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Nervous Reactivity Changes in Patients with Late Post-Traumatic Mental Disturbances

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Summary. A polygraphic study of 105 patients with late-post-traumatic psychiatric disturbances and 158 matched subjects in two control groups has shown marked differences in nervous reactivity. The differences, estimated by testing the electrographic components of the orienting reaction elicited by a repetitive auditory stimulus and its habituation were expressed by changes in the intensity, resistance to habituation, and sequence of habituation of the somatic, autonomic, and EEG components. The character and severity of alterations depended on the site of the traumatic impact, lesional aspect of the craniocerebral trauma, clinical picture of mental disturbances, and features of the EEG tracings.

Key words: Post-traumatic mental disturbances – Orienting reaction – Polygraphy – Nervous reactivity.

Zusammenfassung. Eine polygraphische Untersuchung an 105 Patienten mit später post-traumatischer psychischer Symptomatik zeigte bedeutende Unterschiede der Reaktivität des Nervensystems, verglichen mit 158 Subjekten, eingeteilt in zwei Kontrollgruppen.

Die Reaktivität wurde gemessen mit Hilfe der elektrographischen Elemente der Orientierungsreaktion durch wiederholte Application eines akustischen Reizes und seiner Habituierung. Diese Störungen bestanden aus Veränderungen der Amplitude der Hautwiderstandsreaktion und der Habituierung der somatischen, vegetativen und EEG-Komponenten.

Charakter und Stärke dieser Veränderungen hingen von Lokalisierung und Ausprägung der traumatischen cranio-cerebralen Verletzung, der Psychopathologie und der EEG-Veränderungen ab.

Schlüsselwörter: Psychische post-traumatische Störungen – Orientierungsreaktion – Polygraphie – Reaktivität des Nervensystems.

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Introduction

The orienting reaction in man, an innate adaptive response to any change in the environment, is a complex reaction consisting of somatic, autonomic, EEG, emotional and verbal components (Gastaut et al. 1957; Magoun 1958; Sokolov 1958).

Since the cerebral reactivity disturbances occurring in some diseases of the nervous system can be detected by testing the electrographic components of the orienting reaction and its habituation (Venables 1960; Lader and Wing 1966; Rogozea and Florea-Ciocoiu 1973; Siddle et al. 1973; Gruzelier and Venables 1974) and that the incidence of chronic diseases of the nervous system has increased with the increasing frequency of craniocerebral trauma (CCT), we set ourselves the task to of studying the nervous reactivity in patients with late post-traumatic mental disturbances (LPTMD) and comparing it with the nervous reactivity of the control groups by the same electrophysiologic method.

Material and Methods

Subjects

The study was performed on 263 subjects, 105 patients with LPTMD, 76 normal subjects (control group I), and 82 subjects with a history of CCT but without clinically manifest LPTMD (control group II).

The LPTMD patients were selected among former inpatients with diagnosis confirmed by clinical and laboratory examinations who were now coming to hospital periodically for ambulatory treatment and possible rehospitalization. We included in this group only patients with clinically manifest LPTMD in whom the time elapsed since the CCT which induced the post-traumatic mental disorders varied from 3 months (the minimum time at which the post-traumatic encephalic syndrome may be considered as late) to 19 years. As the patient's psychopathologic picture and evolution is likely to depend also on the age of the post-traumatic process, the above range of time elapsed since trauma up to the moment of investigation was designed to permit the exploration of cerebral reactivity in patients with different types of post-traumatic psychiatric disturbances.

The patients with LPTMD consequent to closed or open CCT[1] were distributed according to their psychopathic disturbances as follows: 23 with personality disorders (instability, low frustration threshold, querulousness, dysphoria, dyssocial, or antisocial behavior), 7 with dementia (various degrees of intellectual impairment associated with a regressive pattern of personality and behavior), 10 with psychotic disturbances (paranoid, affective, mixed) with chronic organic traits, and 65 with neuroticlike states (anxiety, dysphoria, or frank depression, obsessive, phobic, or phobic-obsessive phenomena).

Patients' ages ranged from 10 to 60 years. This range was chosen to permit evidence of possible age-related reactivity differences in LPTMD patients. Sex distribution was 87 (82.9%) males and 18 (17.1%) females.

