiological and psychological approaches to the study of inter-analyzer interaction has been carried out in the given article. Their general view on the biological meaning of inter-sensory relationships is underlined, as well as the difference between their indicators to assess the state of intermodal relationships. It is emphasized that the importance of the interaction of analyzer systems is usually stressed in psychological work, yet, the concept of inter-analyzer interaction is not usually operationalized. The authors propose a working definition of the inter-analyzer interaction and justify the adequacy of using Uznadze's methodology for forming a fixed set as a tool for assessing the state of inter-sensory links.
Key words: *Clinical psychology, Inter-analyzer interaction, Methodology of fixed set, Perception.*

Un análisis comparativo de los enfoques fisiológicos y psicológicos para el estudio de la interacción Inter-analizador se ha llevado a cabo en el artículo. Se destaca su visión general sobre el significado biológico de las relaciones intersensoriales, así como la diferencia entre sus indicadores para evaluar el estado de las relaciones intermodales. Se hace hincapié en que la importancia de la interacción de los sistemas de análisis se suele destacar en el trabajo psicológico, sin embargo, el concepto de interacción Inter-analizador no suele ser operativo. Los autores proponen una definición de trabajo del interacción Inter-analizador y justifican la conveniencia de utilizar la metodología de Uznadze para formar un conjunto fijo como herramienta para evaluar el estado de los enlaces Inter-sensoriales.
Palabras clave: *Psicología clínica, Interacción Inter-analizador, Metodología de conjunto fijo, Percepción.*

Cerebral hemispheres are a complex of constantly interacting central elements of afferent systems, particularly manifested in intermodal interaction.

Despite the long history of studying inter-analyzer interaction (IAI) in psychological literature, there is still no generally accepted definition of this phenomenon. The concept of IAI is either replaced by specific but not synonymous terms (intermodal phenomena, polymodal effects, supramodal or crossmodal (cross-referential) re-encryptions (interactions, syntheses, transfers), or just its invisible presence in the experiment is ascertained, with no working definition or understandable criteria for its evaluation.

In neurophysiological studies, there is a more particular view on interconnections in the sensory sphere, researched from two mutually non-exclusive points of view. On the one hand, IAI is understood as a change in the sensitivity of one analyzer system due to the arousal of another. However, intermodal connections are not limited to the influence of stimulation of some sensory systems on the state of others. Another form of interaction between sensory organs is their joint work, the result of which is the emergence of a whole new and more complex sensory function that cannot be implemented by any of the sensory systems participating in this joint activity taken separately. An example of such intermodal interaction is binocular vision: only the synthesis of visual and proprioceptive information from the oculomotor system makes it possible to evaluate the remoteness of the presented object (Feigenberg, 1975).

In everyday life, the manifestations of intermodal interaction are synesthesia and dreams. Soviet neuropsychology described one of these cases: it was a famous mnemonist S.V. Shereshevsky, who perceived the voices addressed to him painted in various colors (Luriya, 1968).

There are other phenomena related to the field of joint work of sensory systems that require the participation of higher mental processes for their implementation - these are illusions associated with changes in perception in one modality depending on the ideas received through another analyzer (for example, the Charpentier illusion[1] (1891)). Another

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psychological example of IAI is the phenomenon called "visual capture", manifested in the dominance of visual perception in conflict interaction with other modalities (Rock, Jack, 1964). Studies (Miller, 1972; Locher, 1982) showed that if a tactile and visual analyzer gives the subject inconsistent information about the magnitude and shape of perceived objects, then his final judgments will be based upon the visual modality.

The IAI phenomenon has a long history of studying within natural sciences and humanities. However, until now there exists no satisfactory theory of this phenomenon, as there is no accord in the explanation of the concept itself. The definition of common points in understanding the essence of IAI requires at least a brief overview of the history of its study and analysis of the content of definitions found in the generally recognized physiological and psychological scientific literature, which is the main goal of this article.

