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Psychophysiology in Czechoslovakia

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In Czechoslovakia, psychophysiology (Radil 1985) is based on traditions represented by names of J.E. Purkyně (see Radil *et al.* 1988b) and V. Laufberger (Radil 1975). Modern psychophysiological research of human beings, using contemporary neurophysiological, experimental psychological and computer methods, has been developed approximately since the 1960's. This brief survey presents some selected results obtained in recent years. A relatively detailed account of psychophysiological research in Czechoslovakia can be found in the Proceedings of the Psychophysiology Congress which was held in Prague recently (Radil and Bohdanecký 1988).

The psychophysiology of perceptual and cognitive processes

The subjective spatial orientation of a two-dimensional population of dots generated on a screen was analysed (mostly in collaboration with the Institute of Physiology of the Bulgarian Academy of Sciences in Sofia). It was found that the accuracy of the estimate was influenced mainly by the number of elements and their two-dimensional correlations. The test subjects were capable, under certain conditions, of determining orientation better than by interpolating a straight line through a set of dots by the usual standard statistical techniques. If two orthogonal populations of the same dots were presented simultaneously, the test subjects were able to exclude some dots which did not fit spatially into the dominant population. In cases in which both populations were composed of roughly the same number of dots, the subjects showed a preference for one of two possible orthogonal orientations. Error in the determination of orientation likewise depended on how close the orientation was to the vertical and horizontal axis. In angular rotation of the population round its centre so that the original population on the screen also remained in its position, error in determination of the orientation of the total dot population depended, in a non-monotonous manner, on the degree of mutual rotation of the subpopulations. If the dots were replaced by short lines, error in subjective determination of orientation of the population was likewise non-monotonously dependent on the angle differences between the orientation of the lines and of the whole population. Supplementary dots, which were not a part of the relevant statistically defined population of dots, also induced the subjective orientation non-monotonously (if these supplementary dots deviated slightly from the axis corresponding to the sum of the least squares, subjective orientation inclined towards them, whereas with a greater deviation a reverse occurred). These

findings contributed to the identification of certain types of pre-conscious information processing in the visual system (Lánský *et al.* 1987, 1988a,b, 1989a,b, Yakimoff *et al.* 1988, 1989, Radil *et al.* 1988b).

It was found (together with the Institute of Psychology of Helsinki University) that the phase relationships of two simultaneously presented sinus-modulated gratings are very difficult to distinguish. Using "block portraits", the amount of information needed for spatial integration of the final percept was estimated and it was found that maintenance of the image required less information than was needed for its detection. On the basis of these and similar tests, a new type of perceptual visual memory was described. By using the method of limited spatial and temporal sampling of sinusoidal gratings, the conditions for space-time integration in the detection of visual stimuli were determined. The enlargement of visual stimuli (computer-generated texts) in a horizontal direction led to an illusory increase in the subjective estimate concerning the vertical dimension. Evoked EEG potentials associated with the random appearance of unexpected changes in a given parameter of computer-generated visual stimuli (as against acoustic stimuli) did not display a short-latency wave of the Mismatch Negativity type. These tests were of significance for the identification of certain partial aspects of visual perception (Laurinen *et al.* 1989, Nyman *et al.* 1987, 1989, Radil *et al.* 1987b, 1988c,d, 1989b).

In cooperation with the Institute of Physiology of the Bulgarian Academy of Sciences, systematic deviations were found in determination of the position of moving visual stimuli. The time parameters of the processing of visual information depended on the direction in which the stimuli moved (in foveopetal movements the latencies were about 90 ms shorter) and also on the structure of the stimuli (Mateeff *et al.* 1989, Bohdanecký *et al.* 1989b).

It was found in electrophysiological experiments that, with the same inter-stimulation intervals and a reversible visual stimulus (the pattern of a Necker cube), whose interpretation in successive presentations alternated, the response was always preceded by a slow negative shift in the EEG. This experimental design allowed "contingent-negative variation" type of phenomenon to be induced by a single stimulus (Radilová *et al.* 1986).

Differences were found in the amplitude of the late positive components of evoked EEG potentials (the P300 wave) in correlation to the cognitive criterion of correctness and certainty in distinguishing the number of simultaneously presented geometric elements in a visual stimulus (using the paradigm 7 +2). Correctness and certainty were associated with high amplitude of the P300 wave. The amplitude of this wave was further influenced by emotional factors, stimuli with a higher emotiogenic content inducing waves with a higher amplitude. However, when attention was concentrated on these stimuli, the amplitude of the P300 wave induced by indifferent stimuli diminished. Another factor correlating positively with the amplitude of the P300 wave was the instantaneous heart rate. In tests in children it was found that the identification of a large number of elements presented simultaneously in a visual stimulus was associated with a better performance in Raven's test. These experiments showed that the instantaneous cognitive and emotional state influences the perception and processing of information in the human brain (Radilová 1989, 1990a,b, Radilová and Radil 1985).