Control group II included subjects with closed or open CCT in their history but without subsequent clinical manifestation of LPTMD, in whom the severity of the CCT (estimated by the duration of alteration in consciousness and of post-traumatic amnesia), the time elapsed since its occurrence, the age range, and sex distribution were similar to those in LPTMD patients.

Control group I comprised normal subjects whose age range and sex distribution were similar to those in the previous groups.

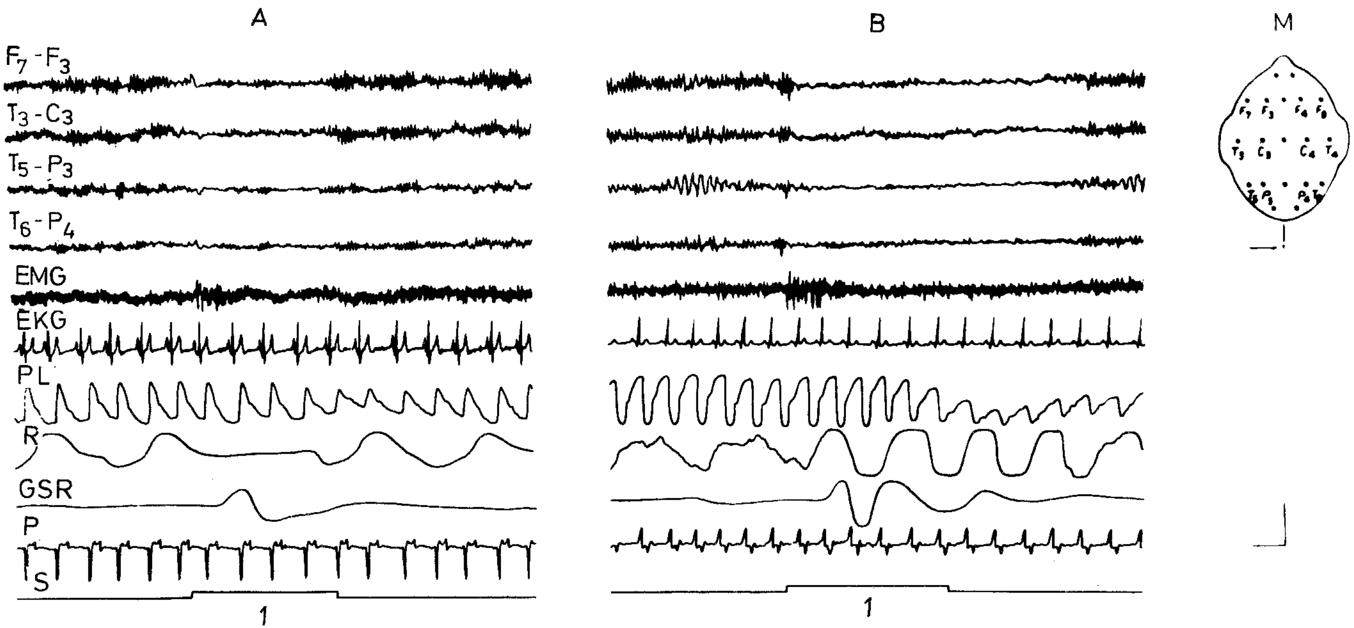

Fig. 1. Electrographic aspect of the orienting reaction elicited by an auditory stimulus. **A** = control subject A.I., aged 31, with CCT in the antecedents but without clinically manifest LPTMD; **B** = patient S.V., aged 34, with LPTMD (post-traumatic personality disorders: dysphoria). *EMG* = electromyogram; *EKG* = electrocardiogram; *PL* = plethysmogram; *R* = respiration; *GSR* = galvanic skin reaction; *P* = pulse; *S* = stimulus; the figure below the stimulus indicates the number of its repetitive applications; *M* = diagram of recording electrode mounting. Bipolar recordings. Calibration: EEG = 50 μV, 1 s; other recordings = 1 mV, 1 s