NEUROPHYSIOLOGICAL APPROACH TO THE STUDY OF INTERMODAL INTERACTION IN THE SENSORY SPHERE

Experimental study of intermodal interaction began with the research of Russian neurophysiologists, a significant contribution to which brought the work of L.A. Orbeli (1934), K.H. Kekcheev (1940), S.V. Kravkov (1948) and others. The authors tried to understand the physiological mechanism underlying the interaction of analyzers and to determine the place of IAI in the integrative activity of the brain. The idea of the basic mechanism of IAI changed with the course of time, beginning with the recognition that "*... every receptor system ... is under the influence of the autonomic nervous system. ... if we act on various receptor units with different stimuli ..., then we cause changes in all receptor systems through the sympathetic nervous system*" (Orbeli, 1934, p. 1112). Then there was an opinion about the presence of ephaptic connections (Kravkov 1948), and the result of all the numerous studies was the experimental evidence of the involvement of the cerebral cortex in the organization of inter-system analyzer rearrangements (Feigenberg, 1975).

Experimental confirmation of the cortical nature of the interaction mechanisms of the analyzers promoted the emergence of new works in which neurophysiologists studied the features of intersensory connections in various brain diseases. The first clinical studies of IAI were conducted under the supervision of I.M. Feigenberg (1975).

The analysis of disorders of intersensory relations in patients of various nosological groups allowed the researchers to develop their own typology of such disorders and to reveal their regular connection with clinical disease patterns. Interaction of analyzers was studied in 485 patients, including 175 patients with schizophrenia, 25 with epilepsy, 24 with reactive psychoses, 181 with traumatic brain lesions, 40 with organic lesions of the diencephalic region, and 40 with vascular lesions of the brain. In terms of the magnitude (quantity) and the direction (sign) of the sensitivity shift, three types of disorders of analyzer connections were identified: weakening, amplification and distortion. The *weakening* of the interaction of the analyzers is expressed in the absence of a sensitivity shift: the state of one analyzer does not change in accordance with the corresponding stimulation of another analyzer or changes to a lesser extent in comparison with the norm. The *amplification* of the interaction of analyzers is manifested in the fact that the shift in the functional state that occurs in one analyzer in response to the stimulation of the other corresponds to a shift in healthy people as far as its sign is concerned, yet exceeds its value in comparison with the norm. The *distortion* of the interaction of analyzers is a type of disturbance in which the sensitivity shift recorded in one analyzer system by stimulation of another is opposite to the shift in sensitivity in the norm.

Weakened interaction of the analyzers was noted in patients with schizophrenia with a clinical pattern of a schizophrenic defect, in patients with a reactive state in the form of pseudodementia, with brain concussion, long-term after cerebrospinal trauma, disorders of cerebral circulation, and traumas of the diencephalic region of the brain. Since in the clinical pattern of these diseases there was a decreased activity of the cerebral cortex, the authors made the assumption that the weakening of the analyzer interaction is connected to this indicant. From psychological viewpoint selectivity mechanisms play major role in gnostic activity as they are not connected with band with characteristics of peripheral analyzer but are defined by "central setting" (Polyakov, 1974). It is well-known that due to actualization impairment when remembering schizophrenic patients restructure their perception as they need to analyze more stimuli's features to identify objects correctly. Such gnostic activity isn't optimal and very energy-consuming – that may cause the increase of sensitivity thresholds.

Therefore, we can propose that increased interaction of analyzer systems could be caused by the increased readiness of "central setting" to percept specific stimuli and all that could result into decrease of remembered images and alternative hypotheses. Amplification of the analyzer interaction was

[1] The Charpentier illusion is a phenomenon when two objects that are common in appearance and of equal mass but of different volume are picked up, the smaller of them is perceived in volume as a heavier object, and a larger object as a lighter one (Arana-Larrea, 1955). The past experience of a person while perceiving two objects that are different in volume, but made of identical material, adjusts both hands before weighing to the perception of different weights, since the larger object always has a larger mass. Because of the equalization of the masses of both objects, the probabilistic forecast is not justified. The mismatch of the actual weight to the probabilistic forecast and adjustment of the muscle spindles leads to an error in estimating the mass – i.e. to the illusion.

observed with reactive paranoid, encephalitis, cerebral arteriosclerosis. The unifying link in such diverse clinical patterns was the presence of Kandinsky–Clérambault syndrome, visualization or phonation of thoughts, visualization of the audible. Based on the obtained data, the researchers came to the conclusion that the phenomenon of visualization of thoughts is closely related to the strengthening of the connections between analyzers.

