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DETERMINATION OF SENSOMOTORIC COORDINATION

The present work brings not only results of an investigation of sensomotoric coordination of lady-telephone-operators, but also a critical and classifying review of the theoretical approaches and results of experimental investigation of different authors. By confronting the data in literature with the mathematical and statistical analysis of the obtained measuring values we have determined the degree of influence of some selected factors that affect the coordination of both arms. The theoretical contribution of the present study may be seen in assaying the significance of certain factors in sensomotoric coordination. The practical effect of the work consists in the possibility of applying the substantiated relations, and of assuming certain parameters of behaviour, as well as in the diagnostic value of the method of aiming.

In the publication we find treatment from the general standpoint of the question of motoric coordination and of its importance for the activity of motion, while from the specific standpoints it is above all its significance in the working activity of man with a particular consideration of the determination of the sensomotoric coordination in aiming which is dealt with. The study tries to substantiate relations between working capacity, efficiency, working conditions, and the personal qualities of the operators. The problem is pressing, and a number of foreign research workers study it. In the Czech and Slovak psychological and physiological literature investigations of the sensomotoric structure are comparatively rare and follow somewhat different objects. From the analysis of single factors of coordination and discoordination of motion we see clearly the significance of the different components and influences that may affect the aiming coordination of the movements of the arms.

An important place must be ascribed to the problems associated with the method of centering, which attracted the interest of several authors as early as in the beginning of the 20th century. Since that time an increasing number of more and more precise methods has been presented, methods that at first were concerned with following the more conspicuous movements, while later they were occupied with performing analyses even of the subtle motoric activities because the results of investigations of aiming motion contributed to the knowledge of the substance of working movements and enabled experts to assay the reflexion of different factors on their preciseness and speed.

The use of the method of centration helped us to draw conclusions concerning the significance of this methodic process for the diagnosis in the psychology of industrial work, for the application of this method under different conditions makes of it an important diagnostic aid. In the single methods of centration evaluated in practical work we can notice an increasing preciseness in the selected progress and likewise an increasing registration of their course and of the results obtained. A detailed study of the investigation methods that were employed by different authors made it possible to suggest a new precise method of investigating the pointing centration movements of the arms. Its advantage lies in the automatic presentation of the stimuli, their automatic registration including, so that the obtained material can be quickly and precisely assayed and the method can be applied also to places of current employment.

It is not only the problems of coordination of motion but also those of its discoordination that are important for the treatment of the theoretical and practical questions of the working movements. The abundance of definitions dealing with coordination betrays gaps

in the uniformity and adequate knowledge in theoretical approach. Onesidedness of some of the definitions and theories is quite evident. An all-round approach is in the history of this investigation an exception.

The problems of the sensomotoric coordination of motion are related to several lines of research. They have been investigated in biology, physiology, and psychology. As for the psychological branches, sensomotoric coordination has been investigated above all by general psychology, psychology of children, and pedagogic psychology, but also by psychology of technical work, the latter depending on the specific aspects, modes, and objects the research is concentrated upon. In the present study an attempt has been made to discuss the theoretical development of the research from the general psychological, psychophysiological, and technical standpoints.

The theoretical sphere of sensomotoric coordination has not been treated satisfactorily in psychological literature so far. In our work we have made use of some theoretical approaches of the problems of coordination of motion. The significance of theoretical approaches in general conception of psychics and in practical application is treated with respect to the dynamic view of the spacial or also temporal components of the working movement involving aiming in the work performed by a driver, operator, stoker, telephone-girl, dispatcher, etc., i. e. in employments implying an increased loading of the central nervous system, but besides also in any other vocation as practically every working pursuit involves some movements of arms that have precise aims fixed beforehand.

The dynamic interpretation of the basic component of activity widens its too narrow conception in psychology, restricted to function. The above interpretation facilitates a transition to stochastic approaches. The hitherto prevailing theories of sensomotoric coordination have kept for the most part within the frame of static or dynamic models. Typical samples of the static conception of coordination of motion are Hering's theory, which reduces motion to the work of protagonists and synergists, Pear's theory of the central factor, reducing coordination to one common factor, and finally the dualistic theory, which ignored the outer conditions of motion, ascribing the determination of the character of activity to psychical factors only.

In the dynamic models we may include e. g. Lewin's theory, which stressed the dynamic relations of tension and relaxation in the act of hitting the aim irrespective of the conscious regulation of the action of volition, Tollman's theory of the force of habit, which pointed out the unequally intense general concentration on the object or aim, Weizsäcker's theory of effect, whose starting point is a constant governing factor, controlling and directing the course of motion, von Kries's theory of three coordinates, according to which the single directions of movements are associated with the directions of visual perception, and the totalizing theory, which takes into account the general progressive aspect of motion, this aspect, however, being according to the views of official psychologists precisely and invariably predetermined. The stochastic modelling of sensomotoric coordination is based on the principles of relation. In contrast to the deterministic models, which take relations as uniformly fixed, the stochastic models are concerned with determining the probability of occurrence of a phenomenon, i. e. with the reliability and preciseness of estimate. They can be used for assaying the intensity of influence of the single variables, for to one value of a certain variable there always correspond more values of another variable. And last but not least, they are useful for critical estimation and classification of theoretical approaches and of the results of the hitherto performed extensive experimental investigations, which have not so far succeeded in satisfactory formulation of an all-round complex theory of sensomotoric coordination.