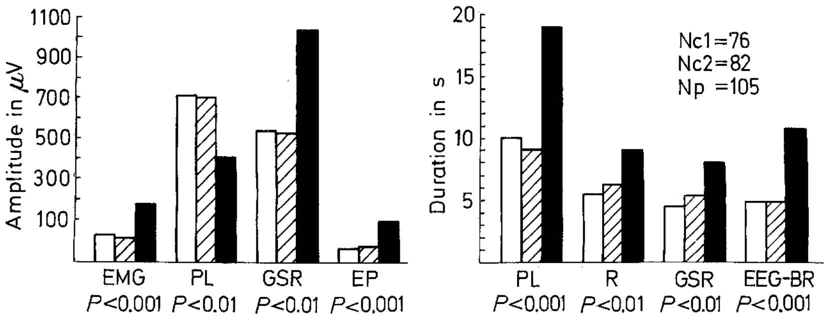

Fig. 2. Changes in amplitude and duration of the components of the orienting reaction elicited by a repetitive auditory stimulus in LPTMD patients taken as a group (mean values calculated on the first application of the stimulus). ▨ control group I (normal subjects); □ control group II (subjects with CCT in their history but without clinically manifest LPTMD); ■ group of LPTMD patients; *EP* = evoked potential; *EEG-BR* = EEG-blocking reaction; Nc1, Nc2 and Np = number of subjects in control groups I and II and of LPTMD patients in whom the mean values were calculated. *EMG, PL, GSR, R* as in Fig. 1. The *PL* amplitude decrease in LPTMD patients expresses clearer peripheral vasomotor reactions than in control subjects

Electrographic Study

After routine EEG recordings to evidence the spontaneous bioelectrical activity and the possible pathologic graphoelements, all the subjects were submitted to an electrographic investigation of the orienting reaction elicited by a repetitive auditory stimulus. The study consisted in polygraphic recordings of the somatic, autonomic, and EEG components of the orienting reaction (Fig. 1).

During these investigations the following parameters were studied: (i) for the somatic component, the amplitude and duration of the somatomotor (EMG) response to repetitive auditory stimulations; (ii) for the autonomic component, the amplitude and duration of the peripheral vasomotor (finger plethysmogram, pulse), electrodermal (galvanic skin), and respiratory responses[2]; (iii) for the EEG component, the amplitude of the acoustic-evoked potentials and the duration of the EEG-blocking reactions elicited by repetitive auditory stimulations (Fig. 2).

The orienting reaction was elicited under standard conditions by a repetitive tone whose parameters (3000 Hz, 90 dB, 5-s duration per application and 30-s interstimulatory intervals) were kept constant throughout the recording. Up to 50 stimuli were used during a recording session. The orienting reaction components were considered habituated if absent during three successive applications of the stimulus. As the autonomic component of the orienting reaction was comprised of several responsive elements (peripheral vasomotor, galvanic skin, and respiratory responses), this component was considered habituated when none of the above mentioned elements was present during three successive applications of the stimulus (Fig. 3). The

1 Open CCT has here the same meaning as that admitted by Cushing (1918), Cairns (1941), Meirowsky (1954), Arseni and Oprescu (1972), etc., i.e., an injury in which a direct or indirect communication exists between the exterior and the intracranial cavity

2 In the autonomic component of the orienting reaction we included, as shown by Gastaut et al. (1957) and Dongier et al. (1957), all the responsive phenomena that are elicited by the repetitive sensory stimulus as a consequence of the activation produced by it at the level of the mesencephalic reticular formation and from that level, through the reticulo-bulbo-spinal pathways, at the level of the preganglionic autonomic centers. This activation is expressed by peripheral vasomotor (finger plethysmogram, pulse), electrodermal (galvanic skin), and respiratory alterations