The distortion of the interaction of the analyzers was recorded in the group of patients with epileptiform seizures of various etiologies: epileptic disease, traumatic epilepsy, epileptiform seizures caused by neural infection. The conducted experiments revealed a connection between the distortion of the interaction of analyzers with convulsive readiness, when the arousal that appeared in one part of the brain is transmitted to its other parts. If we conduct psychological analysis of gnostic activity in schizophrenia and epileptic patients (with epileptiform seizures), the latter would demonstrate inertness (stereotypical images) and slowness. Such features of "central setting" are initially characterized by rigid reaction patterns (with possible paradoxical reactions coming from personal experience) that are not so energy-consuming but also ineffective.

In some case not only the magnitude or the shift of sensitivity in inter-analyzer relations change, but also its type. This happens when the syndrome changes within the clinical pattern. For example, in patients with late effects of brain injuries, a weaker interaction of the analyzers may be observed while not in the epileptic seizure, yet immediately prior to the seizure it is replaced by its distortion (Feigenberg, 1975).

In the same work, the author showed that the very fact of presenting instructions in the absence of real stimulation of receptor surfaces causes changes in intermodal relations, that is, inter-sensory adjustments can occur at different levels of analyzer systems organization: from the influence of sensations taken in isolation to a single yet multimodal perceptual image. Still P.K. Anokhin (1975) emphasized that the effectiveness of the perceptual image is determined by the degree to which it provides an "anticipatory reflection of reality". This is exactly the regulatory function of the image as related to the activity of the subject.

Integration of neural responses to sound and light in the higher sections of the visual system of mammals and humans was analyzed in the works of the psychophysiologist E.N. Sokolov (2003). Later, his assumptions were experimentally confirmed in the works of the physiologist V.B. Polyansky (2010), where the author found cells in the visual cortex of the rabbit, reacting to clicking sounds and electrodermal arousal of the paw. Further studies were carried out by a team of authors (V.B. Polyansky et al., 2015) on the study of the effect of sound on the discrimination of weak light intensities, where a modulating effect of sound on the dependent variable was established.

Thus, physiologists assumed the presence of preset reactions[2], based on the probabilistic structure of past experience and information on the actual situation, as a basic biological index of changes in the physiological parameters of some sensory systems during the stimulation of other. A signal about the onset of a new situation is an irritant acting on one of the analyzers. One of the steps to the preparations for action in the new situation is the restructuring of sensory functions, as a result of which the collection of information on changes in the environment surrounding the organism is improved. The result of such intermodal rearrangements is the mobilization of certain afferent systems and the demobilization of others (Feigenberg, 1975).

THE PLACE AND SIGNIFICANCE OF INTER-ANALYZER INTERACTION IN RUSSIAN PSYCHOLOGY

In order to understand the specifics of IAI as a psychological phenomenon, it is important to analyze not the physical characteristics of the acting stimuli (the length and intensity of the light wave, the frequency and amplitude of the sound vibrations, etc.), the registration of the response electrical activity of the corresponding zones of the cerebral cortex or the measurement of sensory thresholds, but rather gnostic activity and human behavior, which ultimately determines the main difference between the physiological and psychological approaches.

Due to the lack of development of the basic nomenclature of the area under discussion, psychology often identifies such concepts as "modal specificity of the stimulus" and "modality of presentation of the stimulus". Modality as such is always related to the stimulus and is associated with a certain analyzer system. In psychology and physiology, modality means the following: "... the belonging [of the reflected stimulus] to a certain sensory system ...", which is used "... to denote, characterize or classify sensations, signals, stimuli, information, receptors ..." (Big Psychological Dictionary, 2008, p. 376).