In work some relations between working efficiency, working conditions, personal qualities, and working abilities are substantiated. These determinations can represent another stage in the process of forming stochastic models of the coordination of motion.

Of the well-known theories of the coordination of motion we may add to the stochastic models only the fluctuation theory, which may just as well be called oscillation theory, and perhaps also the reflex theory.

When enumerating these stochastic and associated models, we may mention also the rather detailed theory of sensomotoric discoordination, within the frame of which some relations were subjected to experimental analysis. The theory of disintegration of coordinated move-

ments is based on the experimentally frequently substantiated fact that such disintegration involves a disturbance of the cooperation of functional systems. It was May Smith who was the first to point out this phenomenon in 1915. He assumed that it is the matter of a transient influence of fatigue, calling forth disharmonies in the nervous system. Next it was Theodor Ziehen and Mourisse who likewise noticed that under the stress of heavy fatigue a temporary disturbance of coordinated movements occurs. In 1953 Golla, Antonovič, Shaw and others arrived at the conclusion that whipped up mental work increases at first the muscular tone, but later it results in its decrease due to the reduced control of the cerebral cortex over the subordinate centres. It was Bartlett and his fellow workers who contributed substantially to the formulation of this theory by distinguishing two phases of disorganization of the complex psychophysiological functions, whose cause is above all the disturbance of the time component of movements. Cox, Peer, Rüssel followed changes in concentration on the object and in attention, Čapek, Zelený studied the disturbed balance of stimulus and inhibition. Petz on the basis of analysis of factors expressed the view that disturbances have not only the temporary character, but that they are also selective because they affect primarily those structures that participated most of all in the performance of the given task.

From these conclusions it was not far to arrive at the application of the stochastic approach and at utilizing the correlation number for establishing the degree of influence of most various factors on the spacial parameter of the working movement. This approach is a very useful one deserving our close attention as it enables us, when carried out far enough, to elaborate the theory of activity and to apply rationalization to those working activities that have so far kept beyond its reach.

The second part of the present deals with the components of the sensomotoric coordination, three basic aspects being primarily pointed out: the genetic aspect, the physiological aspect, and the optic-motoric regulation of the coordination of motion. The developmental aspect has not received due attention in psychological literature, it has not been systematically treated, and only partial views on this subject can be found in different experimental and monographic studies. And yet, this subject is significant because it represents one of fundamental criteria in the normal development of a child and the results obtained form a basis for the prospective working training. Assays of some aspects of sensomotoric coordination can be found in a number of tests whose object is to follow the level of the sensorial and motoric development of children (A. Gesell, Ch. Bühler, H. Hetzer, K. Wolf, N. J. Ozereckij, M. Gurevič, G. Göltnitz, et al.) The development of the pointing movements was precisely reconstructed according to data in literature, The norms of different authors were compared pertaining to these single movements whose basic component is the act of pointing, the testing procedures were classified according to age.

The physiological component of the sensomotoric coordination was from the historical point of view treated before the psychological approaches were undertaken. In the present work it is stressed that the physiological and psychological aspects of a working movement cannot be separated from each other. The physiological aspect implies different levels of organizing the act of movement (I. P. Pavlov's dynamic stereotype, A. A. Uchtomski's dominant), changes of muscular irritability during work, relations between the afferent systems, the two types of coordination — the binocular and the convergent.

In the successive periods of investigation one can observe an alternating stress laid on either the optical or the motoric regulation of the coordinated movements. The optical control of movements has been much more minutely dealt with than the motoric control, for the application of the latter involves methodical difficulties. It was proved that in different circumstances either one or the other component of a coordinated movement may predominate. Conditions were defined as favourable for the predominance of either one or the other component, and it was found that when certain conditions are observed, it is possible for an individual to get conformed by training to one or the other component of regulation. The last word in the discussion of the problems of the motoric coordination is believed to be Anochin's theory of afferentation and reafferentation, supplemented by Bernštejn's theory of the control of movement.

The third part of the study, dealing with experimental work, concentrates on a few factors that influence the process of sensomotoric coordination. It discusses the influence of training,

the spacial and temporal parameter. A proof is given concerning the relations linking the thirteen followed features in a group of 20 girl-operators connecting trunk-calls, a group which was the object of experimental investigation directly in places of their employment. The effect of training on motoric skill was minutely studied. It had not been known with respect to pointing aiming movements, and for this reason an experimental proof of the effect of training movements of arms was obtained. The results are in conformity with the material in literature dealing with other kinds of coordinated movements. In detail they bring some new data concerning the intensity of this influence. It was found that with the aiming movements it is the spacial parameter that is more affected by the training, while its effects on the temporal parameter are less noticeable, even if its shortening is also statistically significant.