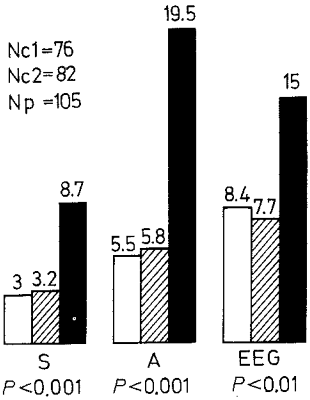

Fig. 3. Resistance to habituation of the three components of the orienting reaction elicited by a repetitive auditory stimulus in LPTMD patients taken as a group (mean number of auditory stimulations required for habituation). *S* = somatic, *A* = autonomic and *EEG* = electroencephalographic components. In this figure the habituation signifies: for the somatic component, disappearance of somatomotor *(EMG)* responses to repetitive auditory stimulation; for the autonomic component, the moment when all the responsive elements (*PL, P, GSR, R, EKG)* constituting this component disappear on application of repetitive sensory stimulation; for the EEG component, disappearance of the acoustic evoked potentials and of the EEG-blocking reactions consecutive to repetitive auditory stimulation. □, ▨, ■ and Ncl, Nc2, Np as in Fig. 2

number of tones required for habituation of the orienting reaction was taken as quantitative index of the resistance to habituation.

Apparatus

A 20-channel ALVAR electroencephalograph was used for polygraphic registrations and for routine EEG recordings. For EEG recordings the 10–20 International System of Electrode Placement was applied. The EMG was bipolarly recorded by surface electrodes from the nape muscles. For registration of finger plethysmogram, galvanic skin reaction, and temporal pulse, appropriate ALVAR transducers were used, while respiration was registered by means of parabuccal thermocouple. The EKG was recorded in standard DI lead.

The auditory stimulus eliciting the orienting reaction was obtained from a SONECLAT-ALVAR phonophotostimulator. The tone was applied to the subjects through two loudspeakers 40 cm from their ears.

The above polygraphic recording were performed in a soundproof room. Throughout the recording session the subjects were lying with their eyes closed.

Measurement of Responses

The acoustic-evoked potentials were measured in μV (10 mm = 50 μV.) The reduction by at least 50% occurring in the amplitude of bioelectrical waves following stimulus application was taken as EEG-blocking reaction. The duration of these responses was measured in seconds (1 s = 1.5 cm). The amplitude of EMG, EKG, finger plethysmogram, respiration, galvanic skin reaction and temporal pulse was measured in μV (1 cm = 500 μV) and their duration in seconds (1 s = 1.5 cm).

The data obtained were processed by the Student's *t*-test.

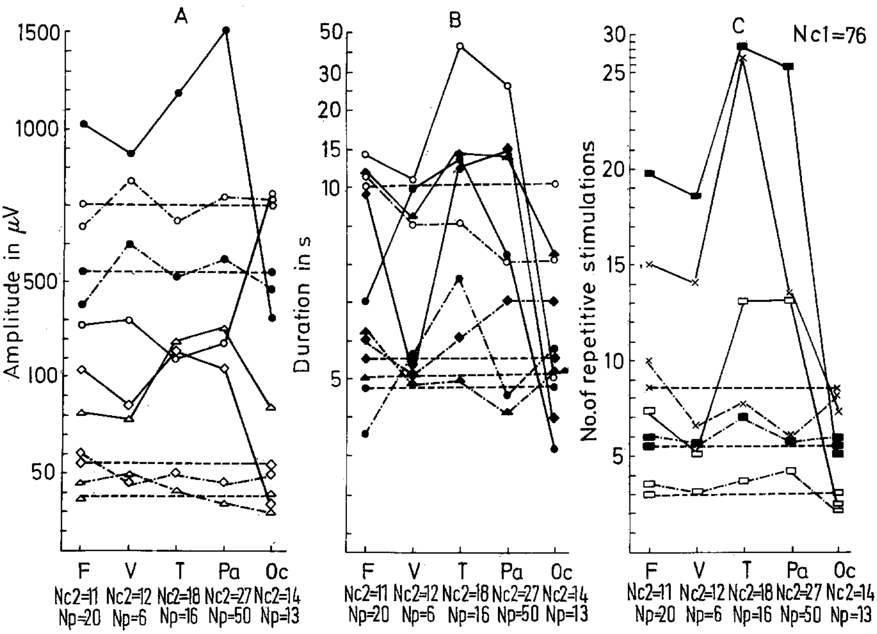

Fig. 4. Relation between the site of impact and the alterations in amplitude (**A**), duration (**B**), and resistance to habituation (**C**) of the orienting-reaction components in LPTMD patients (mean values). Abscissa = CCT with frontal (*F*), vertical (*V*), temporal (*T*), parietal (*Pa*) or occipital (*Oc*) impact. ---- = control group I; -·-·-·- = control group II; ——— = LPTMD patients; ◇ = *EMG;* ○ = *PL;* ● = *GSR;* △ = *EP;* ◆ = *R;* ▲ = *EEG-BR;* □, ■ and × = habituation of the somatic, autonomic, and EEG components