Other experiments, in which the sensory threshold was measured at a time when alpha activity was either present or absent in the EEG, showed that this factor

likewise influences perceptual and cognitive processes. In further experiments, in which auditory evoked potentials were recorded, their amplitude was also found to be contingent on alpha activity as well as on the semantic significance of the stimuli (Bohdanecký *et al.* 1984a,b, Radil *et al.* 1985, Maras *et al.* 1991).

Different experimental results show that some perceptual and cognitive processes are already dependent on the instantaneous state of the brain, although this does not always apply (Bohdanecký *et al.* 1987b, 1989a, Radil *et al.* 1985, 1990, Radilová 1990b).

Sensorimotor coordination and the control of motor processes

In research on the peripheral and central manifestations of visual-oculomotor integration, it was found that limitation in the involvement of oculomotor mechanisms in the processing of information depended both on the angular velocity of the relevant eye movement and on saccadic movement when optokinetic nystagmus failed. An analysis of brain potentials bound to saccadic eye movement ("lambda" waves) showed that, in right-handers, the duration of premotor positivity was shorter, and its amplitude was lower, in saccadic movements to the left, while the P3 wave had a shorter latent period and a lower amplitude. Conversely, in saccades to the right, the P1-N1 waves were higher. It was further found that saccade-bound potentials in upward eye movements were similar to those in horizontal movements, whereas downward movements were characterized mainly by marked initial negativity. Typical changes in the reactivity of the visual-oculomotor system were observed under the influence of alcohol and caffeine and in patients with pathic central fatigue. These findings have contributed to deeper knowledge of the system in question and to clinical utilization of some of the results (Zikmund and Jagla 1979, Zikmund 1986, 1987, Jagla and Zikmund 1989a,b).

Visual motor coordination was studied by one- and two-dimensional tracking methods. It was found that the incidence of errors rose during positive or negative acceleration and that in reverse tracking it was higher than in normal one; it likewise depended on the rate of movement of the stimulus (target). Two-dimensional tracking is more difficult than one-dimensional tracking. A correlation between the success of tracking and the instantaneous heart rate were found. The incidence of errors also depended on the instantaneous phase of the cardiac cycle, but only in simple, one-dimensional tracking; in more complex one-dimensional tracking this correlation disappeared (here the velocity of the target or its size changes in correlation to the incidence of errors) and the same applies to a two-dimensional tracking. An EEG analysis in relation to the instant of the error and its correction demonstrated DC shifts and changes in EEG spectra (Bohdanecký *et al.* 1987 c, Indra *et al.* 1987a,b, 1989a,b, 1990, Mates *et al.* 1988, 1989, Radil *et al.*. 1987a, 1988b).

Studies on following rhythmic tonal sequences by simple motor reactions were performed (partly in collaboration with the Institute of Medical Psychology, the Ludwig-Maxmillian University in Munich). It was confirmed that the response usually preceded the stimulus, by several hundredths of a second. It was found that this anticipation was correlated to the number of tones in the stimulation pattern. In more difficult stimulation sequences (owing to experimental manipulation with

feedback information on the performed movement, or if individual stimuli in the stimulation pattern were omitted), this anticipation increased, whereas a rapid sequence of stimuli, or if the stimuli were prolonged (in this case before the next tone), anticipation was shortened. It was found that regular rhythmic sequences could be followed very exactly, even if a large number of stimuli were omitted during stimulation (in that case the subjective rhythm was only slightly accelerated compared with the objective rhythm). Sequences composed of stimulation patterns with irregular intertonal intervals were difficult to follow, but gradual lengthening or shortening of the intertonal intervals in the pattern was distinguished relatively easily. An analysis of motor responses (to tapping) showed that changes of these in the course of a tone sequence were only exceptional (e.g. they lengthened if one of the stimuli in the stimulation pattern was prolonged, or if the stimulus preceded a long intertonal interval). This indicator was influenced by the general situation (the duration of movement was short in rapid stimulation sequences) and probably also by experience (the movements of subjects who played a musical instrument were faster than those of non-musicians). The timing of motor reactions was likewise influenced by the way in which the acoustic patterns of which the stimulation sequences were composed were accentuated. These tests brought results significant from the aspect of identification of the timing of cerebral processes (Franěk *et al.* 1987, 1988, 1989a,b, Radil *et al.* 1987a, 1990, Mates *et al.* 1990, Müller *et al.* 1990, Ilmberger *et al.* 1990, Kagerer *at al.* 1990).

