Psychiatric Electroencephalography

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Acknowledgements

The motivation for beginning and completing the monography is the result of a permanently ongoing controversial discussion with exponents of a highly unsatisfactory status quo.

Therefore, since this book would not have materialized without all those numerous persons I cannot name individually, I owe them deeply. If I express my appreciation to them in the first place here, I have by no means any intention of being sarcastic since controversy can often lead to greater gains than the pleasant, but otherwise redundant, confirmation of friends and like- minded persons.

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Preface

There is nothing trendy about this book - on the contrary! For this reason, many will consider it as a provocation, an annoyance, even. However, this is no judgement, since there are fecund annoyances. We agree with PIAGET (1974), who emphasizes in his autobiography that two scientists who start from different premises with regard to a certain problem could only be interested in an obvious non-agreement - provided their personalities allow for it - for only through the articulation of the non-agreement would it be possible to learn something about facts or their interpretation. We have nothing to add to this.

From an historical perspective, psychiatric electroencephalography was introduced with great hopes, but work soon came to a standstill. During the introduction of psychopharmacology in the Sixties to Seventies, the EEG even played a central role as a tool for psychiatric research. The resistance and objections from representatives of a then still humanities-oriented psychiatry are history today. Nevertheless, a steady, and for the past decade almost rapid loss of importance of the EEG in psychiatry cannot be denied. In this situation it seemed highly appropriate to precede the book with an analysis of its causes (chapters 1 and 2). Its purpose is to prove that this loss of importance is not the result of the unproductiveness of the method itself but of an inadequate handling of the method.

Hardly anyone remembers today the promises of so many prominent EEG-experts in the early Seventies that the increased availability of powerful digital computers would result in significant breakthroughs in psychiatric research through quantification. In those days, competition in research turned into competition among researchers to get funding for ever more powerful computers. What was lost in the process was the purpose. The means turned increasingly into an end in themselves, until over the years the question of "what for" made those who asked it look like outdated "armchair philosophers"...

Instead of admitting failure after a decade of searching in vain for the proverbial needle in the haystack, instead of an honest cost-benefit analysis and an analysis of cause and effect with the appropriate conclusions, the indefatigable search continues, at increasingly higher costs. It seems impossible to argue effectively against this hectic method-centered modus operandi since it faithfully follows the trend of "naive adoration of data in modern technocracy" ("naive Datengläubigkeit moderner Technokratie", HEIMANN 1991). Moreover, the prestige of research is measured more than ever by the use of expensive, externally funded equipment. Compared to this, the "primary equipment" of the researcher, such as observation and methodological awareness (in contrast to method-centered research) is not in very high demand.

This present worrisome situation has been summarized recently by the scientific journalist Jörg ALBRECHT (1992): "Today's self-respecting biologist does not concern himself with animals and plants [not to mention human beings, the author] but with membranes, molecules, mutations". This "atomization of biology" is being pushed so far that in the end everything consists of nothing but quarks. It is evident that this type of biology may lose - or has already lost - its topic, the conformity of all living things with natural laws. The same, of course, holds true for the psychiatry that indefatigably and ever more emphatically proclaims itself to be "biological". What and, more importantly, where, is its opposite, i.e. a non-biological psychiatry that needs to be rejected? The farther this brand of psychiatry becomes removed from biology and moved towards chemistry and physics, the more stubbornly it insists on the "biological" attribute.

Biology is, as KRETSCHMER (1919) stated in forever valid terms, the science of life not the science of the body or soul. This semantic reversion of the term "biology" coincides with, among others, a growing disregard for morphology. Just as, according to a university professor in a biological discipline, a student today can graduate in biology without any knowledge of the species, i.e. without being able to recognize wheat from rye (KÜNNEMANN 1992), one can acquire an international reputation as an EEG-researcher without having the least knowledge of the laws of the spontaneous morphodynamics of the resting EEG.

