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Perception, Movement, and Action

The problem of perception is one of the most important in psychology. Its study is of the utmost significance since each and every sensory act discloses a genetic connection between the material and the ideal and, to use Lenin's expression, "The energy of an external stimulus is transformed into a fact of consciousness" [1, vol. 18, p. 46]. But research on perception is very relevant in a practical sense as well. Scientific and technical progress has created a great many professions whose basic content involves perception, recognition of visual images, and their interpretation and transformation. The principal task of some of the new professions is to create new visual images and new visual forms.

Research in this area has refuted the false idea that modern automation and mechanization of production reduce the role of perceptual processes in human cognitive and practical activity while, at the same time, increasing the role of its intellectual and logical components. The progress of technology not only does not reduce the importance of studying perceptual processes: it even poses new problems to the psychology of perception.

Many contemporary types of activity require of a human being operational and accurate exercise of perceptual, intellectual, and executive

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 Izbrannye psikhologicheskie trudy [Selected psychological works] (in 2 vols.), Vol. 1, *Psikhicheskoe razvitie rebenka* [The Psychological Development of Children], pp. 119–53. The Russian work was published for the first time in the book *Poznavatel′nye protsessy. Oshchushenie. Vospriiatiia* [Cognitive Processes. Sensation. Perception] (Moscow: 1982).

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functions. A person must work under conditions that substantially alter the characteristics of sensory and perceptual processes, for example, visual perception in an unmarked space, perception under conditions of weightlessness, and so forth. Sensory and perceptual deprivation have become an important problem. Man must also work under conditions of information overload. The development of devices of reflection confronts human perception with ever newer tasks, requiring rapid detection of signals and accurate discrimination and identification of signals under conditions that sometimes are far from optimal.

Thus, perceptual processes, even now, at the present stage of development of technology, play no less important a role in man's activity than intellectual processes.

Visual culture, like aesthetic perception, is becoming an inseparable part of cultivating good work habits and work skills in human beings. The need for systematic perceptual training and aesthetic education demands a solid theoretical and methodological foundation, and unraveling the psychological problems of perception is a key to the establishment of that foundation.

Quite a bit has already been done with regard to technical modeling of certain logical components of activity, and considerable achievements have been chalked up in the development of computer technology. But there are still many unsolved problems in the domain of creating, perceiving, and recognizing devices. The difficulties that arise in this regard are in large measure due to the fact that the structure of perception has been insufficiently explored. A more detailed conception of the latter, taking into account the various levels of processes of information-processing in a perceptual system and the distinctive features of the dynamics of these levels of functioning, will help us appreciate not only the merits but also the shortcomings of discrete models and open up ways to create more perfect perceiving and identifying devices.

Thus, the contemporary world confronts the psychology of perception with complex and difficult tasks that make greater demands on this area of knowledge.

Psychology and the psychophysiology of sensory processes are among the most developed domains of the science of psychology. Empirical methods of investigation and techniques of precise mathematical processing of the results obtained were first used in these areas. Moreover, the largest quantity of proven facts and empirically grounded general propositions have been obtained here as well. However, despite the undisputed achievements, there are certain lacunae in the psychology and psychophysiology of perception that are impeding the further development of this area of science and obstructing resolution of the theoretical and practical tasks involved.

For a number of reasons, psychologists and physiologists for a long time devoted their attention largely to study of the sensory effects arising under the influence of various objective inputs, and the process of perception—its objective laws and its role in the practical activity of the subject—remained untouched by research. To overcome this important shortcoming, a fundamental change in the subject matter and methods of psychology in general and in the psychology of perception in particular was required.

For decades psychology was unable to find a place for the subjective images of reality in the general system of human behavior. It either held fast to the postulate of an interaction between the ideal and the material—which contradicted the foundations of natural science—or maintained parallelistic epiphenomenolistic views, thus practically denying any role to the mind in the activity of the subject.

Soviet psychology inherited the extremely important problem of the vital role of the mental aspect of man's life in an unresolved state and addressed it on the basis of the Marxist-Leninist conception of dialectic relations between the material and the ideal. Soviet psychologists, in studying the function of mental processes, particularly sensory and perceptual processes in the regulation of human behavior, have had an opportunity to rely on the findings of contemporary physiology and anatomy, and later, on the achievements of such domains of knowledge as information theory and cybernetics.

It was found that a specific program, whose function was performed by mental reflection, and the images of objects and the actions that were to be effected with those objects played a substantial role in complex forms of human behavior and the behavior of higher animals. There is persuasive evidence of the crucial role of sensory processes in the control of human movements. In analyzing the structure of the anatomical apparatus responsible for the movements of higher animals and man, A.A. Ukhtomskii [2, vol. 5] noted that it had unique features compared with artificial mechanical devices in that it had a considerably larger number of degrees of freedom. Ukhtomskii concluded from his discussion of these findings that neither the bone and muscle apparatus as a whole nor any one of its parts was a ready-made mechanism for the performance of any specific purposeful act, but rather merely an aggregate of certain anatomical components necessary for creating such a mechanism. Such structural features of the motor-muscular apparatus explain the extreme plasticity of the behavior of higher animals or man, and, at the same time, make the task of controlling this behavior extraordinarily difficult and complex.

Since control entails limiting the degrees of freedom and there are practically no such restrictions in the structure of the peripheral executory mechanisms of living organisms, psychological mechanisms must assume the functions of regulating purposeful actions. It was initially assumed that these mechanisms could perform these functions on the basis of rigid patterns that predetermined the nature and the sequence of the requisite movements. However, later it was found that such rigid programming could not produce a purposeful movement.

N.A. Bernshtein [3], who developed Ukhtomskii's propositions in biomechanical and physiological studies, came to the conclusion that no system of efferent, triggering impulses, even the most precisely calibrated one, could unambiguously produce a required motor act, because of the multitude of degrees of freedom of the kinematic sequences of the human body and the ambiguity of the effect of muscular tensions, given the fact that the initial state of muscles is continuously changing, and because external and reactive muscular forces, not under the body's control, play a major role in the dynamics of any motor act.

M.T. Turvey [4], a contemporary American scientist who drew on Bernshtein's theory in his studies, reached an analogous conclusion. He also thought that an integral motor act could not be explained solely in terms of the innervation of individual muscles: there are no simple and precisely defined connections between innervation impulses and the movements they cause. In analyzing the organization of a movement, Turvey, following Bernshtein and other investigators, concluded that it was necessary to examine regulatory mechanisms. The gist of this idea is that purposeful movements are regulated not by a rigid (previously established) pattern, but by an image of the action, which itself is a structure *in a constant state of evolution*. This postulate is illustrated quite well by the way the letter A is written: a human being can trace the letter A in a multitude of different ways (with his fingers, with his whole hand, taking a pencil in his teeth, or even with his foot). It is unlikely that there is a ready-made regulatory pattern for each way of executing this movement, especially as we are not taught to write A by holding a pencil in our teeth, even though we find it not difficult to do so.

Hence, this again raises the question of how purposeful movements are regulated. The general answer to this question was given some time ago, by I.M. Sechenov, who wrote, “Sensation invariably plays the role of regulator of movement; in other words, sensation causes the latter and modifies it in strength and direction” [5, pp. 236–37].

Bernshtein’s studies clarified the mechanism of “regulation of movements by sensation” in complex acts of human behavior. His studies showed that the task of regulating movement, which cannot be accomplished by precise triggering impulses, can be accomplished by corrections made, during the course of performing an action, on the basis of efferent signalization occurring in the process of the motor act, that is, by “sensory correction.” Long before cybernetics came into being, Bernshtein discovered the mechanism of feedback in his particular branch of knowledge and clarified its role in human behavior.

However, sensory impulses entering the nervous system as movements are being carried out are not, in themselves, sufficient to regulate an action; and *intelligent information* is not in itself able to correct a movement as it is being performed. In order correctly to assess this information and appropriately recode it into *executory information* in a system of suitable efferent impulses, the person must at least have a rough idea of what must be done and how to do it—he must have a certain program for the intended actions. Information obtained about the actual values of the regulated parameters of a movement are compared with pre-programmed values, and in this way the necessary corrections can be made in an action as it is being performed.

Turvey presents an interesting conception of these processes in the work mentioned above. He thinks that a movement is accomplished through the coordination of structures that are relatively autonomous in the particular aspect of a movement’s organization. But the actual genesis of a movement is a heterarchy whose higher domains contain a small number of large and complex coordinating structures, while the lower domains contain a large number of detailed and simple structures.