Disturbances of sensorimotor coordination which did not correlate with intelligence were found in children with minimal brain dysfunction. In the investigation of visual-motor reactions induced by meaningless, numerical or alphabetical visual stimuli, it was found that the reaction times of afflicted children were always longer. A detailed study showed that, with the contemporary method by which children with minimal brain dysfunction are taught in schools, no further improvement of the sensorimotor parameters studied was achieved after the age of 10 years. On the other hand, in a transcultural comparison of similarly afflicted children in Prague and in Skopje (Yugoslavia), it transpired that an environment richer from the informative aspect had a more positive effect on the mental development of these children. These findings, as well as being a source of fresh knowledge, can contribute to the rationalization of diagnostic and rehabilitation techniques (Cakirpaloglu and Radil 1990a,b, 1991).

In other experiments, eye movements were studied during the examination of polygonal geometric shapes whose semantic meaning changed in correlation to their spatial orientation. It was found that semantic interpretation influenced oculomotor parameters. In a differently organized experiment, eye movements were analyzed during a cognitive test in which the subjects were given the task of determining the sequence of relevant nonsense words according to their alphabetical characteristics, paying no attention to "noise" words. A correct solution was generally associated with progressive fixation of the relevant words (Radil *et al.* 1986, 1989a, Bohdanecký *et al.* 1987a).

In the analysis of attentional processes preceding exposure to stimuli requiring a reaction, it was found (as part of a joint programme with the Institute of Psychology of Vienna University) that the amplitude of DC electronegative deflections of the brain potential before a pre-signalized and expected stimulus was higher if a non-stereotype reaction was required (Bauer *et al.* 1989a,b).

One particular case of experimentally impaired sensorimotor coordinating speech is "Lee's effect" – a type of stammer induced by a delayed auditory feedback during speech. It was found that the method is of diagnostic significance in neurotics and schizophrenics, in whom, in addition, changes in the perception of artificial words were also observed (Baštecký *et al.* 1980, 1982, 1986).

Detectable speech changes likewise occurred in association with emotional stress (Šulc 1986, Šulc and Remek 1988).

Learning and plastic brain processes

Research on conditioned reflex learning is a traditional theme in our psychophysiology. During the past few years it was found that the urinary secretion of adrenaline and noradrenaline increased during the first, nonspecific phase of elaboration of the nociceptive conditioned reflex (changes in the skin electric potential after electrical stimulation as the unconditioned, and sound as the conditioned, stimulus). The correlation between the palpebral conditioned reflex and certain personality factors showed that if the conditioned stimulus (a tone) preceded the unconditioned stimulus (a flash of light), personality factors did not influence the result of conditioning, whereas if the two stimuli were applied strictly simultaneously, extroverts learned better. With the first type of learning, conditioned palpebral reflexes were elaborated better if the stimuli were applied during inspiration (as against expiration). Mathematical analysis of the learning curve for this type of conditioning helped to understand its nature. The EEG recordings during palpebral learning were also described mathematically. A systematic comparison of palpebral learning parameters when the conditioned stimulus precedes (or is followed by) the unconditioned stimulus and when both stimuli were applied strictly synchronously showed that, in the first case, learning was more rapid than in the second one. If conditioning was repeated in ten sittings, learning was more effective when the unconditioned stimulus came first than when both stimuli were applied simultaneously. It was demonstrated that the classic palpebral conditioned reflex elaborated at a single sitting with one-second intervals is a genuine conditioned reflex. The distribution of spontaneous palpebral movements – blinking – in relation to time was also analyzed and was found to be influenced by instantaneous mental activity. In other experiments, vasomotor conditioned reflexes were induced, using air blown into the nose as the unconditioned stimulus and a sound as the conditioned stimulus. The actual timing of the two types of stimuli was also analysed in this case and vegetative and EEG indicators were recorded at the same time. Surprisingly, when the unconditioned stimulus preceded the conditioned stimulus. Conditioning was more effective, evidently owing to interference with the conceptualization of the experimental situation. The above experiments facilitated deeper comprehension of the mechanisms of human learning (Dostálek *et al.* 1978a,b, Dostálek and Kufudaki 1981, Hyšková *et al.* 1982, Hrudová *et al.* 1983, 1985, 1987, Wackermann *et al.* 1986, Stančák *et al.* 1988, Málková *et al.* 1989, Kubešová and Dostálek 1990).