The "modal specificity" of the stimulus (or modality of the stimulus) in this case means such characteristics of a stimulus that cannot be perceived by other analyzers. That is, it is the qualitative result of the analyzer systems, e.g. color, sound, taste, smell, temperature, pressure, etc. This is the information that comes from the sensory system as a result of its arousal (stimulation), these are the sensations that are "*... such simple mental processes caused by different types of energy (mechanical, electromagnetic, chemical, thermal), when energy sources acting on receptors are isolated as such from integral*

[2] Preset reactions are the preparation of the systems of the organism (in this case, sensory systems) for action at the actual time (Feigenberg, 1975).

and complex structures in which they exist in the real world only as their components" (Chuprikova, 2015, p. 320). Here it is important to emphasize that, despite the specificity of the sensory response to external stimuli, the transfer of information to the central nervous system occurs according to the universal code, which creates conditions for the activity of analyzers as a single functional system. However, this fact does not negate the specificity of the function of individual receptors that emerged in phylogenesis as a result of adaptation to the action of a certain kind of stimuli, which gradually become adequate for the given sense organ.

"Modality of presentation of the stimulus" is related not to the characteristic of the stimulus itself, but rather to the form of its presentation: for example, the "word" can be presented audially or visually: both in written form and in the form of a picture or gestures (sign language interpretation). It should be born in mind that if an object is a stimulus, its image or the elements of sign systems, then it is rather a multimodal stimulus related to the processes of perception.

In the experimental psychological studies of the IAI it is impossible to study and evaluate sensations only (Fomina, Kovyazina, 2018). First, despite the fact that the only source of perception of objective reality are sensations, the reality surrounding the organism is never reflected in its structure of activity as a chaos of disparate sensations, but is rather represented in the form of objects: "*... reality is not felt, but is perceived, because you can feel, for example, color, but in reality we see not just a color, but an object of this or that color*" (Uznadze, 2004, p. 194). Such psychological phenomena as retained image, color, size and shape constancy, sensations in the phantom limbs, also indicate that the most significant thing for a human is an object of perception, which remains unchanged with altered or absent sensations. The opposite bright example demonstrating the primary role of object perception in the organization of human activity is the cases of agnosias that make a person "virtually blind" despite the preservation of basic sensitivity (Luriya, 1962). Secondly, if the sensations being the content of the perception of a certain objective image, are numerous and autonomous from each other, then the object itself always represents a single whole (Leontiev, 2000). Numerous experiments of Gestalt psychologists confirm the postulate that the properties of parts (sensations) depend on the whole objective image, and not vice versa. The correctness of the analysis of sensations through perception is confirmed in the experiments of Yu.F. Polyakov (1974). The author has shown that in patients with schizophrenia, the characteristics of sensations do not change in general, but depending on the structure of which perceptual processes they are considered. Thirdly, psychologists will not be able to analyze changes in the structure of activity, studying sensations only, since they depend on the state of the corresponding analyzer systems, and therefore are not subject to development and have no psychological content. While perception: "*... also implies an object, and this has nothing to do with the senses, therefore the possibility of expanding perception in the direction of seeing within its image an increasingly more common object is infinite. It depends on the level of mental development of a person. Consequently, along with intellectual development, there is also the possibility of developing perception*" (Uznadze, 2004, p. 202). The constant development of perception during the human life was also highlighted by L.S. Vygotsky (1982), introducing such its properties as orthoscopy and meaningfulness. Investigating the interaction of analyzers through perception, psychologists have an opportunity to draw conclusions about the state of perceptual and mental activity.

Thus, in their studies psychologists can use only subjective stimuli, that is to work with the modality of presentation of the stimulus, and not with its modal specificity.

As for the functional significance of IAI in the ontogenetic aspect, most psychologists agree that the joint activity of all analyzer systems not only forms a multimodal picture of the world, but is also necessary to achieve an adaptive result useful to the organism (Uznadze, 1958; Ananiev, 1961; Soloviev, 1971).

In Russian psychology it was B.M. Teplov (1935) who was the first to touch upon the topic of the "interaction of sensations". He considered every complex act of perception as the result of the synthetic work of analyzers. Experimental studies carried out by the author made it possible to approach the diagnostic value of studying the integrative activity of analyzer systems and show that disorders in inter-analyzer connections occur prior to severe disorders of higher mental functions (HMF).