The *image of a future action*, or a specific notion of an impending action, occupies a central place in the organization of a movement. In accordance with the general conception of a movement, the initial idea we have of an action must necessarily be indeterminate compared with its final form in the executory commands for muscles. Put more simply, the *image of an action* cannot, and must not, be constructive for the concrete details of a motor act. An *image of an action* contains an abstract assessment of the *body's pose* and the discrete perceptual properties that may be needed for regulating a movement, but that are also represented in abstract form. As a movement is performed, the *image of the action* is progressively concretized on the subsequent levels of regulation of a movement through the introduction of detailed perceptual information into that movement. A unification of coordinating motor structures takes place on each level with the aid of the corresponding visually identified properties of the external environment.

It is quite understandable that the process of formation of an image of a situation, the actions that are to be performed in it, and the regulatory functions of an image were examined by physiologists in their general form: and it is on this point, in particular, that Bernshtein turned to a psychological examination. Hence, I should like to stress the difference between our approach to the problem and a physiological study, which concentrates on the mechanisms of successive transformations of stimulation in peripheral receptors, in intermediate neurons, and at higher stages of the central nervous system. These transformations (sensory coding and recoding of information) take place when both the simplest and the most complex informative acts are performed; but despite their importance, they cannot fully explain the specificity of perception as a person's mental activity.

We know that sensory processes, which vary depending on the specific situation, are a necessary link in more complex mental acts of perception, and indeed form the basis of those acts. Studies of the mechanisms of sensory coding endeavor to clarify the complex sequence of events linking the transformation of stimuli to the formation of a neural impulse. These transformations are accomplished by receptors that morphologically are very specifically specialized: every receptor transforms some one dimension of the stimuli acting upon it. What this means, generally speaking, is that the nervous system is organized not for direct linear conduction, but for the detection of differences. The various impulses acting on the input of a receptor are then transformed into signals that are universal for the entire nervous system. This neural code is a frequency-impulse code.

The groups of receptors within the same analyzer, plus groups in different analyzers, transform multidimensional stimuli. The creation of neural models of multidimensional stimuli takes place through the integration of incoming data from both individual receptors and groups of receptors or receptor fields.

These investigations go back not so much to traditional study of processes of perception as to the classic current in physiology represented by N.V. Vvedenskii [6], with the one difference that the subject of investigation is afferent systems instead of the neuromuscular apparatus.

Studies of the receptor mechanisms and of the integration of sensory information in the retina often discuss the issue of how the eye traces a contour without special training. This question has been the subject of numerous empirical studies on the basis of which many authors have concluded that recognition of a contour and of segments of images bearing essential information about an object takes place by virtue of the phenomenon of physiological contrast and eye micromovements. V.D. Glezer and I.I. Tsukkerman [7] thought that the contour and fine details were such segments of an image. They assumed the presence of hereditary mechanisms for identifying and recognizing simple shapes. Such a mechanism is the coding of a shape via the magnitude of the excitation or the distribution of excitation in vertical and horizontal directions. It should be pointed out that the number of instances of the nervous system's coding of the simplest configurations increases steadily. We have evidence that an isolated frog retina responds to presentation of different geometric figures with various volleys of impulses, and that recognition of a moving image and pinpointing of its contours and of elements of a visual image such as angles takes place in the retina. A large number of diverse detectors has been discovered empirically.

Numerous studies of the development of processes of perception in ontogeny have indicated that the visual system is already basically formed at birth. It is assumed that the neonate has an almost full set of programs for processing visual information. The neonate is able to respond to variations in different characteristics in the visual field, such as, for example, the spatial distribution of brightness, a change in the time contour of brightness, an object's orientation in the field of vision, and movement. It is not difficult to see that all these parameters characterize the physical properties of objects. It is significant that the capacity for this kind of *analysis* is qualitatively identical with the capabilities discovered in study of the developed visual system, although there are also quantitative differences.

There is also evidence that a neonate's visual system is incomplete and underdeveloped. Subsequent maturation of the visual system is mediated by the influence of the environment, by learning, and so on. The extent of such influence is verified empirically and interpreted in different ways; for instance, it is said that the visual environment shapes the brain in its own likeness, but there are others who deny that the external environment has any defining influence on the formation of the visual system.

It is obvious that study of the mechanisms of maturation of the visual system will help us understand the origin and the specificity of sensory coding. It is also quite clear that the processes of such coding are the premise for the formation of processes of perception; without them, perception is impossible. However, these processes are not identical with one another. For example, it has been shown in some widely known studies of visual deprivation that the first to break down are the mechanisms of comprehension, interpretation, and utilization of incoming information for the organization and regulation of behavior, but that the image of the visual environment in the cerebral cortex remains intact.

I have focused especially on the problem of sensory coding since confusion of this process with perceptual processes complicates elucidation of the initial levels of perception. There is still a question about the factors causing the transformation of premental sensory processes into perceptual processes. A.N. Leontiev [8] studied the problem of the genesis of mental reflection of reality in phylogeny and offered the hypothesis that the decisive role in this process was played by special changes in the conditions of existence of living organisms and the associated increased complexity of their behavior. Premental reflection (in the sense of susceptibility to stimulation from different biologically significant influences) puts in its appearance in organisms living in a homogeneous environment under conditions in which the sources of life do not have material embodiment. Such sources as food dissolved in an aqueous medium, the energy of solar rays, heat energy, and so on, are all necessary for sustaining plant life.

In the process of evolution, some species of organisms move from life in a homogeneous environment to life in a materially structured environment. This transition from a vegetable, plant form of existence to an animal existence is attributable largely to changes in the source of food and the use of not only inorganic but also organic substances as food. Under such conditions, behavior directed toward getting edible plants and animals must necessarily conform to the features of these complex objects, to their relations to one another, and to their position and their movement in space.

Object-related conditions of existence ultimately give rise to object-related forms of reflection of the environment and to the modeling not only of stimuli but also of objects serving as the focus of behavior.

Under simple conditions, if the environment is relatively unchanged, or if it varies within strict limits and in accordance with rigorously defined parameters (as takes place, for example, when autonomic functions are performed), regulation takes place via sensory coding and the neural models, formed on its basis, of the corresponding stimuli. But under the more complex and endlessly varying conditions of the objective activity of animals seeking plants and pursuing prey, fleeing hunters, and building nests and holes, to say nothing of the higher forms of productive labor activity on the part of humans, such sensory processes can no longer in themselves ensure appropriate control of behavior. At this point the signal conducted along a neural circuit cannot be directly switched over to executory mechanisms.

In a sensory or neural model of a stimulus, all of the information received from a multidimensional source is registered in the states of the corresponding center. These states have nothing in common with the state of the information source. In contrast, the perceptual image of an object bears a certain likeness to the perceived object.

The prejudices of psychophysical parallelism, which are very deeply rooted in the thinking of psychologists and physiologists, can encourage the invalid hypothesis that essentially these two models are identical, and that a perceptual image is only a subjective duplicate of the sensory physiological model and only a psychological epiphenomenon. However, deeper analysis shows that they differ not only introspectively but also in their objective qualities. As has been persuasively demonstrated in studies of the constancy of perception, objects in conformity with which behavior must be shaped produce totally different signalization under different conditions of observation, and the entire task is to decipher this signalization correctly or to build, on its basis, an adequate image of the perceived object. A perceptual image is a form of object-related reflection; it is much more dynamic than a purely physiological model would suggest and more adequately reproduces objects and a situation as a whole, despite the constantly changing conditions of perception. Hence, it is, in principle, capable of regulating much more complex forms of behavior than premental, purely physiological models.

The distinctive nature of a perceptual image is due to the specific features of the perceptual code. In the narrow sense of the term, a code is an aggregate or a system of units of the alphabet in accordance with which information is broken down and encrypted. At the same time, identified elements are integrated and united in an integral, perceptual image. Whereas in sensory coding external influences are translated into an alphabet of internal states (differing qualitatively from external influences) of the channel of communication (neural processes and the states of peripheral receptor apparatuses, intermediate neurons, the central ends of analyzers, etc.), whose organization reproduces only the quantitative measure of information, in perceptual coding or, better, recoding, external influences are translated into the language of object-related images, objective pictures of perception localized in the external world. In other words, whereas in the process of sensory coding the model of the stimulus is formed, in the process of perception an image of the object is created and used to regulate behavior.

However complex the mechanisms for the transformation and conduction of stimuli may be, if there is no connection with the external environment and the incoming information has no relation to the external world, we cannot speak of perception. It is important to point out that objective materiality, being the fundamental property of perception, conditions all of its uniqueness as a mental act; ". . . sense data . . . ," wrote S.L. Rubinshtein, "immediately acquire objective significance, that is, they are related to a specific object" [9, p. 243]. Other important properties of perception, such as integrity, meaningfulness, and constancy, are derivatives of objective materiality and the subject's capacity to relate incoming impressions to integral objects that have a relative invariance, despite the continually changing conditions of observation. This property marks a qualitative difference between perception and premental forms of sensory regulation of behavior.