The method-centered actionism which presently dominates the scientific world is counterproductive not only because it ties up, without any prospect of success, personnel and money - it also obstructs and prevents the formulation of theories which requires a modicum of continuous thought, desperately needed in the face of the deluge of data. The continuous construction of new highways that frequently turn out to be nothing but dead-end streets often covers up valuable old roads. This way, important trains of thought, which for a variety of reasons never gained maturity, disappear from view. Generally, the commercially available electronic databases hardly cover the past decade. To limit oneself to their use means not being in tune with the traditional knowledge of our discipline, or even to be cut off from it. This is true for psychiatry in general but certainly for psychiatric electroencephalography. Therefore, we considered it necessary to provide our readers not only with a textbook but also with a bibliography that is integrated in the text and is as complete as possible. Those who want to deal successfully with the present and help create the future need a historical perspective. The contemplation of what was and which past views eventually proved valid sharpens the eye for the rediscovery or new discovery of those paths which will more likely lead to the goal. In accordance with our understanding of electroencephalography as a primarily morphological discipline, we have attempted to provide as many detailed examples of registration as possible.

The author

Contents

1.

The EEG in Psychiatry – Only Screening for Neurological Disorders or More?

Those who today - more than 60 years after the first publication of "Über das Elektrenenkephalogramm des Menschen" by BERGER in 1929 - take their information from articles in manuals and textbooks must come to the conclusion that the contribution of the EEG for psychiatric theory and practice has been very meagre.

If we ask for the reasons, we can choose from two alternatives. The first would be that one cannot, by definition, draw any psychiatrically relevant conclusions from an EEG; the second, that we have not been able, thus far, to extract the information actually contained in the EEG. The prevailing opinion is that the first is true. In German-speaking countries one can still sense the lingering authority of R. JUNG (1950, 1953, 1967).

> "For the present, the psychiatric application of the EEG remains limited to epilepsy and its peripheral area, to the exclusion of basic organic brain disorders and to shock therapy. For psychiatry in the more specific sense the EEG has not yet yielded many positive results. „and further: "Neither for schizophrenia nor for manic-depressive disorders do we know of any changes in the EEG that can be used for diagnostics." (JUNG 1950, pg. 291, translated from German).

On the other hand, we can quote KENNARD (1952), who stated at approximately the same time as JUNG: "The bulk of records seen in psychiatric EEG laboratories are quite different from those of other clinical services. At these meetings it used to be true that those of us who read such records were grouped to discuss in a minority among ourselves. We have been consistently unable to explain ourselves to the other groups." It is not in the least because the differences mentioned by KENNARD were unspecified and not secured biometrically that JUNG'S view eventually gained dominance worldwide.

KÜNKEL (1980) identified methodological imperfections as the reason for the unsuccessful search for „disorder-specific" patterns in EEGs. He complained, among other things, about the insufficient explanation of the terms "normality" and "abnormality."

In the English literature, too, it is generally agreed that the usefulness of the EEG in psychiatry consists in the exclusion of neurological malfunctions ("organic screening", i.e. LOW 1979; HALL et al. 1980; STRUVE 1984; TAYLOR et al. 1985; SMALL 1987; GARBER et al. 1989.

In her manual article, SMALL tried to redefine the value of the EEG for the psychiatry on the basis of DSM III. As quintessential conclusion we read that: "In summary, the importance of the EEG ... is primarily to rule out organic mental disorders" (pg. 533). WARNER et al. (1990) recently opened the discussion on whether empirical proof exists for the usefulness of such neurological screening. They considered an EEG finding as useful if it led to the change of the diagnosis and/or the therapy. A retrospective study including 698 psychiatric in-patients showed that this was true in only two cases.

The authors therefore drew the following conclusion: "... Its clinical use as a screening tool remains questionable." There exists, without any doubt, the need for further empirical clarification, since the rationality of the common practice is questioned.

Those who see opportunities for the psychiatric EEG that compliment or complete neurological screening are in opposition to the general opinion. A questionnaire distributed to the psychiatric departments of German university hospitals in spring 1991 confirmed our suspicion that the EEG is used almost exclusively for neurological screening. We also learned that only in rare cases do the psychiatric departments of university hospitals have their own EEG labs. The EEG examinations usually take place at the EEG lab of a neighbouring neurological hospital or at a central neurophysiologic facility.

At this point it must be mentioned that the way to view and to evaluate a certain item such as an EEG in general is determined by the characteristics of the population under observation. This means that what from a neurological perspective seems irrelevant can be essential from the psychiatric perspective. On the other hand, in neurological populations frequent and important characteristics will not easily be recognized in psychiatric materials or remain without clear pathognostic relevance. As needs to be proved in the following, the popular but erroneous opinion that there exists under the name "clinical neurophysiology" an electroencephalography that is independent from the observed matter and stands on its own has clearly hampered progress.