Results

No significant difference concerning the intensity and the resistance to habituation of the orienting reaction were found between the normal subjects (control group I) and the subjects with CCT in their history but without clinically manifest LPTMD (control group II) (Figs. 2 and 3).

The orienting reaction in LPTMD patients was, as a rule, more intense than in control subjects (Figs. 1 and 2). The intensification of the reaction was expressed by a significant increase in the amplitude and duration of its components, as shown by the increased amplitude and duration of EMG discharges (somatic component), more conspicuous and persistent galvanic skin reactions, peripheral vasomotor reactions and respiratory alteations (autonomic component), increased amplitude of tone-evoked potentials and increased duration of EEG-blocking reactions which assumed the appearance of intense, generalized tonic reactions (EEG component) (Figs. 1 and 2). It is noteworthy that intensification of peripheral vasomotor reactions (i.e., of vasoconstrictive reactions elicited by the repetitive sensory stimulus) was expressed by the decrease in the amplitude of plethysmographic reactions, which made this amplitude by in reverse relation (in the

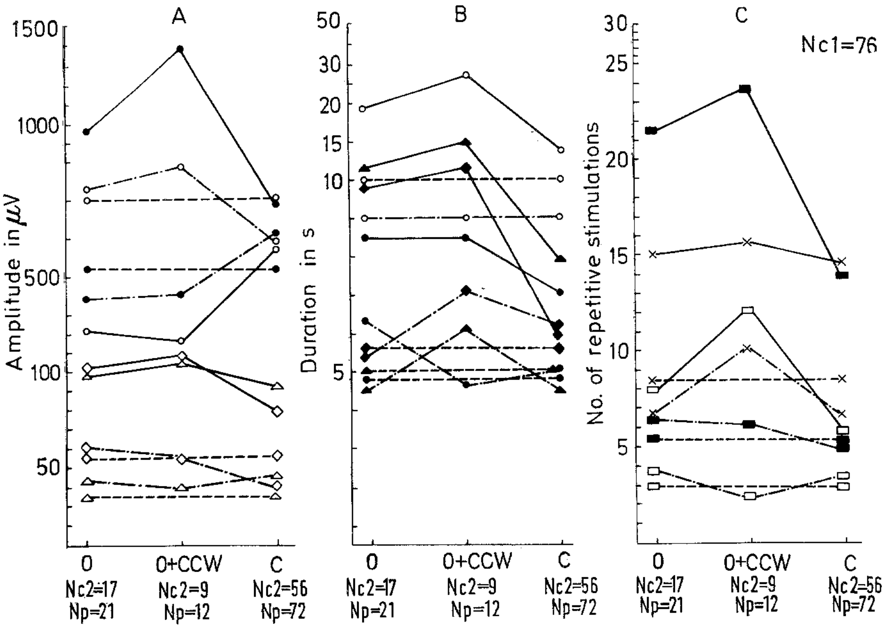

Fig. 5. Relation between the lesional aspect of CCT and the changes in amplitude (A), duration (B), and resistance to habituation (C) of the orienting reaction components in LPTMD patients (mean values). Abscissa: *O* = open CCT accompanied either by scalp wound or by cerebro-spinal fluid fistula, or by a hemorrhagic lesion, but without craniocerebral injury; *O* + *CCW* = open CCT associated with craniocerebral wound; *C* = closed CCT. Legend as in Fig. 4

mirror) to the amplitude of the other components of the orienting reaction (Figs. 2, 4A, 5A, 6A, and 7A).

Habituation of the orienting reaction in LPTMD patients also underwent significant changes: increase in the resistance to habituation of the three components and alterations in the sequence of their habituation as a consequence of the more marked increase in the resistance to habituation of the autonomic component (Fig. 3).