The problem of the objective materiality of perception is of great practical as well as theoretical significance. Thus, evaluating the role of objects in the formation of perception is one of the factors determining the direction of the sensory education of the child. Contemporary technology also devotes considerable attention to the objective nature of perception. One can give examples of information models for different systems of regulation in which the property of perception is taken into account. When an information model is constructed for an operator, the best capabilities are organized to obtain objective perception. Various memory devices perform this task in that they graphically reproduce the parameters of technological processes that are essential for regulation. The development of alphabets of coded symbols with relatively more or relatively less *pictorial quality* reflecting the attributes of the objects to be regulated pursues this same goal. The effectiveness of perception is increased through the use of new types of visual indicators that replace the numerous isolated devices and provide a *pictorial* representation of the situation.

The problem of the subjective nature of perception has long been a touchstone of psychologists, physiologists, and philosophers. From the standpoint of introspective psychology, which limits the object of investigation to the phenomena of consciousness, the very posing of this problem has entailed essentially irresoluble contradictions. Indeed, how can an observer relate a perceptual image to an external object if the latter is presumed to exist for the subject only in the form of contemplation, only in the form of a subjective image?

The history of psychology is full of clever attempts to resolve this problem (which is irresoluble when the question is posed in this way) by referring to associations of one kind of sensations with other kinds (for example, visual sensations associated with tactile and kinesthetic associations), mental processing of incoming sensory data, internal intention, which is supposed to enable the subject to objectify his internal states of consciousness, and so on. And although, with all these skips and jumps of thought, some progress has been made in elucidating the actual features of the process, on the whole, things have not moved forward, since investigations have focused on the interaction of processes taking place within consciousness, whereas the task was to study at a concrete psychological level the nature of the connection between these processes and the features of external material objects. For this it was necessary to break decisively with the traditions of introspective psychology and to regard the subject not only as a contemplative theoretician but as a practical actor adapting to the external world and altering these latter processes in accordance with his own objectives.

The first step in this direction was taken, of course, by I.M. Sechenov [5], who pointed out that mental and, particularly, perceptual processes are integral components of holistic adaptive reflex acts, and that they exercise a regulatory function in the behavior of animals and man.

A decisive change in understanding the objective materiality of perception took place when Soviet psychologists began to work on this problem on the basis of the philosophical postulates of dialectical materialism concerning the role of practice in man's cognition of the reality around him. Through studies of the formation of different perceptual processes in different types of activity [8, 10, 11], investigators saw perceived objects in a new light, that is, not just as objects of contemplation but as objects of practical, material action. Thus, the problem of relating a perceptual image to a real object assumed a concrete and perceptible form that enabled it to be subjected to objective experimental study. According to the new viewpoint, a perceptual image is formed and exercises its regulatory functions in a process of specific orienting-investigatory activity.

Study of the genesis of perceptual processes in connection with the development of the purposeful activity of the subject has also provided a key to understanding a previously insoluble problem, namely, the objective materiality of perception. Since the objective materiality of perception is a product of the activity of the subject (both practical and cognitive and orienting activity) and the nature of this activity changes in the process of development, the objective content reflected also changes.

The point is that objects in themselves possess a vast number of properties, and the subject cannot and need not, in a particular case, take them all into account in performing diverse actions. As objects of perception, these objects, so to speak, let the subject see only a particular side of themselves as a function of the well-formed perceptual actions he already possesses that will enable him to discern in the object particular properties or a particular content. Thus, unlike a material object, an object of perception undergoes a certain change as an activity is developed. This finds expression in changes in the objective alphabet of perception, in changes in the operational units of the perceptual process that assume a different nature depending on [the child's] developmental level.

The dynamics of development of the objective content of perceptual actions is characterized, on the one hand, by a transition from the reflection of concrete, immediately perceived properties of objects to their external connections and relations, and from these to the perception of internal properties and latent relations. On the other hand, perception moves from a schematic whole in which the parts are not differentiated or are only externally connected to a whole based initially on the external, but then later, on the internal relationships among its parts and different aspects. This development of objective content, that is, the transition from simple, elementary images based on single attributes (properties) of objects to complex images formed as a result of establishing internal connections and relations among the existing properties of the object, and then to a synthesis of integral images, also produces changes in the structure of perceptual actions. Through these actions the subject gets his bearings in the surrounding reality and reflects those properties of it that are necessary for living and acting in it and for solving ongoing problems. Hence, the processes of perception cannot be looked at in isolation from the real life of the subject, or without analyzing the task the subject accomplishes. This is very important since the tasks the subject accomplishes in the process of his vital activity determine those objects and their properties that must be discriminated for accomplishing this or that action; similarly, the tasks also determine how the necessary properties are identified.

This demonstrates the subjectivity of a perceptual image, that is, its dependence on motivation, emotional state, or other attitudes. However, the subjectivity of an image does not mean that it does not adequately reflect reality. This raises the question of the mechanisms responsible for this objective reflection.

According to the traditional neurological model, the ultimate substrate of sensory processes is the cortical level of analyzers, where neural processes are also purportedly transformed into mental images. However, a nervous process is only propagated or transformed in the nervous system, and how its transformation into an adequate subjective image can take place remains completely unintelligible. This has given rise to a false alternative: that is, either we must recognize the sign nature of sensations and perceptions, or we must totally give up trying to provide a scientific explanation of them. The crucial step in moving beyond such conceptions was taken by Soviet psychologists who began to regard perception as a system of actions oriented toward examining the perceived object and forming an image of it (standard). Studies of the role of "reduplication" of the object by movements of the hand and eye in the formation of a mental image follow this line of thinking [8 and others].

It seems to me that there is no physiological model of activeness (regardless of whether it be a model of the reflex arc or a reflex circuit) that can "include the object" with its specific objective properties. In such a model the object can serve only as an external component relative to the particular process, as a stimulus that must be recoded into a series of nervous impulses. To include the object in the system of human activity, one must go beyond a physiological description of activeness and look at it in psychological terms as external, purposeful activity of the subject. That kind of activity includes the object, with all of its specific features, as an intrinsic, organic component of itself.

We find some profound thoughts on this issue in Hegel [12], who showed that whereas a plant, in interacting with an object, destroys the latter and transforms it into itself, a higher form of life is characterized by the fact that in the process of its activity an animal employs an object, but leaves it as it is. There is reason to assume that the key to understanding the origin of perception as an objective image, as an image of an object, lies in this objective nature of the activity of living creatures.

A more detailed clarification of the role of a perceptual action in the formation of an adequate perceptual image may be found in a number of arguments in a certain sense analogous to the arguments used by N.A. Bernshtein to clarify the rule of sensory correction in the regulation of human movements. Because of the multitude of degrees of freedom of surrounding objects relative to the perceiving subject, and because of the endless diversity of conditions under which they appear, these objects continuously change in appearance, displaying different sides to us. In other words, neither a sensory impulse nor the stimulation of a receptor can in itself unequivocally determine the emergence of an adequate perceptual image. A connection is necessary to rectify inevitable mistakes and to bring the image into line with the object. However, if an image is materialized only in the internal processes of the organism (in the states of a receptor or in the cortical nucleus of an analyzer), it will be impossible to compare the image with its original, and thus the requisite correction will not be able to take place.

Consequently, the process of reflection must be externalized, which takes place in the form of perceptual actions that assimilate to their external form the perceived object and align themselves with the features of the object [8]. The effector components of such actions include movements of the hand as it feels an object, movements of the eye tracing a visible contour, movements of the throat reproducing audible sound, and so forth. In all these cases, a copy is created that is comparable with the original, and signals of discord will adjust the image as it is being formed, that is, perception, insofar as it subserves a practical activity, is checked and corrected by this activity. Just as the subject's motor behavior can, according to N.A. Bernshtein [3], be coordinated with the conditions of a problem only through sensory correction, the adequacy of a perception is, in the final analysis, achieved through effector correction.

It is these efferent links that, by assimilating to the object, ensure the construction of an adequate image. Without the participation of movement, our sensations and perceptions would not possess the quality of objective materiality, that is, they would bear no relation to objects of the external world, which, strictly speaking, is what makes them mental phenomena. Thus, the motor function is not limited solely to the creation of optimal conditions for the functioning of perceiving systems; the most important thing is that movements participate most directly in the construction of a mental image, and indeed are a necessary component of a perceptual action. The movement of perceiving systems is of decisive significance for processes of formation of an image and processes of recognition of what is already known. The participation of movements and actions, organized in different ways, in processes of perception is also a basis for explaining the partiality and subjectivity of perceptual images.

It is obvious that there is such an intimate organic connection between movement and action that everyday consciousness often does not draw a distinction between them—indeed, equates them. In fact, they are not identical. The psychophysiology of normal and pathological motor activity is broadly acquainted with instances of compensation, in which certain movements substitute for others in the accomplishment of the same actions. Movement without action is possible, for example, in convulsions, epileptic seizures, and the like, when the actions of the motor systems have no purposeful characteristics. Also, action without movement is possible, as in the case, for example, of a mental action, which takes place on the ideal level, in the imagination.