In order for the organism's reactions to the surrounding reality to be optimal, the analyzer systems should not simply accept and store information coming from outside, but also provide such its processing by the subject of activity, as a result of which its organization (integration) takes place, which adjusts all processes (both physical and mental) to the formation of correct behavioral activity (Uznadze, 1958). Thanks to the well-coordinated work of the sense organs, it is possible to adequately process incoming information, which creates the foundation for the full development of all human HMF.

It is known that the simplest types of generalization are implemented at the level of perception and memory. So, during involuntary fixation of traces, it is necessary to pay attention to the process of the fixation itself. It is predominantly connected not with the memorization power, but rather with the formation of a certain stereotype. As a result of numerous repetitions, qualitative changes in the traces occur. "*... The action of repetitions on the engrams (traces of memory) makes profound qualitative and structural changes in them. Engrams under the action of repetitions become more detailed, more precise, more accessible for ecphory, not just more intensive. ... Repetition is necessary not to ensure that the presented development is stronger, but first of all, that it can be isolated as something*

separate and persistent from those unequal situations in which it enters as a part. ..., repetitions ... do not act by mechanical summation, but as a factor contributing to the isolation of something common from all these incomplete repetitions" (Bernshtejn, 2003, pp. 209-210).

Since the 1920s, the Georgian School of D.N. Uznadze (1958) experimentally studied the mechanisms of behavior that determine the active and expedient adaptation of a person to the constantly changing external environment and the adequate organization of all mental activity. Subsequently, this mechanism, arising on the basis of the needs of the organism and its environment, was called a "set".

The set formed by the individual does not simply determine his attitude to the situation, but also unfolds in his perception, being a consistent psychic state or a psychological counterpart of preset reactions. The latter became a scientifically proven fact when the possibility of transposition of a set from one correspondent organ to another, and from one modality to another was demonstrated, that is, the set as a result of the effect of the objective image in one sensory field mediates further perception processes in other analyzers.

B.G. Ananiev (1961) considered the principle of associations arising under the action of a complex stimulus as the "material basis" of the IAI, the result of which is the formation of temporary connections between the brain ends of various analyzers participating in the act of perception. The combination of sound, light, chemical, mechanical and other stimuli is repeated in the environment with a certain stability. The probabilistic order of following one of the stimuli after the others forms an integral act of human behavior reacting to a certain order of external influences from the chain of associations - a dynamic stereotype.

The issue of the types of interaction of human analyzer systems was touched upon in the works of I.M. Soloviev (1971). In healthy people, the author identifies four types of influences of one sense organ on the activity of the other. The first type includes increased clarity and contrast in one analyzer system due to the arousal of another. The second kind includes those phenomena when some perceived properties of the object do not cause direct arousal in the main analyzer system, but are perceived by other analyzers. As a result of such intermodal interaction, the image perceived by the leading sense organ is supplemented. The third type, according to the author, is the reflection of the same properties of the object by two different analyzers. The result of such a joint work is the improvement of perception by the leading sense organ. So, an object that produces sounds can trigger not only an auditory orientation reflex, but also attract the look of a person. In the fourth kind of IAI, various analyzers take simultaneous (or almost simultaneous) and joint participation in the reflection of various properties of the same object and connect them to a single autonomous system. This very kind of afferent interaction helps a person to understand the surrounding reality better and, consequently, relying on the perception of one property, to make a judgment about the other.

In pathological cases, IAI is characterized by peculiarities not observed in the norm: some afferent systems transfer their function to others, new connections between sensory organs are developed, the main and auxiliary analyzer change places depending on the severity of the disorder and on the specific conditions of their activity. Thus, similar to the physiological typology of IAI disorders, an example of the *weakening* of the interaction of analyzers in clinical psychology may be agnosia, in which the relative retention of elementary sensitivity is noted (Luriya, 1962); *amplifications* of the interaction of analyzers can include the phenomena of anticipation, described in local pathology in left-handers (Dobrokhotova, Bragina, 1994) and accompanied by changes in the sphere of sensations; whereas hallucinations serve as convincing examples of the *distortion* of IAI.