While no statistically significant electrographic changes in the orienting reaction were found in relation to the patients' age, sex or profession, hemisphere involved or etiology of CCT, significant changes were recorded in relation to the site of traumatic impact, lesional aspect of CCT (i.e., to the severity of the trauma), clinical picture of mental disturbances and features of EEG tracings.

1. Peculiarities Related to the Site of Impact (Fig. 4A–C)

The most marked increased in the intensity of the orienting reaction and in its resistance to habituation were found in patients with LPTMD consequent to traumata with temporoparietal or predominantly temporoparietal impact ($P < 0.05$) followed in order of severity, by those with impact in frontal or predominantly in frontal area and in vertex. In cases with occipital impact the values were, as a rule, decreased below those of the control values.

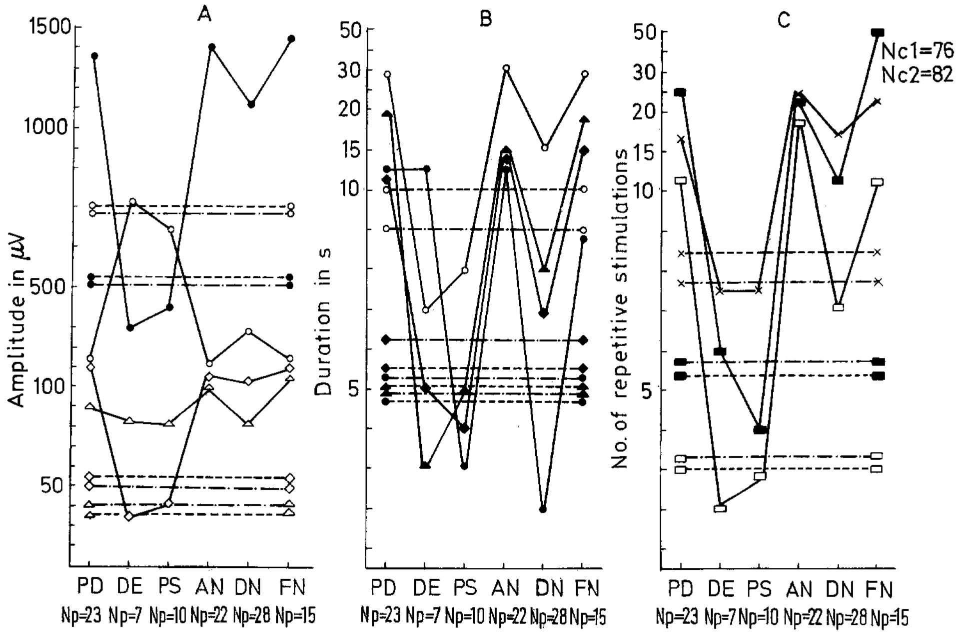

Fig. 6. Relation between the clinical picture and the changes in amplitude (**A**), duration (**B**), and resistance to habituation (**C**) of the orienting reaction components in LPTMD patients (mean values). Abscissa = post-traumatic personality disorders (*PD*), dementia (*DE*), psychotic disturbances (*PS*); post-traumatic anxiety (*AN*), depressive (*DN*), obsessive (*ON*) neuroticlike states. Legend as in Fig. 4

2. *Peculiarities Related to the Lesional Aspect of CCT (Fig. 5A–C)*

The increase in the intensity of the orienting reaction and in its resistance to habituation was more marked in cases of LPTMD secondary to open than in those secondary to closed CCT ($P < 0.05$). Among the cases with open CCT the values were higher in those with post-traumatic craniocerebral wounds than in those displaying simple wounds of the scalp or in those without wound but with a cerebrospinal fluid fistula (otoliquorrhea, rhinoloquorrhea) or a hemorrhagic lesion (otorrhagia, rhinorrhagia).

3. *Peculiarities Related to the Clinical Picture of LPTMD (Fig. 6A–C)*

The intensity of the orienting reaction and its resistance to habituation were significantly increased in patients with post-traumatic personality disorders (instability, dysphoria, dyssocial behavior) ($P < 0.02$), while decreased, as a rule below the control values, in those with post-traumatic dementia or psychotic disturbances (paranoid, affective, mixed), the lowest values being noted in post-traumatic dementia.