Whether we will be able to promote the development of a genuine psychiatric EEG depends considerably, under these circumstances, on how convincingly we can present our arguments and on the open-mindedness of our readers.

In the following we first ask the reasons for the prevailing pessimistic opinion. We can distinguish between external reasons that are based on institutional realities and internal, i.e. methodological-scientific ones. By pointing out existing obstacles for the development we, at the same time, state the conditions that are necessary for a future psychiatric EEG. Of central importance in this is a methodological framework that allows the justification of relating the EEG and psychiatry. The ensuing discussion of the conditions for the development will seem, at times, too theoretical. This will be especially true for the reader with previous knowledge of electroencephalography and certification by a professional organization, since he will be expected to question essential areas of supposedly secure knowledge in their entirety. However, the success of our undertaking depends on how far we can initiate a critical discussion of established habits in viewing and thinking. The well-known demand to first present facts before proceeding to theory leads into a vicious cycle. In contrast with prevailing opinion, facts or diagnoses do not necessarily speak for themselves (see also 2.2.6). They must always be interpreted, and that requires a theoretical basis. This holds true whether the researcher is aware of his basic theoretical assumptions or not.

2.

Conditions for the Development of a Psychiatric EEG

2.1. Conditions for the Framework

To avoid any misunderstanding at the outset, we want to stress that it is not our primary intention to question the usefulness of the EEG for neurological screening. Rather, we are of the opinion that, in addition, it is possible to extract information that is relevant to psychiatry from the EEG. The reason for the prevailing pessimistic attitude herein is due, in part, to unfavorable external circumstances that prevent the creation of the necessary base of experience from the beginning. The situation seems hopeless where recording and interpretation occur apart from psychiatry. When a colleague from the neurological department next door is also responsible for the EEG of psychiatric patients, the result, of course, will be a purely neurological screening. A psychiatric department without its own EEG lab gives up, from the beginning, the possibility to use the EEG as a research tool. Since the complete dependence on external diagnosticians prevents gaining and accumulating its own insights, the demand for the development of a genuine psychiatric EEG can only be met with rejection, disbelief or, at best, skepticism. However, even in situations where the psychiatric department has its own EEG lab, an increase in knowledge is not guaranteed. Seemingly without fail, communication barriers arise between clinician on the one hand and EEG interpreter on the other. All too often, both sides want to protect their own territory. Inevitably, such territorial protection results in the limitation of the experience and knowledge horizon. Thus, the misinterpretation by many a clinician of the EEG as an almost objective routine lab test is common, in analogy with the determination of electrolyte or transaminases. Of undiminished value and particularly valid for the electroencephalography in psychiatry remains until today what MATTHEWS (1973) summarized more than 20 years ago as follows:

"The greater part of the work of most EEG departments consists of doing single records in patients referred by physicians almost wholly ignorant of the value and limitations of the technique, or who even openly admit to using EEG as a form of supportive psychotherapy."

Failure to correct the tendencies that turn the EEG interpreters themselves into a tool must have a negative effect on the interaction between colleagues and, consequently, on the willingness to communicate with each other. On the other hand, the autistic drawing up of EEG descriptions and interpretations that all but ignores the interests of the physician is the rule rather than the exception. Although the separation of the written record into description and evaluation is generally accepted, many EEG interpreters do not view that evaluation as being for the physician's benefit, but rather as a summary of the previous long-windedly explained individual facts. This behavior is often fostered by the unfortunate lack of missing clinical experience of the EEG interpreter. Voluminous explanations, irrelevant to the doctor in charge, create legitimate doubts about their usefulness. Thus, the EEG as a whole is discredited.

2.2. About Methodology

Besides the aforementioned reasons, rooted mainly in institutional politics, the development of the psychiatric EEG has been hampered by the absence of a "methodological consciousness." This is characterized by the piling up everywhere of uninterpreted or uninterpretable mountains of data, underneath which the original question has been lost. Considering this state of affairs it is not surprising that there is widespread resignation about the possibility of gaining knowledge. Today, an older generation of high-profile researchers who would be able to direct the work potential of the upcoming younger generation into the right channels based on their own research experience, is desperately missed. Instead, we meet everywhere with an activity that is centered on methods and technology thanks to successfully acquired means financed by grants, foundations, and sponsors. The mountains or landfills of data thus created result from the naïve belief that through primary quantification, i.e., through the mere application of certain signal-analytical procedures that are, for example, also used in seismology, scientifically significant insights can be gained (see also 2.2.2). Hand in hand with the development of electronic data processing the electroencephalography mutated into an electroencephalometry that is dominated by pharmacopsychiatry.