But, as has already been pointed out, there is a necessary connection between movement and action; and the latter (at least in its initial form, that is, in the form of an external material action) necessarily includes motor components. To understand the nature of the connection between these two processes, we must look at the principal properties of an action, which, according to A.N. Leontiev [8], consists of purposefulness and object-relatedness. An action always presupposes some purposeful transformation (in the real world or in the mind) of an objective external situation.

The connection between action and movement is defined by the function the latter fulfills in a purposeful act. Orienting movements of receptor apparatuses are no exception. According to the point of view I am developing here, these movements play a crucial role in the formation of a perceptual image. However, what is important here are not the physical properties of such a movement in themselves (composition, speed, spatial form, etc.), but rather those properties associated with the function the studied motor processes exercise in the subject's actions.

As experimental findings have shown, physically similar movements of receptor apparatuses can exercise different functions in an action, and, accordingly, can have different cognitive effects. Thus, earlier, L.I. Kotliarova [13, 14] discovered, in studies done under my supervision, that hand movements identical in form, performed by the subject as he blindly traces the contours of a planar figure, yield completely different cognitive results depending on whether those movements perform an executory function (when, for example, the fingers are used to place a string around a figure to measure its perimeter) or an orienting function, consisting in an action whose purpose is familiarization with a new object. This example indicates that analysis of the movements of receptor apparatuses in studying their role in the formation of a perceptual image is absolutely necessary and fruitful.

The essential role played by motor activity in perceptual actions has been confirmed by studies of the processes of constructing an image and visual search and recognition under conditions of stabilization of an image on the retina. It has been found that all these processes are also accomplished on the basis of a motor alphabet that has been dubbed the alphabet of *vicarious perceptual actions* [15]. Vicarious perceptual actions consist of selective variation of the sensitivity of specific segments of the retina under the regulation of low-amplitude eye movements.

Movements of a 2–4-degree scope were found to take the form of either drift or rapid jumps. Psychologically, this was expressed in an ability to let one's attention wander over the field of a stabilized image. If the subject was deprived of this ability, he was unable to solve any task. Essentially, what was discovered was a mechanism that compensated for stabilization relative to the anatomic fovea, that is, to the zone of clearest retinal vision. This mechanism was called the *functional fovea* mechanism.

Before low-amplitude eye movements under conditions of stabilization were recorded, the possibility of moving the gaze over an image that was stabilized relative to the retina gave the impression of ideal attention. The above-mentioned study obtained data indicating that information may be gathered through vicarious actions not only from a stabilized image but also from an afterimage and a visualized image. The findings of such studies indicate that motor activity participates in perception not only externally but also essentially. Motor activity constitutes the texture and the means of development and perfection of perceptual actions.

There is one other important aspect of the role of motor activity of perceiving systems, namely, the different characteristics of a movement (trajectory, fixation, etc.) that serve as an objective and quite reliable indicator in the study of perceptual actions. Recording movements makes it possible to link the distinctive features of the functional aspect of actions of perception and recognition with the logic of development of objective content. We obtained important data on the structure of actions of perception and recognition using just this method.

The study of perceptual actions entails considerable difficulties since, in developed forms of perception, there is no mutually unambiguous correspondence between the perceptual action and the executory action performed on its basis. Identical perceptual actions may subserve different forms of behavior, that is, different tasks are accomplished using them. And there are also inverse relations, in which identical tasks may be resolved with different perceptual actions. An analysis of perceptual processes is further complicated by the fact that the appearance of new, for example, visual, tasks and the development of ways to deal with them is annulled or, more often, masked by forms of perceptual actions that were used to resolve more elementary tasks. Hence, the range of perceptual tasks accessible to the organism is all the broader the higher the organism is on the evolutionary ladder.

As empirical data have shown, perceptual actions operate in an expanded, external form in the early stages of ontogeny, in which their structure and their role in the formation of perceptual images are most clearly manifested. Thereafter, they undergo a number of successive changes and contractions until, ultimately, they are tantamount to an instantaneous act of perception of the object. This act was described by representatives of Gestalt psychology and taken by them to be pristine, that is, genetically primary.

Here we see the fundamental importance of genetic or developmental study for clarifying the nature of perception, since study of the development of perceptual actions can provide the key to their true structure and role in the reflection of reality. Thus, it is difficult to draw rigid lines between the operations of discovery, discrimination, and identification in developed forms of perception; but this proves to be possible in a genetic study. The question of differences between the above-mentioned operations is quite serious since different levels of perception are an achievement not just of a specific age or a stage in the development of perception. Each subsequent level does not annul the preceding one by virtue of its appearance. In other words, there is a place for every action formed in the process of development of the structure of developed perception. In particular, operations of discovery and discrimination of informative attributes relevant to tasks and familiarization with these attributes have been distinguished in action directed toward the formation of an image. Moreover, in the study of perceptual activity, mobile interrelations and mutual transitions between operations and actions have been found in the study of perceptual activity.

Let us describe in more detail how an image is constructed in preschool children. Our first operation in [studying] this process was that of discovering an object. This type of discovery should not be confused with two others, namely, discovery by means of active search on the basis of some already-formed image, or discovery through recognition. We should also stipulate that all children were found able to distinguish various shapes of objects. Hence, our criterion for the construction of an image of a new shape was not discrimination, but recognition or reproduction. To perform these tasks, the children had to single out the attributes of an object that were most informative from the standpoint of the particular task and familiarize themselves with them. In our case, this attribute of figures was undoubtedly the contour of an object. We found that the perception of figures definitely did not begin in young preschoolers with discrimination and examination of the contour, although the children certainly were able to discriminate relatively simple figures from their backgrounds and see the boundary between the object and the background and even were able to follow accurately with their eyes a pointer moving along the contour. Nonetheless, they did not independently single out the contour of a figure as its most informative content. For this an analysis of a number of attributes and the selection from among them of the one that was most essential for the particular problem was necessary. The children in a sense tested the different attributes, chose specific, characteristic details of the figure, and perhaps were guided by its size, and so forth. Only when it was found that familiarization with these attributes did not result in successful recognition did the subjects single out the contours of the object and familiarize themselves with it in detail.

Consequently, the second operation of perception was to single out that content that was most informative for resolving the particular problem. At this stage the children displayed chaotic eye movements. The ability to single out particular perceptual content and work with this unit formed only gradually; and this operation dwindled away, so to speak, beginning to last for only micro-intervals of time. It is, for the present, still difficult to draw a distinct boundary between the operation of discovery and the operation of identification and discrimination. The ability to detect individual attributes in an object is rooted in the anatomic-physiological structure of the apparatuses of perception. As for identification of any specific properties as appropriate for the task of familiarization, this operation requires special study. The acquired ability is used to resolve not only the task in which it developed but similar tasks as well. If a new task requires orientation to another content, the operation of discrimination takes place anew and continues until the given content is found.

The described operations of discovery and discrimination of perceptual content are among the least studied. As a rule, they elude the eye of investigators working with experienced observers. In cases in which the observer must deal with material new to him, investigators analyze more carefully processes of training and sensory learning in which the operation of discrimination of perceptual content that fits the particular task, for example, is quite apparent. There are many professions in which the observer must find a specific content for the resolution of some particular task and to single out from among a vast number of attributes those that are most informative and most in line with the purpose of the impending action. The development of skill in reading topographical maps or decoding aerial photographs is a quite clear, but not the only, example of such an activity that requires operations of discrimination. The development of the perceptual act and the operation of familiarization begin with this operation.

The singling out of perceptual content can be accelerated considerably by special organization of sensory learning. In many cases this is done, but it is not always done deliberately and systematically. Most often a learner simply looks at the results of the actions of an experienced observer and, by means of trial and error, gradually learns to discriminate this content and construct a perceptual action. Sometimes even an experienced observer cannot say on the basis of what attributes he identified a useful signal from among all the noise or was able to identify signals. Attributes used by different observers to gain their bearings in solving the same task may not coincide.

The difference between the operations of discovery and discrimination, respectively, evidently lies in the fact that the observer potentially is able to discover, and in fact does discover, different properties of objects—color, size, shape, and the like. But as the observer becomes acquainted with an object, and as he discovers a number of its properties, he begins to discriminate only one property, or only a small number of properties, which is (are) most informative. In other words, he transforms certain properties (or sets of properties) of objects into operational units of perception. The person may be aware, to a greater or lesser degree, of this process of testing or verification of the informative value of discrete properties. Attributes of objects that have been discovered, but not singled out or discriminated as operational units, may be retained in the observer's memory; but they can also be obliterated.