Significant increases were also noted in patients with post-traumatic neuroticlike states, particularly in those with anxiety or phobic elements, while in patients with depressive phenomena the intensity of the orienting reaction and its resistance to habituation were less marked, though higher than in control subjects.

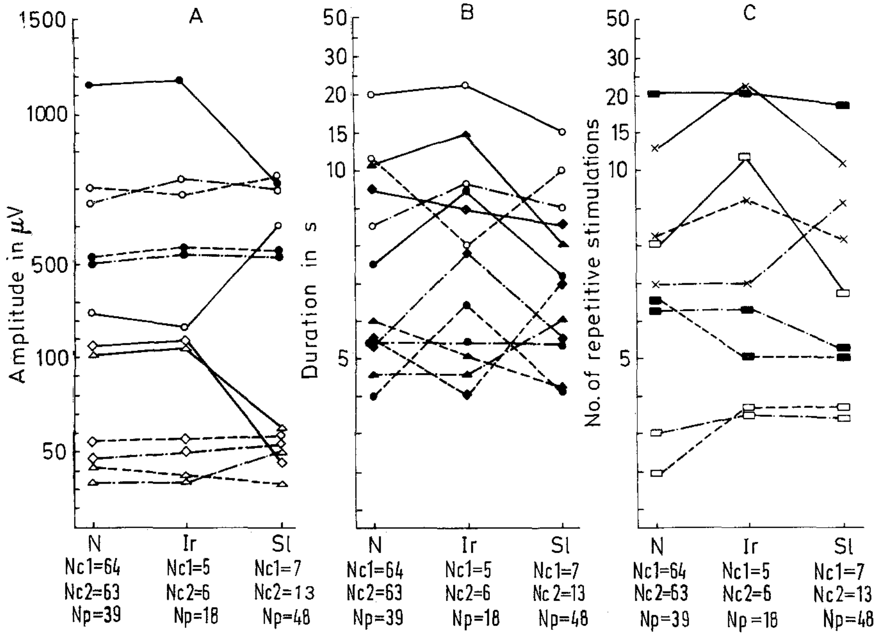

Fig. 7. Relation between the character of EEG tracings and the changes in amplitude (A), duration (B), and resistance to habituation (C) of the orienting reaction components in LPTMD patients (mean values). Abscissa: N = subjects with normal EEG tracings; Ir = subjects with fast EEG rhythms or irritative type electrographic abnormalities; Sl = subjects with slow EEG tracings or focal electrographic abnormalities of the deficit type. Legend as in Fig. 4

4. Peculiarities Related to the Features of EEG Tracings (Fig. 7A–C)

The increase in the intensity of the orienting reaction and in its resistance to habituation was more marked in cases with normal EEG tracings and especially in those with fast EEG rhythms or diffuse or focal irritative type EEG abnormalities ($P < 0.05$), while less marked in cases with predominance of slow rhythms or presence of some focal electrographic abnormalities of the deficit type when the amplitude of the somatomotor component (EMG) of the orienting reaction was situated even below the control values.

Discussion

The alterations in the orienting reaction and in its habituation, found in LPTMD patients, point to the existence of nervous reactivity disorders in these patients[3]. The disorders may be ascribed to the effects induced by the post-traumatic residual lesions in the central nervous system (CNS) on the structures and pathways involved in control of arousal and implicitly on the background level of arousal[4].

3 By nervous reactivity disorder we understand a modification in the superior integration of sensory messages and implicitly in the control of adaptive reactions to environmental factors. When such a modified integration results in an inappropriate exaggeration or on the contrary, depression of the adaptive reactions, a hyperreactivity or a hyporeactivity sets in, respectively