> The fact that certain automatic analysis programs such as CEEG, BEAM, and Neurometrics are protected by patents should be indication enough for the significant commercial interests involved.

Considering the lack of theoretical leadership it is no surprise that in this method-dominated transformation process the non- medical technical support personnel became increasingly important. Today it is almost considered normal that in EEG research engineers and mathematicians are leading the way.

But who can dispute despite this enormous technological input, that the result of these activities is still miserably minute? And how could it be any different, considering that theory-free, method-dominated quantification is on the same epistemological level as astrology and alchemy? This faulty development, in urgent need of correction, is also the culprit for the unwillingness of young scientists to do research in the area of clinical electroencephalography. Added to this has to be the common misconception that nothing new can be learned from the EEG anyway.

It is certain that the generally observed decline of clinical electroencephalography cannot be reversed by lamentation:

> "The trend apparent throughout the world to cut back clinical electroencephalographic units in favor of other neurophysiologic investigative techniques is both unjustified and dangerous" (KARBOWSKI 1990; see also NIEDERMEYER 1985).

We consider the surgence of newer imaging procedures of the radiologists as an opportunity rather than a disadvantage for

the EEG. Since these procedures cover the structural-diagnostic needs of neurology far better than the EEG it would seem logical to investigate the EEG in its functional-diagnostic characteristic, especially for psychiatry. In the following we would first like to explain the effects of the lack of methodological consciousness exemplified in the discussion about terminology. This will be followed by several chapters in which we will develop our framework step by step.

2.2.1 Terminology

There is a common consensus that for scientific terms, consistent usage is of utmost importance. Compared to the underlying facts, the terms are viewed as less important. Discussions about the semantics of terminology, therefore, are considered more or less a waste of time - why should we wrack our brains over the meaning of terms? As scientist, one is likely to be interested only in the facts. If one paid enough attention to the facts one would also know what certain words meant. We, however, consider the terminology of primary importance (s. a. WITTGENSTEIN 1953). Every act of delimitation happens through the use of symbols or terms. Because there exists no act of delimitation without linguistic terms, it seems logical to us that facts cannot exist without linguistic terms. It is not true that the meaning of terms can be deduced from the items they signify. On the contrary - items can be delimited by the meaning assigned to terms. Therefore, clarifying the scientific terminology must have absolute priority. It is no coincidence that discussions about the semantics of terms always become acute when the question for the failure of science is posed (KUHN 1968)

2.2.1.1. "Normal" versus "Abnormal"

BENTE (1964a) probably saw the problem most clearly when he held the uncritical use of the term "normal" responsible "for the paralyzing and unfounded pessimism that has invaded the field of electroencephalography of endogen psychoses" (transl. from German). He intimated at another time how one should proceed instead: "One cannot start from the superficial and unclear criteria of normality but must be open-minded towards the finer morphology of the EEG" (BENTE 1961, transl. from German). Although many authors before and after BENTE expressed their discomfort with the common practice (LIBERSON 1944; GREENBLATT et al. 1944; KOOI et al. 1964; OBRIST u. BUSSE 1965; HELMCHEN 1968; STRUVE1976; DONGIER 1978; LAIRY 1978; TORRES et al. 1983) this had almost no consequences. "Normal" and "abnormal" are value-judgments and are therefore closely related to a specific point of reference. "Normal" per se is nonsensical, just as well as "abnormal". In medicine, the term "normal" is applied to discern healthy from ill. Because of the longtime integration of the EEG into neurology, we can assume today that in general "normal" or "abnormal" is used for the neurology-specific distinction of healthy and ill. That the neurological perspective has been adopted as exclusively valid is