There is a tendency to regard the discrimination of attributes as something that is self-evident, requiring no special effort or action. This indeed may explain the naive question of what properties, for example, color or form, are discriminated earlier in the individual development of perception. The sequence is dictated by the task of perception.

The next operation of perception is *familiarization* with already identified perceptual content. This process is considerably more organized compared with the first. The techniques and the means of familiarization with the various attributes of objects develop according to their own dynamic. Recordings of eye movements in the phase of familiarization with already discriminated perceptual content (if one can say that tracing the contours of an object is such content) have shown that the eye moves along the contour, and that there are almost no movements over the field of the figure. An image, an internal model of the shape of the object, is constructed. Extension over time and sequence are characteristic features of the action of familiarization, which does not remain unchanged. The methods of examination become progressively more refined, and the generalized schemata of a perceptual action are formed; in these schemata familiarizing components gradually begin to intermesh with the identifying components. The methods of familiarization become increasingly economical and effective.

As a result of operations of discovery and discrimination of informative content and familiarization therewith, a perceptual image of an object is formed. Once it has formed, recognition (reproduction) is possible. However, in this case the act of recognition is based on another system of reference points and attributes compared with those that were used to construct the image.

By familiarization or examination, what is meant is the action of an observer upon the first presentation of an object. Upon subsequent presentations, the observer already brings something from past experience and compares the image formed as the result of familiarization with the present object. Genetic or developmental study enables us similarly to describe the development of actions of recognition. In the initial stages, they largely resemble perceptual actions. The eye moves along the contour of the object, but no longer stops at every point. The number of such points is greatest in four-year-olds and declines as children grow older. The number of movements per unit of time increases. This parameter and the characteristics of the trajectory corresponding most closely to the features of the figure indicate that for recognition (in the initial stages of its development), a second familiarization with the object is necessary, plus construction of its image, which, to be sure, now takes less time.

The transition to a new way of dealing with a task of identification or recognition is quite apparent in five-year-olds. But because this method is only just forming, it, too (if to a lesser degree), is in expanded form and hence accessible to observation and recording. Actions of recognition already differ considerably from perceptual actions at this age; they contain only allusions to an examination of the figure. The gaze halts on only certain points of the object, but movement along its contours is still evident, and a correspondence can be established between the characteristics of the trajectory of eye movements and the shape and properties of the object being recognized. In older children, the trajectory of eye movements is even more compressed. It is sufficient for the eye to pass over only a small segment of the contour to recognize the figure; the similarity of the form of the trajectory of the process of recognition and the object diminishes even further. Recognition takes place solely on the basis of discrete attributes. This indicates that a considerable quantity of the information contained in the object becomes superfluous, and is not used for recognition. A comparison of discrete *support* attributes with a standard image formed earlier is sufficient for recognition.

The trajectory of eye movements in recognition of an object by adult subjects is compressed to a maximum. There are so few of these movements that it is difficult to judge from them what attributes the subject has selected to identify or recognize the figure. Nor can one discover any external correspondence between the trajectory of eye movements and the properties of the object. Thus, the development of actions of recognition displays a dual dynamic. On the one hand, it is a series of transformations involving a change in the *alphabet* of images, and, on the other hand, it is the dynamic of the motor components of actions of recognition, that is, they are reduced to one type of movement, and functions are transferred to another type.

On the whole, in examining the distinctive and unique features of perceptual actions and actions of recognition, it is important to stress that they differ mainly in the fact that they are aimed at accomplishing different tasks, but also in the fact that they are oriented toward the discrimination of different objective contents in the object and are accomplished through different systems of the motor alphabet. The discrimination in the object of attributes that serve as elements in the establishment of connections and relations as an integral image is constructed is characteristic of a perceptual action. Once an image has formed, a subsequent action of recognition is based on recognition in the object of merely discrete (distinctive) attributes that enable it to be placed in a particular class. It is important that in the first case, the process of discriminating attributes is determined largely by the characteristics of the object, whereas in the case of actions of recognition, attributes are used that are essential from the vantage point of the previously formed image. In this case, recognition comes after the detection of attributes determined by a deliberate search.

In studying the processes of formation of images and recognition, we have found that the ways these processes are accomplished also differ. External perceptual actions whose function is to collect information from the external world become *vicarious perceptual actions*. Their main function is to collect information from a trace accumulated on the retina. It should be pointed out that the development of an action of recognition proceeds in a direction contrary to the development of a perceptual action. Whereas the structure of the latter undergoes change as an action unfolds and its motor components are strengthened, in the latter, movement is gradually compressed. The development of a perceptual action proceeds in the direction of discriminating increasingly adequate objective content; the development of an action of recognition proceeds in the direction of the most integral assessment of content. Hence, we can see that recognition may be simultaneous, but not the process of constructing an image.

Processes of recognition take considerably less time than processes of image formation. However, in actions of recognition that have already been formed, the sequence of change in methods of recognition over time can be the inverse of the sequence found in developmental studies. Whereas in developmental studies the sequence is from expanded actions of recognition and subsequent discrimination of the necessary attributes to a simultaneous method of operation on the basis of integral criteria, under certain conditions the sequence of changes is from simultaneous to successive recognition. This replacement of one method of action by another is matched by a succession of types of images used in the process of recognition.

We use the concept of a standard, or an operational unit of perception, to define not only criteria for the objective content of perceptual actions and actions of recognition but also for determining methods for discerning the content of an object. Content refers to compact, semantically integral structures formed as a result of perceptual learning by dint of which practically one-act (simultaneous) integral recognition of objects and situations becomes possible regardless of the number of attributes they contain.

M.S. Shekhter [16] noted that standards are a specific system of distinctive attributes that serve as criteria for the differentiation of one class from another. He proposes that the formation of standards be called processes of assimilation of distinctive features. He argues in detail that it is invalid to confuse these processes with processes involving the use of already discriminated and fixed distinctive features. This definition focuses on the nature of the attributes used for the recognition of objects. Other investigators, while noting the distinctive feature of the structure of organization and content of standards, have stressed their operational nature and the function of active interaction with the object of recognition (with an action) [17, 18]. The active nature of standards is brought out especially clearly in cases of pathology. Under the influence of pathological factors, standards can also almost totally subordinate sensory processes to themselves and suppress the influence of objective stimulation.

In our earlier works [21, 22, and others], in defining standards the accent is placed on regarding them as specific tools or instruments for the realization of perceptual actions or actions of recognition. Standards mediate these actions just as practical activity is mediated by tools and mental activity is mediated by words. Standards, like models, are functional organs of the individual. As noted above, in the construction of an image, the systems of perception are assimilated to the properties of an object; but in recognition, the characteristics and the orientation of the process of assimilation change substantially. These changes consist in the following [22]. On the one hand, the subject reconstructs, with his own movements and actions, some likeness of the perceived object; and on the other, a recoding takes place: the incoming information is translated into the language of the operational units of perception that the subject has already learned. The second aspect is a reflection of the fact that assimilation of the object to the subject occurs at the same time as the subject assimilates to the object. Hence, we can see why there is no isomorphism between, for example, the trajectory of eye movements and the contours of objects at certain stages in the development of perceptual actions, especially in recognition, in which the process of discovery and identification of recognizable attributes is subordinate not to the distinctive features and properties of the object, but to a standard activated in this process, in which the criteria of recognition have already been discriminated.

Processes in which the first type of assimilation takes place are directed toward discriminating elements, properties, and so forth, in real objects and, most importantly, toward the establishment of connections among these elements. Processes in which the second type of action are assimilated are directed toward finding in the object properties that are most in line with the already-existing standard and enable the object to be placed in a specific class. Thus, the direction of these processes differs, and the nature of the objective content they discriminate is also different. In the first case, these are attributes of the object intrinsic to it and among which relations are established for the formation of an integral image of the particular object; in the second case, these are more informative attributes discovered in the object in order to identify an object with given standards or to choose an appropriate standard, from among a series of alternatives, for its subsequent identification.

Assimilation of the first type takes place through external perceptual actions whereas assimilation of the object to the subject takes place through vicarious perceptual actions. Both have their own feedback mechanisms. In the process of constructing an image, feedback moves from re-formed image to the object, whereas in the process of recognition, it moves from the object to the standard.

The most difficult task in the study of perceptual actions and actions of recognition is to provide a substantive description of the different levels of formation of operational units of perception. The difficulty is further compounded by the fact that many operational units are formed simultaneously and are, to a certain extent, interchangeable. That is why the question of the criteria of perception is so complicated and why we spoke, above, of the specificity of actions of recognition. But it should not be forgotten that the exchange of operational units of perception is only outwardly the express result of the development of processes of perception. So long as the observer operates with one class of operational units, the development of perception and recognition occurs through automation of specific methods of investigation, discrimination, and comparison of the same properties of stimuli. But any automation has its limits, and it turns out that this type of development comes to an end. The second limit within this type of development is operational memory or short-term memory, which has a limited value and a threshold character, that is, when it is overfilled, processes of familiarization of comparison are either slowed or curtailed. If vital problems require an increase in productivity and in the speed of processes of perception, this is possible provided this method of action is replaced by another based on a reorientation toward new attributes of objects or on the formation of structures from previously discriminated attributes.