The first basic hypothesis was the assumption of a close relation between the exactness of the coordinated pointing movements of the right arm and the left arm (P-L). The correlation coefficient ($r_{PL} = + 0,935$ if P is more than 0,01) showed that between the two actually exists a very close linear dependence. As the regression equation ($P = 0,655 L + 0,85$; $L = 1,332 P = 0,63$) makes it possible to calculate the exactness of centration of the left arm, in further experiments only the exactness of the aiming movements of the right arm (P) was taken into account. The minor errors of the regression equations (6,4 and 8,0 %) and the statistically insignificant differences of the arithmetical means referring to the exactness of coordination of the two arms show that the found differences in the spacial parameter of the right arm and the left arm are a matter of chance.

The second working hypothesis, which was formulated in the first part of the work and experimentally verified, concerns the essential influence of age on the exactness of the coordinated movement of arms; it was confirmed by the calculation of the correlation coefficient, which proved to be reliable on the 5 % level ($r = - 0,535$). This sign (F) was associated with sign T (duration of employment of the operators). The obtained total correlations and regression equations were the basis for calculating partial coefficients of correlation, expressing the exactness of sensorimotoric coordination of pointing movements as a stochastic function of the age and duration of employment of the girl-operators. We find in them confirmation of the null hypothesis, i. e. the independence of sign P (exactness of coordination) on sign T (duration of employment), as well as its refutation, i. e. confirmation of the dependence of sign P (exactness of coordination) on sign F (physical age).

The third working hypothesis assumes dependence of sign P (exactness of coordination) on sign D (index of the stress of the shift). This dependence was confirmed, for the existence of a relation between them was established ($r_{PD} = - 0,60$) and it was proved that the exactness of coordination decreases in proportion to the fact whether the telephone girl works in a shift that is denoted as a shift of higher stress.

In the fourth working hypothesis we come across the assumption of a relation between the exactness of coordination (P and the handicaps in the working place (PR) in a municipal trunk-call office, but the calculations made in advance have not been confirmed. Neither have been confirmed the relations between sign P and the following signs: ISU, IISU, INP, and IINP (index of subjective chronic fatigue, intensity of this index, index of the neurotic symptoms and its intensity).

The obtained material made it possible to perform classification of the telephone girls into subgroups of individuals with the same qualities and those that differed as to other qualities. There were altogether five subgroups, partly of equal age and duration of employment, and partly differing in age and length of employment. Yet, even this classification of operators into subgroups did not confirm the hypothesis about the heterogeneity of the investigated series, while signs ISU, IISU, INP, and IINP failed to prove significant with respect to sign SK (working performance). Nevertheless, in relation to sign P (exactness of coordination) some dependences appeared to be significant. Thus for instance, in the subgroup of elderly operators the exactness of coordination of the arms was found to be considerably reduced. From the testing of the differences between the subgroups another very important fact could be derived, i. e. that operators who entered the work as young girls adapted themselves very quickly, the exactness of their coordination reached soon its climax, but when they grew old the exactness of centration got significantly reduced, irrespective of the dura-

tion of their employment. Significant is also another conclusion, namely that the superiors estimate the operators in a trunk-call office according to their personal impression and other criteria without taking into account the sensomotoric coordination that is manifested by them in the course of their connecting the trunk-calls although this accomplishment is one of the basic aspects of their working activity.

The relation between sign SK (working performance in the shift) and the other studied signs has not been assumed. Neither has any of such relations been substantiated on the basis of statistical material. It is only the relation between SK and D (the working performance and the stress of the shift) whose correlation coefficient approaches the limit of statistical significance, but nevertheless, remains below it. No more did the tests applied to sign PR (handicaps of the working place) supply a proof of its statistical significance, so that we may take for granted that the working performance per shift in working places with different handicaps and in situations involving four degrees of working stress did not differ.

The conclusions may be applied in practice. There are, in fact, quite a number of possibilities of concrete application. They may be helpful particularly in investigating and determining the degrees of working load in working places of different character and the results may be serviceable in diagnosis, they may be useful as aid in estimating the progress of convalescence after injuries or illnesses, in deciding upon therapeutic treatment, in forming diagnoses and prognoses. And finally they may contribute to the basis for introducing rationalisation measures in different types of working places. Here we have in mind the problems of motoric rationalisation, inducing the respective authorities to undertake an all-round investigation, including necessary measurements and drawing conclusions, of the relations between the working man, his means of production and his working milieu with the object of suggesting such measures of improvement as would secure the optimum working conditions. A practical application of the centration method depends on the introduction of automatic stimuli according to a carefully prepared programme and on an automatic estimation of the two basic parameters of the working movements.

The act of experimental verifying and substantiating the influence of the single factors and of determining the degree of disturbance of the sensomotoric coordination will make it possible to estimate the load involved in the different forms of work and thus to establish a more reliable basis for motoric rationalisation, while it will at the same time contribute to a more precise formulation of the discoordination theory of motion.