also evidenced when in studies of a psychiatric matter the neurological criteria for normalcy are applied. This happens even though different reference points for normalcy are imaginable, such as the ideal type or the statistical average type. If EEGs of psychiatric patients are divided in "normal" and "abnormal" from the beginning - which until today is common practice for clinical routine examinations as well as for clinical studies - then only the "abnormal" EEGs seem noteworthy. The very small gains for clarification of such studies then consist in the statement that groups of schizophrenics or depressives differ either not at all or only in degrees with regard to the EEG - usually because of a higher degree of "non-specific" abnormalities. When KÜNKEL (1980) deplores the unsuccessful search for "disorder-specific" EEG patterns he simultaneously clarifies the goal of the respective efforts. Apparently, the significance of the EEG in psychiatry is being seen as dependent on the degree to which it provides an external validation of the psychopathologically based psychiatric diagnosis. However, "disorder-specific" patterns can only be expected if it were possible to assign specific neurological syndromes to the diagnostic "units" of the psychiatry which were also reflected in the EEG (see also 2.2.4) As we know today, however, this is explicitly not the case. This also makes all prophecies of an objective psychiatric classification through a spectral-analytically quantified EEG implausible (MORSTYN et al. 1983; MORIHISIA et al. 1983; SHAGASS et al. 1984; JOHN 1988; JOHN et al. 1988).

> Despite common consensus, the claim that it is possible to objectify the DSM-III-classification through calculations with 705 interdependent variables which were extracted without any hypothesis from a one-minute section of a resting EEG is foolish. Lately, however, there seems to be a learning process going on. Instead of a validation of clinical diagnoses we have been reading:".. different categories of pathophysiological processes may underlie similar psychiatric manifestations in behavior" (JOHN et al. 1991). A thorough analysis of the problems addressed here that form the center of the current psychiatric interest will follow in Chapter 2.2.4.

The narrowing of the range of possibilities resulting from the use of terms such as "normal" and "abnormal" has led to an elimination of all those EEG-characteristics that have to be regarded as neither "abnormal" or "disorder-specific" but as gradual variations of normal-physiological behavior. But it is just those unspecific phenomena that might be of utmost importance for the psychiatric EEG. Those who like KÜNKEL (1980) see the cause of the problem created by the distinction "normal/abnormal" as just a matter of insufficient definition clearly miss the point. This is also true for GIBBS (1982) when he recommends his canon of detailed individual checkpoints that one has to study diligently:"... there are about 30 specific types of electroencephalographic normality." Only, improved definitions will not do here. The solution rests solely in an uncompromised and consistently maintained renunciation of value judgments like "normal/abnormal." We are certainly aware of the resistance to such a demand since in the medical education the search for the diagnostically specific has the ultimate priority. Because secretly many a psychiatric researcher is still looking for the "schizococcus." The immensely successful paradigm of infectiology has had far too deep an impact on the linear-causality based understanding medicine has of itself and, consequently, of psychiatry. Far less popular is the idea that for certain disorders, only

phenomena that are not specific to this disorder but nonetheless of pathognostic significance in the context with certain other, equally unspecific phenomena, can be described.

2.2.1.2. "Allgemeinveränderung" [General Slowing Down of Frequencies - the translator]

Another term which is limited to the German-speaking countries and which hampers the development of the psychiatric EEG is "Allgemeinveränderung." The meaning of the word suggests a general evaluation that encompasses gradations. "It is used to describe the curve as a whole" (JUNG 1953, transl. from German). Hardly any other EEG-related term is equally popular in German-speaking countries. This is probably the result of its undisputable usefulness in evaluating the course of traumatic, inflammatory or toxic encephalopathies. Although we do not want to engage in any discussion about the practicality or necessity of the term "Allgemeinveränderung" in neurology and neuro-surgery, we must point out certain inconsistencies. JUNG (1953) defined the slight "Allgemeinveränderung" by an irregular alpha-rhythm and a certain proportion of theta. According to JUNG, the slight "Allgemeinveränderung" shows "flowing transitions to the irregular EEG" and is present in 5 to 10 percent of healthy adults and, even more frequently, in healthy children between the age of 10 and 14 years. It is our opinion that such a vague definition cannot be satisfactory in a discipline where the physician needs clear distinctions. One might ask what importance the slowing of the alpha-frequency from 12 Hz to 10 Hz, noticed during the course of the illness, or the continuous spreading of the dominant alpha-activity to the frontal brain regions has for the user of "Allgemeinveränderung." Based on the meaning of the term which suggests a pathological change, it seems nonsensical and potentially misleading to characterize the EEG of healthy children by the term "Allgemeinveränderung."