We have by this time accumulated considerable material for a typology of standards for recognition and for the organization of methods of action corresponding to them. One of the main characteristics of standards is the structural organization of their constituent attributes previously discriminated in the object. All attributes from which standards are constructed fall into three groups structurally: (1) simple (elementary, primary); (2) complex (generalized, secondary); and (3) integral. An elementary attribute consists of one simple objective property and, for this reason, cannot be further broken down. According to E.L. Levenberg [23], this attribute contains an indivisible and independent property. Complex attributes consist of combinations of simple attributes, and can be successfully broken down into simple components. In contrast to a combination of simple attributes, integral standards exist as whole, indivisible units. It is characteristic of such an attribute that it figures in an action of recognition as elementary and irreducible, although in the process of acquiring an action of recognition, it is formed of complex attributes [16, 24].

V.D. Glezer [25] used the term *simple attributes* to designate attributes that are discriminated by innate mechanisms of the visual system (receptor fields, detectors). The time required to discriminate them does not depend on the informational content of the stimulus, but only on the duration of formation of a signal in the nervous system. Signals about all elementary attributes are formed simultaneously. This conception of simple attributes corresponds to the form of sensory coding, in contrast to perceptual coding, whose principal characteristic is that the discriminated properties have an objective reference. As pointed out above, perceptual coding is the result of the development of practical and, especially, perceptual activity. The reduction of simple attributes to the sensory form of coding causes difficulties in providing a substantive description of complex attributes. V.D. Glezer suggests that a complex attribute is "any logical function" of simple attributes. The focus in this case is on the specific features of the functioning of these "complex attributes," by which complex attributes perform a distributive function, that is, they make it possible to distinguish an image described by a set of these functions from other images. Such a conception of simple (primary) attributes is found in R.M. Granovskaia's work as well [26].

Other authors use the term *simple attribute* to refer to one irreducible, objective property discovered in an object. It is characteristic of complex attributes, which are different combinations of simple attributes, that they do not contain all the simple attributes describing the object, but the essential ones, the "critical" ones, or, as they are also called, the most "informative" ones from the standpoint of their significance for recognition.

M.S. Shekhter has written [16] about one other possible classification of attributes of recognition. This classification is based on whether the particular (previously discriminated) attribute of an object is distinctive and whether it is permanent. An attribute of an object (class of objects) is considered distinctive if it exists only in objects of the particular class and is not encountered in other objects. A permanent attribute is an attribute that an object (class) always possesses, that is, it is intrinsic to all members of the particular class, without exception. Relations between these two groups of attributes are analogous to relations between sufficient and necessary properties, that is, in the choice of a standard from among a series of alternatives, orientation (reference) is characteristically based on the distinctive attributes of an object. Consequently, a standard may also include one attribute if it is a distinctive and permanent one, but it may also be formed by different combinations of distinctive attributes (complex standards). In the latter case, as a task of recognition is being accomplished, there is successive detection (choice) in the object of all distinctive attributes and their identification. In complex standards, as a rule, specific relations are established among the attributes of which they are composed and which depend on their disparate objective significance and their probability characteristics. Functionally, this will be manifested in the sequence in which attributes are detected and in the fact that searching for them and finding them prepare the conditions for subsequent actions with another attribute.

In the process of training, a transition to recognition using another type of standards, integral standards, is possible. These are the result of integration (not simply the summation) of a series of perceptual qualities and function as one indivisible attribute. The possibility of such integration (which is distinct from the transition to a parallel processing of several attributes) is experimentally confirmed. The process of recognition on the basis of an integral standard is, in principle, constructed in the same way as recognition on the basis of a simple attribute, that is, the principle of identification. M.S. Shekhter [49] has shown that perceptual attributes are synthesized in integral standards, whereas complex standards may be formed from combinations of both perceptual and conceptual attributes. The latter are found in analytic characterization of a figure, and are the result of dissection of a figure into elements and the relations among those elements. Conceptual attributes are general properties of all versions of the particular object (class of objects) that form the distinctive features of the object only as a whole, not each of them separately.

It should be noted that, apparently, the difference between conceptual and perceptual attributes is not only what properties of the object are identified for recognition but how deep is the objective content underlying them.

It is obvious that with a similar structure of organization, attributes may be discriminated with respect to other parameters as well. For example, one other qualitative characteristic of attributes is called a *category*. A number of studies have shown that attributes of different categories (for example, shape, color, orientation, position, size, etc.) have differing influences on the time and accuracy of recognition. Recognition of shape and color is the most effective, and recognition of size, the least. Many studies have shown that the mechanism of recognition varies as a function not only of the structure of the standards but also of the category of the attributes. This is reflected in the facts that actions of recognition have different orientations and that different functional systems participate (are activated) in them. Almost all investigators stress the differentiating (discriminating) aspect of attributes that constitute standards for recognition. However, the specificity of the functioning of distinctive attributes is sometimes described as a system of logical operations (e.g., the method of intersections, the method of binary classifications, the method of movement along a tree of attributes, etc.), or research may be oriented toward study of the factors influencing the process of choice (finding an appropriate standard).

Thus, the question of the ways in which discriminating properties are used in the process of recognition has not yet been sufficiently studied. This question is usually considered in connection with the nature and structure of standards or operational units of perception. Because the principal functional principle of recognition is a process of comparison, two fundamental mechanisms of comparison are studied: successive comparison and parallel comparison. A number of studies have shown that parallel comparison is the mechanism in the case of recognition of such categories of attributes of an object as shape, size, position, orientation, and color. It is hypothesized that information about the different categories is processed in parallel in the perceiving system, whereas in the system of formation of a response, the processing takes place successively. The successive mechanism can be used in recognition of one category in a situation in which there are a number of alternatives: if the standard is still not adequately defined; when recognition is based on complex standards; or if the indeterminacy of the objective content increases, and successive study of the object is necessary.

Two methods of recognition, successive and simultaneous, have been distinguished in connection with the above. It should be pointed out that this division is based on two empirical facts: first, there is an absence of successive fixations in simultaneous recognition, and second, substantial differences are observed in the time of recognition by the two methods. In the literature considerable attention is devoted to the role of both methods, and the simultaneous and successive methods are often regarded as mutually exclusive, belonging to different systems participating in recognition. For simultaneous recognition, the subject characteristically relies on integral attributes of the object that function as a single attribute. The simultaneous method takes place in accordance with a previously compiled and proven program that is determined by the objective and structural characteristics of the integral standard. A task of recognition can be accomplished by the simultaneous method under constant conditions, which are determined or known beforehand.

Some authors distinguish two successive stages (phases) in simultaneous recognition on the basis of integral standards. It is assumed that, in the first phase, a model region or zone is discovered to which the presented stimulus belongs, whereas in the second phase, the object is accurately placed in a specific class. This hypothesis is based on the fact that in incomplete recognition, the subject nonetheless localizes the object not in the zone of indeterminacy, but in a more or less defined zone, embracing both the standard and certain nonstandard variants [16].

In successive recognition, the object is examined element by element, and the attributes of recognition are successively identified (discovered); in this case, the next choice is made after the preceding one has been assessed, and, moreover, is determined largely by the results of that assessment. The simultaneous and successive methods of recognition differ with regard to the nature of the attributes used and in the fact that they are accomplished by different means. For the first, the main means or instruments are internal perceptual actions, and the object is recognized on the basis of integral attributes. In the second, the emphasis is on external perceptual actions, which are based, in turn, on complex standards representing different combinations of simple attributes. The successive approach may be necessary when the indeterminacy of the identified objective content of the object increases. In that case, the action of recognition is directed toward identifying the object's actual attributes. The significance of the discovered attributes is determined on the basis of, for example, similarities or differences in some of their properties, that is, as a result of comparison. An action of recognition is usually accomplished after discrimination of subsequent attributes in comparing them with preceding ones. Only after this successive analysis, evaluation, and generalization on the basis of the chosen criteria has been accomplished can the object be classified appropriately. The task of choosing a standard from among the entire series of alternatives is also, for the most part, accomplished by means of the successive method. However, because the indeterminacy of the criteria results not from any objective character of the stimulation but derives, so to speak, from within, the accuracy of choice is determined by the degree of difference that exists among the alternatives. Finally, the most complex case may be regarded as that in which the first requirement is to construct a standard on the basis of an analysis of relations among the attributes contained in the initial conditions, after which actions of recognition in the strict sense may be performed. In such situations it is more difficult, for a variety of reasons, to use preformed criteria of recognition (standards); it thus becomes more difficult to organize actions of recognition and to accomplish them successively because they include the functions of image formation. In comparing the two basic methods of recognition, we might note that each of them also has gradations of complexity. At one pole of this continuum we find simple processes of recognition carried out on the basis of programs in accordance with a preassigned standard; and from the entire variety of attributes of the object, only those that meet the requirements of the latter are taken into account. This subordination of actions of recognition to a standard means that they are internally highly ordered and that their execution is quite rapid. However, the accuracy of these actions is high only under very restrictive conditions. At the other pole are actions of recognition closely akin to processes of image formation; processes that are much less restricted by the rigid framework of existing standards are more sensitive to the distinctive features and properties of the objective diversity and hence have no definite internal order: their organization depends more on the structure of the objects.