Making a research on deaf children, Soloviev (1971) emphasized that the connections between various systems of sense organs have their compensatory characteristics and are damaged unevenly: the kinesthetic analyzer is more damaged from the loss of hearing, whereas the visual analyzer suffers much less. V.V. Lebedinsky (1985), analyzing children with mental retardation, drew attention to the general functional weakness in interpersonal relations, resulting in separation (isolation) of perception, actions and emotions. Researches on Charpentier illusions with children with profound mental retardation conducted by L.S. Vygotsky also demonstrated the isolation of analyzer systems, leading to an unreasonable perception - these children did not see the illusion, which *"... can serve as a reliable diagnostic criterion (according to Demoor) for distinguishing profound oligophrenia from mild mental retardation"* (Vygotsky, 1982, p. 375).

Thus, psychological studies also emphasize and theoretically interpret the place of IAI in the structure of human activity, as well as its importance in the regulation of behavior. However, there is no classification of IAI disorders, since there is no unambiguous working definition, clear and precise qualitative and quantitative indicators that can change in the course of the disease quite naturally and reflect changes in the functional state of the brain.

The authors of the given article, using the theory of the national school of psychology by L.Vygotsky – A. Leontiev – A. Luriya define IAI as the influence of the perceived image of an object in one sensory system on subsequent perception processes in other sensory systems, the result of this influence is the emergence of qualitative and (or) quantitative phenomena in the analyzers originally not affected by the stimulus (Kovyazina, Fomina, 2018).

Stable changes in interpersonal relationships may indicate a disorder of the integral work of the central nervous system (even with a poor or completely absent neurological picture) and be considered as an indicator of an unfavorable recovery

prognosis. In other words, IAI can be an additional criterion for assessing the effectiveness of various treatment and rehabilitation activities.

CONCLUSION

Studies in the field of intermodal interaction not only put the issue of integrative brain activity into an interdisciplinary context, but also greatly expand the possibilities of clinical psychology. In particular, the study of the features of intermodal connections in healthy people will allow us to identify the dependence of relationships in sensory systems on the specifics of the HMF and thus approach the development of criteria and range of the spread of the mental norm; whereas the study of IAI disorders can open new opportunities for studying clinical and psychological syndromes in various diseases. A.R. Luriya (1962) noted that a full analysis of the neuropsychological syndrome is possible only when the changes occurring in the character of intermodal relations are taken into account, and the basis of any compensatory rearrangements is the interaction of a whole complex of afferent systems.

Both the physiological and psychological approaches coincide in the vision of the place of IAI in the structure of activity and its significance in the regulation of human behavior. Based on the latter, it is possible to experimentally study intermodal interaction in clinical psychological research.

The method for the formation of a fixed set of D.N. Uznadze simulates the mismatch between the foreseeable event and the situation that exists in reality and allows to operationalize the IAI through such an indicator as illusions. The latter can become a qualitative and quantitative criterion for assessing the state of inter-analyzer connections in humans. Fixing the number of illusions, the dynamics of the set and its transposition in sensory modalities, one can draw conclusions about the state of IAI in healthy and sick people. At the present time, in addition to the Uznadze effect[3], it is possible to name only one illusion that meets the above-stated requirements and valid for the IAI research – that is the Charpentier illusion.

CONFLICT OF INTERESTS

There is no conflict of interests.

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[3] The Uznadze effect (the illusion of the Uznadze set) is a phenomenon consisting in the fact that when one perceives two objects that are uniform in appearance and of equal mass but different in volume, a certain number of times (usually equal to 15), a set is formed to perceive a larger volume of the subsequent subject matter. In the case when there is a substitution of one of the two objects presented for the one identical to the remaining ones, that is, their volumes are equalized, the set, based on past experience, affects the subsequent perception processes, creating illusions. One of the objects equal in volume continues to be perceived as a larger in volume a certain number of times.

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