Since "Allgemeinveränderung", at least in its medium degree, connotes a disturbance of the brain function, it further worries us that one also talks about "Allgemeinveränderung" in connection with the effects of psychotropic drugs. A diffuse theta/delta dysrhtyhmia in encephalitis certainly represents something completely different from the picture that is the result of high clozapin dosages which, at first glance, is very similar. While in the first case a severe clouding of consciousness might be present, the patient in the latter case frequently will be quite inconspicuous intellectually, a difference often not reflected in the EEG report (s. a. 3.2. and 4.5.). This creates additional mysteries for the recipient of the EEG report.

However, "Allgemeinveränderung" is unsatisfactory not only for semantic and pragmatic reasons. The term also obstructs the gathering of new scientific insights. The implied restriction of the term to frequency characteristics precludes consideration of other aspects. This is particularly true in the aspect of EEG dynamics which is extremely important for the psychiatric EEG. Yet, thus far, there has been scant discussion of it (s. a. Chapters 2.2.2., 2.2.4., and 3.1.) If the terminology allows only the distinction between with or without "Allgemeinveränderung", markedly disturbed dynamics of

significant vigilance will necessarily be classified as without "Allgemeinveränderung". However, since without "Allgemeinveränderung" and "normal" are considered to be synonymous, the question about the importance of disturbed vigilance dynamics seems, after this determination, pointless. Therefore, "Allgemeinveränderung" turns out to be a terminological procrustean bed that obstructs any possibility to gain new insights. The EEG interpreter, who because of generally accepted convention has only the choice between two alternatives usually, will not dare to seriously consider other possibilities.

2.2.1.3. „Krampfbereitschaft" (Proneness to epileptic seizures)

The question of increased "Krampfbereitschaft" is in tandem with the question about "Allgemeinveränderung," the question most frequently asked by physicians. In psychiatry, this question presents itself for all patients treated with psychotropic medication. It is also of particular importance during the withdrawal phase of addiction patients. Under these conditions, clinical experience alone suggests a higher seizure risk. The physician wants to know from the EEG interpreter whether the risk in a particular case is considered to be higher or lower than expected based on general experience with comparable patients. Another question of interest for the physician is whether the degree of risk has changed in the course of treatment. Although there is no empirical proof for this view, it seems to be difficult to rectify the general assumption among physicians that the risk of seizure be deduced from the distinctiveness of paroxysmal potentials in the EEG. Unfortunately, some textbooks also contribute to the confusion. Consider the following: "They [the paroxysmal potentials - the author] generally are the expression of an increased seizure risk." and further: "that such potentials are proof of an increased seizure risk, yet under no circumstance of a manifest seizure disorder." (KÜNKEL 1980, transl. from German). We emphatically reject the claim that it is generally possible to predict an increased seizure risk from an EEG.

First of all, the term "risk" suggests, either in connection with epileptic seizures or for whatever other causes, a designation of this term relative to a certain context of observation. The context of this observation would have to be expressed by a statement such as the following: Paroxysmal potentials in the resting EEG are, according to general experience, an indication of the probability of epileptic seizures to such a degree that prophylactic and therapeutic measures are justified. It should be indisputable that there is no such generally acceptable connection between the EEG record and pathological behavior. This is not influenced by the fact that the EEGs of epileptics between seizures show significantly more frequent paroxysmal potentials than those of non-epileptics.

If we examine the historic roots of "Krampfbereitschaft" (seizure risk) we again encounter JUNG (1950). Although he correlated the seizure risk in epileptics not with the distinctiveness of paroxysmal potentials but with the degree of

"Allgemeinveränderung" he introduced the solely EEG-based diagnosis of "latent seizures," exclusively reserved for healthy persons. As criteria, he used the proof of dysrhythmia in connection with sharp waves. Acceptance of "latent seizures" implies giving up the logical distinction between the levels of clinical and physiological phenomena. In other words, what would seem to be logically incommensurable levels of description are thus declared equal. This is manifested in the opinion that it is possible to express one phenomenon (the seizure) through the other (such as sharp waves) or that one is a reflection of the other. Such a violation of the logical premises, of course, has practical consequences. Those who equate paroxysmal potentials with latent seizures or increased seizure risk will also justify anti-epileptic medication based solely on the EEG findings. Despite numerous solid arguments to the contrary, this irrational practice is applied even in university institutions. The indication for therapeutic anti-convulsive medication only has a rational-empirical basis when an epileptic seizure can be extrapolated from the case history.