4 The term arousal is used here as a synonym of "activation" (Hebb 1955; Malmo 1959; Hare 1970; Mawson and Mawson 1976)

The existence, in patients with mental disorders, of a relation between background arousal and reactivity is supported by the literature showing that the increase in the background arousal determines a hyper-reactivity (Duffy 1962; Lader and Wing 1966; Allen 1969; Lindner et al. 1970; Goldman et al. 1971; Blackburn 1975), and its decrease, hyporeactivity (Lindner 1942; Hare 1965; Schmauk 1970). It emerges, therefore, that the intensification of the orienting-reaction components noted, as a rule, in our LPTMD patients and the delay in their habituation should be attributed to the increase in the somatomotor, autonomic, and cortical arousal. Our data agree in this respect, with those of Schacter and Latané (1964) and Valins (1967) showing intensification of some of the orienting-reaction components in patients with mental disorders in whom the background arousal is increased, and with the data of Lader and Wing (1969) who noted a disturbance in the habituation of these components. The delay in the process of habituation of the orienting-reaction components in psychiatric patients has also been reported by other authors (Cohen and Patterson 1937; Shakow 1963; Callaway et al. 1965; Milstein et al. 1969).

Among the components of the orienting reaction the autonomic one was the most resistant to habituation in our LPTMD patients. This might be attributed either to the different degree of activation of the cerebral structures, namely to a more persistent activation of the hypothalamic autonomic centers, or to a deficit in the nervous mechanisms controlling the autonomic activation, the result being in either case a dissociation in the habituation of the orienting-reaction components. In this connection, disturbances in the autonomic activity in psychiatric patients have been reported by many authors (Schacter and Latené 1964; Goldstein 1965; Hare 1968; Blankstein 1969).

The dependence of reactivity disturbances upon the background level of arousal is also illustrated in our study by the relationship found between the severity of the orienting-reaction alterations and the character of EEG tracings, the most marked hyper-reactivity being noted in LPTMD patients in whom the EEG activity displayed signs of increased cortical arousal (fast rhythms or abnormalities of the irritative type). These results are in agreement with the observations of Blackburn (1975) on aggressive psychopaths.

From our data, the severity of reactivity alterations and implicitly of background arousal modifications in patients with LPTMD may be related to the extent of post-traumatic lesions, for the most marked hyper-reactivity was noted in LPTMD secondary to open CCT, especially when these were accompanied by craniocerebral wounds, in which case the residual lesions are particularly extensive and may determine marked functional disturbances accompanied by marked increase in the level of the arousal.

The differences found in reactivity alterations as a function of the site of traumatic impact demonstrate that the reactivity disturbances in LPTMD are influenced also by the morpho-functional peculiarities of the structures involved in the post-traumatic lesions. Thus, the fact that the most marked hyper-reactivity was noted in patients with impact in or predominantly in the temporoparietal region may be explained by the functional importance of this area and the richness of its connections with the structures involved in the control of arousal (Ramon y

Cajal 1911; Lorente de Nó 1933; Papez 1937; Klüver and Bucy 1939; Gerebtzov 1941; MacLean 1952; Adey et al. 1956; Nauta 1958).

The data obtained in our LPTMD patients also show the existence of some reactivity differences as a function of their psychopathologic picture. Thus, in patients with post-traumatic personality disturbances and neuroticlike states, a more marked hyper-reactivity was noted. From this point of view, our observations confirm on the one hand: the assumption of McCord and McCord (1964) that the patients with personality disorders are more responsive to environmental modifications than normal subjects; the observations of Quay (1965) concerning the diminution in these patients, of the capacity to adapt to the sensory input, and on the other hand: the data of Briullova (1958) who found a hyper-reactivity in patients with post-traumatic neuroticlike states.

Other authors found a hyporeactivity in patients with personality disorders which they ascribed to a reduced level of arousal (Hare 1968; Borkovec 1970), but which may be attributed also to the experimental conditions which, in our study, might have been relatively stressful.

In the patients with post-traumatic psychotic disturbances and dementia, the hyper-reactivity was less marked than in patients with personality disorders and neuroticlike states. This finding supports the observations of Lynn (1963) and Saarma (1974) concerning the more moderate hyper-reactivity in patients with psychosis.

We believe that differences in reactivity noted in LPTMD patients and related to their psychopathologic picture which also emerge from the observations of Shagass et al. (1974) and Saarma (1974), arise from differentiated disturbances of the mechanisms modulating the subcortical function, the consequences of which on the reactive plane become interwoven with the respective patient's psychopathologic symptomatology itself.

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