Studies done by V.M. Gordon [17, 18] suggest that these methods of recognition are two phases of a single process. The law governing the connection between phases is subordinate to the "development of the result," the task of complementing integral attributes identified in the first phase of simultaneous recognition and generalized assessment, and the elementary attributes identified in the successive phase. Developmental studies [20] of the formation of actions of recognition have shown that both the simultaneous and the successive method may equally be a means for achieving a result. From the standpoint of this type of analysis, the principal difference between them is merely the nature of the objective content, that is, the quantitative and qualitative use of the attributes. Consequently, the connection between the phases and their order in the general organization of the process of recognition should be subordinate to the development of the result obtained in the preceding phase. We observed an example of this kind of connection in recognition of comparatively simple attributes of the object and of more complex attributes using only a standard and an integral alphabet. The complexity of the attributes influenced only the duration of the phases and their inclusion as an additional method of processing, that is, their complexity may have caused changes in their individual particular properties, but not in the structure of the process and the law governing the connection as a whole. In the final stage, the means for expressing the result of activity in symbolic form (verbal response) were added to the means for identifying and developing the objective concept of the resultant activity. This processual feature of the last phase of the solution, specifically its duration, also depended little on the composition and characteristics of the preceding phases and was linked most closely to the content, represented in symbolic form.

If we look at the relations among these means in general, we can conclude that the former involve adding more knowledge and transferring that knowledge to a domain of considerably vaster scope, though more detailed. Actions involving naming, on the other hand, are subordinate to the task of reflecting the product or putting it in another form or another language.

Let us look at the question of how transition or, more accurately, translation, of movement into an image is possible. A theory of perceptual actions cannot be considered well founded without clarification of the essence of this question.

The movements of an animate body reproducing the form of other bodies are internally connected with a search that includes an orientation toward the future. Following the example of N.A. Bernshtein [27], we call such movements *live movements*. The problem of their origin is, however, one of the origin of sensitivity or sensation and of the mind. This should be understood in the sense that a live movement may be regarded as the genetically original unit of analysis of mental reality. What can modern science propose specifically in this regard? The most essential attribute distinguishing live movement from mechanical movement is that the former is not only, indeed is not so much, the displacement of a body in space and time as the mastery and overcoming of space and time. In other words, live movement is an active chronotrope.

A.A. Ukhtomskii justly wrote that physiologists (and also psychologists, we may add) initially did not accurately characterize real movements of the organism and had to be satisfied with rough descriptions. But the time has come when science can speak of the "microscopy of a chronotope." This, wrote Ukhtomskii, is "microscopy not of immobile architectures, but of movements in a fluid and changing architecture as it is engaged in activity. And in this we shall have a new revolution in natural science, the consequences of which we cannot at present overestimate" [28, vol. 5, p. 75].

Bernshtein's method for recording and analyzing movements and the studies he carried out on their basis enabled him to formulate a number of extremely important postulates. The principal one is that movements of a living organism may be regarded as morphological objects.

> The fact that they do not exist wholly at each moment, but unfold in time, that they incorporate the time parameter in their existence in a somewhat different way than, for example, do anatomic organs or tissues, in no way excludes them from the ranks of objects to be studied morphologically. On the contrary, the idea that movement in many respects is like an organ (existing, like anatomical organs, within the coordinates x, y, z, t) is extremely fruitful. [27, p. 178]

According to Bernshtein, a living movement is an evolving functional organ "possessing its own biodynamic fabric" [27, p. 179] (by functional organ is meant, according to Ukhtomskii, any temporary combination of forces capable of accomplishing a specific objective).

Such a complex structure as a living movement as described should possess specific vital functions, for the description of which Bernshtein used the concept "motor task." The task of constructing a movement in a unique, real, objective situation is fantastically complex. To deal with it, a body with a mind is forced in some way to comprehend the extremely complex physics of a concrete, *objective* situation and coordinate it with the body's biomechanics.

The resolution of such tasks truly requires the formation of extremely complex functional organs whose fabric must include not only physical, utilitarian, executory acts but also cognitive and emotional-evaluative components that Bernshtein himself linked to "models of a required future." Bernshtein's living movement is not a reaction, but an *action*, not a response to an external stimulus, but the *accomplishment of a task*.

Although movement takes place in external geometric space, it also has its own space. Bernshtein introduced the concept of a "motor field" on the basis of his generalization of the totality of motor properties in their interrelations with external space. The lack of stable identical lines in the motor field and the irreproducibility of movements suggest that a living movement is not learned, but built anew each time. The motor field is constructed through *searching, testing movements, probing space in all directions*.

Since a motor task is part of the very definition of a living movement, the latter must be regarded as possessing *characteristics of objective meaning*. Let us examine its structural features in order to find a place in this movement for cognitive and emotional-evaluative components.

To do this let us employ a quite abstract experimental situation for the study of a motor act. The sense of the situation was that a new action was formed in the subject, an instrumental, spatial, motor habit. The subject's task amounted to learning how to control a spot visible on a television screen with the aid of an organ of control that had three degrees of freedom. Because of the novelty of the task and the quite modern technology of recording movements, the process of formation of a new action could be subjected to macro- and micro-structural analysis. The new action was regarded as an emergent, functional structure consisting of perceptual and executory actions responsible for the formation of an image of the situation, compiling a program of action, and implementing that program and controlling its result [28].

The results most significant for us were obtained in the initial stages of learning reactions when different types of inversion were introduced between the perceptual (visual) and motor fields, when breakdowns were introduced into the implementation of a well-learned action, and when delayed (or distorted) feedback about the course and the results of the action carried out was used. In these cases, we were able to observe the process of development and destruction of the functional structure of an action.

Cognitive and executory components (the formation of a program, and implementing, checking, and correcting it) were clearly discriminated in a thoroughly assimilated action of aligning a guided spot with a target. Despite the fact that the correlation between two actions changed in moving from one action to the other, these changes did not disrupt its general, clear structure. Another picture was observed in the stages of formation or when the above disorders were introduced into the course of the process studied. In these situations, the precision of execution of the action suffered, and the time required to perform it increased. But the main point is that an integral action was broken down into a multitude of smaller actions, separated either by total arrests or by a considerable delay, each of which did not achieve the goal. This was possible only when all actions were implemented together.

The first stage of mastery of an action is similar to the situation described by Norbert Wiener:

> If I shoot at a target with a one-dimensional bullet, the probability of hitting a specific point on the target is equal to zero, although the possibility is not ruled out that I will hit it. Indeed, in each specific case, I will necessarily hit some point, which is an event of zero probability. Thus, an event of probability 1, namely, hitting any point, may consist of a totality of events each of which has a probability of zero. [29, p. 101]

And, in fact, as a result of a (sometimes large) number of unordered, helter-skelter movements giving the impression of being random, the assigned point is hit. These chaotic movements serve as a source of information about possible movements in space. They help the subject sense space in every direction. After making some minor movement, the subject does a quick check and notes the path for further movement or locomotion. At the beginning of learning, a movement itself does not have an executory function, but actually fulfills a *cognitive* function. It is not so much a means for achievement as a source for obtaining information. A generalized *image* of the situation as a whole, an image of the working space (motor field), is constructed on the basis of this movement.

All these things are characteristic of an orienting-investigatory activity that includes *testing* actions in its composition. N.A. Bernshtein called such behavior "extrapolated search."

Movement has not only a temporal but also a spatial coordinate, because of which many thinkers have linked it to memory and prediction. The functional structure of an action contains two cognitive units (stages). The unit of formation of a program of an intending action (i.e., "elements of prediction," according to Sherrington, or a "required future," according to Bernshtein) precedes the physical stage of an action. The control unit (i.e., the memory element) comes after the phase stage of an action (for simplicity's sake, we are examining a situation of a discrete action).

We recall that Bernshtein considered "a look into the future" or a model of the future a basis for the resolution of any motor task. He spoke of the existence of the unity of opposites of two categories (or forms) of modeling the perceived world: a past–present model, or a model that has come into being, or a model of what is about to occur. The second is transformed into the first in a continuous flux.