Specific states of the brain influencing neuronal processes

Considerable attention has been paid to research on the mechanisms of the effect of hatha-yoga exercises on central nervous processes and on physiological regulations. Different specific EEG patterns in particular hatha-yoga exercises have been described. In the exercise "Agnisara", an increase in the amplitude of alpha activity and its spread to rostral parts of the brain were followed by the appearance of EEG spindles with a frequency of about 13 Hz ("chí rhythm"). In addition to this "chí" rhythm, detailed EEG analyses during the exercises "Nauli", ""Bhastrika" and "Suryabhedana" showed sinusoidal activity with a frequency of 26-33 Hz in the parieto-occipital and midsagittal region and bilateral paroxysmal activity (despite the fact that the subjects were healthy) in the parieto-temporo-occipital region. In other experiments, the electroencephalogram was studied during the exercises "Suryabhedana", "Nauli", "Kapalabhati", "Kumbhaka" and "Uddiyana" and at rest. The most pronounced finding was an increase in the inter-hemispheric coherence function of the EEG. In "Nauli", power increased in the delta range and in "Kapalabhati" in the theta and beta range, mainly in the precentral region. In "Kumbhaka", EEG activity underwent little change and in "Suryabheda" power in the beta range fell. In the exercise "Madhy-Nauli", a significant change occurred in the auditory evoked potential, with disappearance of the Ni-Pi component and the appearance of a positive wave with a latency of about 280 ms and the maximum in the occipital region. These EEG findings testify to the existence of specific localized processes in the brain in various hatha-yoga exercises (Dostálek *et al.* 1984, Roldán and Dostálek 1985, Roldán *et al.* 1987, Novák and Dostálek 1990). Further experiments demonstrated that all hatha-yoga exercises with a marked respiratory component had a pronounced effect on the cardiovascular system. This applied to the exercise "Zelandra Bandha", during which changes correlated to the style of breathing occurred in the heart rate, and to the exercise "Nauli", in which the heart rate lowered down, the blood pressure altered and changes occurred in the ECG (Lepičovská *et al.* 1988b, Lepičovská and Dostálek 1988). In experiments carried out likewise under normal conditions, an increase in the length of periodic components of the cardiac cycle was observed during respiratory arrest (Stančák *et al.* 1987).

The beneficial effect of hatha-yoga exercises on health is both a theoretically and practically important question, which was studied from the above findings and others (Dostálek and Lepičovská 1982, Dostálek 1985).

Hypnosis, another specific state of the brain, is also being studied. The state of patients with functional disturbances of the oesophagus improved if, while they were under hypnosis, they were given instructions on how to relieve their symptoms by a given motor manoeuvre under normal conditions (Černý *et al.* 1988). It was also found that repeated specific hypnotic suggestion led in both healthy individuals and in patients with atopic eczema to pronounced elevation of their cutaneous threshold for pain: the clinical state of patients with atopic eczema improved markedly at the same time (Hájek *et al.* 1989, 1990). Pain associated with an increase in alpha activity in the EEG was also suppressed during the special Indian concentration "Kaavadi" (Lepičovská *et al.* 1988a).

In other experiments, the extent of the mobility of hemiparetic patients improved progressively during exercises carried out under hypnosis, when inhibited

spontaneous motility was gradually facilitated (Šnýdrová *et al.* 1985, Radil *et al.* 1988e).

This chapter should also include experiments in which a given – desirable – state of the brain was induced by means of a biological feedback. Experiments with feedback signalization of the heart rate were carried out, the primary aim being to improve regulation in patients who had otherwise proved to be untreatable. In about one third of the cases (mostly functional tachycardia) the heart rate fell and the symptoms improved at the same time (Šimek *et al.* 1987, Hrachovinová *et al.* 1989).

The actual (particularly the emotional) state of the examined subjects was naturally likewise influenced by psychotherapeutic treatment, thereby altering their reactivity in the desired direction (Bouchal and Kukleta 1987, Kukleta 1989).

The effect of neurosurgery and of electrical stimulation during stereotaxic operations forms a separate category. The duration of the effect of electrical stimulation was an interesting phenomenon. If the electrodes were localized in the spinal cord, the effect of antinociceptive stimulation lasted only a few hours, whereas at the cerebellar level it lasted up to several weeks and in the thalamus up to several years. Stimulation of the posterior parts of the hypothalamus induced a somatovegetative anger and anxiety reaction, whereas stimulation of the anterior parts evoked parasympathetic signs accompanied by corresponding subjective feelings. Auditory or visual hallucinations leading to impulsive behaviour could be mitigated by an operation on the posterior hypothalamus, although afterwards the hallucinations still persisted. In its preliminary stage were performed with the neurotransplantations aim of improving the state of schizophrenic patients (Nádvorník 1990, Kolařík *et al.* 1988).

The effect of drugs with an affinity for the nervous system on lateralized brain functions presents new experimental possibilities. For instance, it was found that diazepam, as an anxiolytic, inhibited the right hemisphere more than the left one (Černý *et al.* 1990).

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