This raises a question: What is the mechanism of transformation of one model into another? This process takes place in the present as a living movement is being accomplished. But the interrelations of past–present and future prove to be a source of movement: only what has yet to come determines the movement. This idea was expressed by many thinkers in the past. For instance, Augustine wrote: "Expectation is a thing of the future; memory belongs to the past. On the other hand, the tension in an action belongs to the present: through it the future becomes past. . . . Consequently, there should be something in an action that relates to what is not yet" [30, Part 2, pp. 302–3].

One may conclude that space and time are present in a living movement in an inseparable unity. The translation of time from the future into the past is possible only on the basis of active, efficacious action in space on the basis of overcoming and mastery of space. A movement serves as a necessary connecting link between prediction and memory. The discrepancy between them is overcome through the present, at the expense of the tense action therein.

The simultaneity of the spatial picture of the world is possible only as a result of successive action, extended over time, in this world. A living movement is truly an active chronotope, a unique means for overcoming space and time. This is possible because a living movement is a means for transforming space into time, and vice versa. Thus, a living movement has characteristics of existence as well as characteristics customarily called psychological or subjective in the strict sense. In other words, meaning and sense exist therein in underdeveloped and hence difficult to dissect form.

The structural features of a living movement are being studied more and more. The most recent results indicate that it has a quantum-wave character. The space–time characteristics of quanta are determined by the motor task, the degree to which the action of which they are a part has been assimilated, and the speed with which the action is accomplished. The existence of quanta of an action is crucial proof of the heterogeneity of a motor act and explains why a motor act can be reorganized into a cognitive act, which, in the final analysis, often leads to an operational transformation of an integral action [31].

The unity of a movement and the mind appears to us so clearly that it can be argued in terms similar to those used by A.F. Samoilov, as follows:

> Our famous botanist K.A. Timiriazev, when analyzing the correlation among and the significance of the different parts of a plant, explained: "A leaf is indeed the entire plant!" It seems to me that we should be just as entitled to say: "A muscle is the entire animal! Muscle made an animal an animal, and muscle made man man." [6, vol. 3, Book 2, p. 938]

Pursuing this line of reasoning, we might say that a living movement is the mind! Regardless of the categorical form in which these comparisons are expressed, they really do reflect the essential features of the phenomena they describe.

A description of living movements, actions, and images of reflection required a *new conceptual apparatus*, the foundations for which were laid in the works of Sherrington [32], Ukhtomskii [2], Bernshtein [3, 27], Zaporozhets [33], Zaporozhets et al. [20], Leontiev [8], and others. These phenomena cannot be described in terms of either reflex theory or stimulus-response theory. They require terms corresponding to concepts such as "a model of a required future," a "motor task," "prediction," "simultaneous images," "the transition of time into space through movement," "the subordination of movement to an object," and so forth. All these concepts and terms are taken from the psychological theory of activity and the theory of orienting-investigatory activity, in which the mind is the organ of activity. These theories examine specific live actions, mental actions, and images and ways to study them. One of the main problems faced by these theories is to determine conditions for that great leap in the evolution of life that led to the genesis of a mental action, that is, of the mind, which is governed by principles other than those governing inanimate nature.

A.V. Zaporozhets [33] and A.N. Leontiev [8] worked on the problem of the genesis of mind and stressed the significance of the active nature of the subject in this process. In his investigations Leontiev used the transformation of imperceptible stimuli into perceptible stimuli as the experimental model of the process of genesis of sensibility (he studied the process of the genesis of a sensation of color in the skin of the hand). It was found that the emergence of sensibility and an orientation to color are possible only under conditions in which there is *active action* in a *search situation*.

The genesis of the sensation of objective properties of the surrounding world is only one aspect of the matter. No less important is the genesis of sensations of one's own movements in this world. There is persuasive evidence that "before being transformed into voluntary movement, a movement must be perceptible (whether on the basis of indirect or direct attributes is of no interest)" [33, p. 88].

Hence, we find ourselves confronted with a situation in which a movement is a condition for the genesis and development of sensibility and sensation. Sensation, in turn, is the condition for the further development of a movement and for its transformation from an involuntary to a voluntary movement. From this standpoint, a sensation is just as much the basis of a movement as its result, and just as much an impulse toward movement as a brake on it. The adaptive effect of a motor act is inseparable from the cognitive effect.

All of these things indicate that the biodynamic fabric of a living movement must contain (or generate) elements of a "sensory fabric" [23], which is the building material for the formation of an image. The sensory fabric is the potential, subjective, motor field, preserved in space, of the simultaneous mold (schema) of the biodynamic fabric or the congealed biodynamic fabric (the number, large or small, of accomplished movements). The sensory fabric is the lasting motor experience remaining after a movement has been completed and participating in the construction of a new movement.

P.Ia. Gal′perin [34] has presented an interesting hypothesis on the origin of the mind. He suggests that the mind comes into being in a situation of a unique and irreproducible task. The subject can accomplish the task directly only if the way to effective action is prepared by testing and measuring, which can be done only at the level of images. In my view, these arguments, though correctly grasping the essential characteristics of the mental, nonetheless require further theoretical and empirical development.

The above-described characteristics of the biodynamic and sensory fabrics are not sufficient in themselves to enable us to analyze the process of image formation. Images are subjective phenomena that arise as a result of practical activities with objects, or sensory conceptual and intellectual activities. An image is an integral reflection of reality in which the basic perceptual categories (space, time, movement, color, form, consistency, etc.) are simultaneously represented. The most important function of an image is to regulate activity. To fulfill this function, this reflection must be objectively valid.

There is reason to believe that a perceptual image is something separating the subject from the world of objects at no stage in its evolution. The direction of development of perception in all cases is a transition from a broadly adequate reflection to reflection that is also adequate in its details [35–38].

The proposition that perception is adequate at all stages in its development should be extended to include the development of the mind as a whole as well, and of each mental process in particular. Any stage in the development of the mind has its own permanent value. At any stage in development, the mind is not a partial, but an integral structure, although it does, of course, have a zone of proximate and a zone of more remote development. This integrity of the mind is matched by an integrity of reflection of the world that varies in depth and completeness, but nonetheless does not cease to be integral.

Earlier it was stated that psychophysiology and psychology have produced nonclassical interpretations of movement and sensations according to which the biodynamic and sensory fabrics have a single source and are two aspects of a single whole. Let us examine this from the standpoint of the genesis of a visual image. Two types of structures are distinguishable in visual perception: a spatial structure, which involves localization and the coordinates of a three-dimensional space of the surrounding world, and a structure of proximal stimulation, which is related to anatomic coordinates on the retina. Studies of the microgenesis of a visual image and the stabilization of an image on the retina have demonstrated that these structures are relatively independent of one another although they are interrelated in the actual act of perception. Both structures are also characterized by specific iconic properties. Iconic properties of structures constitute the sensory fabric of an image, which, as a rule, is fused with the objective content of the perceived reality, that is, it is localized in an external, three-dimensional space. Iconic sensory properties (the perceptibility and sensitivity of movement) are also present in the biodynamic fabric of a movement.

The spatial structure of an image is a product of the objective actions of the subject through which the latter transforms the biodynamic fabric of movement into the sensory fabric of an image. What we have said applies not only to the process of image formation but also to an image once formed: a snapshot may be regarded as accumulated movement, a simultaneous copy of movement. The biodynamic fabric of a movement is present in compressed form in both the engendered image and the embodied image.

As a spatial image is formed, it is filled with objective properties and enveloped in the sensory fabric; at the same time it is situated, together with the latter, in external space. What we have said applies equally to the sensory fabric, which is related in its origins to the biodynamic fabric. The situation is more complicated with respect to the sensory fabric, which in origin is associated with the properties of proximate stimulation (with the light and color properties of the surroundings). One can assume that this type of sensory fabric does not initially possess objective (and accordingly pictorial) properties. These are acquired as this fabric fuses with the spatial structure of the image and, together with it, is externalized and localized in the external space. After this fusion has occurred, the image is an integral and indivisible whole.

Consequently, movement and light are to an equal degree building material of a visual, spatial picture of the world. Moreover, both forms of sensory fabric become reversible. The sensory fabric, which has its source in movement, and action, which initially is practical and then is perceptual, play a leading role in the formation of a spatial image [20]. The sensory fabric, which has its source in proximal stimulation, occupies a leading position in the formed image. As a movement is constructed, reverse translation takes place, that is, the sensory fabric of the image is transformed into the biodynamic fabric of movement. Movement initially as well as ultimately is a kind of substance of the image.

The evolution of an image, which we have not considered in our discussion here, consists of the transformation of a spatial image into perceptual models, into meanings, and into symbols. In recent years, elements of abstraction have increased; and the relative weight of biodynamic and, especially, sensory fabric has decreased proportionately.

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