> Van DONSELAAR et al. (1992) assessed the cumulative risk of another seizure within two years at 81% in the cases with proof of paroxysmal potenials in the interval EEG, as compared to12 % in cases in which this proof did not exist.

Our criticism is certainly not directed at the prophylactic prescription of anti-convulsants after brain lesions or during drug rehabilitation treatment. However, in these cases, the prescription for prophylactic treatment should be independent of the EEG record.

To our knowledge, there is no empirical proof for a regular interdependence between the risk of seizures and the proof or distinctiveness of paroxysmal potentials. Instead, MILLER and BLUME (1993) recently stated: "The lack of a significant relationship between tonic-clonic seizures and number and length of epileptiform bursts suggest that EEG is not a reliable forecaster of tonic-clonic seizures in patients with primary generalized epilepsy." Further, "epileptiform bursts occurring only on activation by sleep, photic stimulation or hyperventilation lack prognostic significance...."

Numerous authors also excluded such an interdependence for patients during drug rehabilitation (WIKLER and ESSIG 1970; KOUFEN and BECKER 1980; MATISON 1983; van SWEDEN 1984; SCHMICKLAY et al. 1989; TYNER et al. 1989). Whether the EEG allows the prognosis of focal-symptomatic seizures after cerebral trauma is at the least doubtful (COURJON 1970). The sharp high-amplitude waves usually observed under the influence of neuroleptics indicate at best a slightly increased seizure risk. In contrast, the seizure risk in high-frequency spikes and occasionally poly-spike patterns which are typically thymoleptics-induced is somewhat higher.

The lack of a regular connection between paroxysmal activity and seizure risk even in clinically established epilepsy is evidenced most clearly by the fact that for at least half of these patients the seizure-interval EEG, even in the case of

repeated recordings, do not show any paroxysmal potentials. This finding, which is hardly new, has only recently been replicated by DESAI et al. (1988). Two thirds of 100 randomly selected epilepsy patients did not show any seizure-interval paroxysmal potentials. This seems to confirm the observation by HOPKINS and SCRAMBLER (1977): "A biometrical test with so many false negatives would never have entered clinical practice." But since paroxysmal potentials are considerably more frequent in seizure patients than in healthy persons, we must question the pathogenetic significance of these graphoelements. The paroxysmal potentials are generally interpreted as the expression of a tendency of synchronous discharge of extented neuronal populations which exceeds the physiological measure. We know from the EEG that these synchronizations have localized accentuations as well as a tendency toward irradiation. Whether this spreading tendency is limited to a specific region or whether a partial or even complete generalization correlated to an epileptic seizure ensues depends on hypothetical irradiation-restricting mechanisms. For those mechanisms, no indications exist in the EEG which are comparable to the synchronization. Therefore, it is impossible to objectify the irradiation-restricting potential that counteracts the excitatory irradiation. However, this is exactly what would be necessary to allow statements about the seizure threshold and thus about the seizure risk from the EEG. Often, a decrease in the seizure frequency, i.e. the seizure risk during treatment with anticonvulsants, is accompanied by an increase of paroxysmal activity in the seizure-interval EEG. Only in pyknoleptic, primary generalized petit-mal epilepsies is the seizure-controlling effect of the anticonvulsants reflected in a regular decrease of the paroxysmal activity (MILLICHAP 1965; DALBY 1969; MILLER und BLUME 1993). Remarkable in this context is that carbamazapine causes an increase of paroxysmal activity in every other epileptic. Here, the seizure- reduction appears independent of the EEG effect (f. e. JEAVONS 1972; RODIN et al. 1974; WILKUS et al. 1978).

It would be appropriate to use the terms "paroxysmal potentials", "latent seizures" and "seizure risk" as synonyms only in the case of a one-on-one matching of EEG and behavioral phenomena. Since this is not the case (s. a. 2.2.5.) we are obliged to make a logical and clearly defined distinction between these description levels. Exceptions, such as the unequivocal correlation of 3/s-spike-wave patterns and an observable absence in infants do not beg this rule. As with "Allgemeinveränderung," one can contrast the gain or damage caused by use of the term "Krampfbereitschaft" (seizure risk). As explained before, a seizure-prophylactic treatment based on the EEG cannot be justified. This, however, would be the only advantage of "seizure risk." While the advantage of "seizure risk" remains doubtful, we must expect negative effects in all those false-negative cases where necessary therapeutic or prophylactic measures are not taken because there is no proof of paroxysmal potentials.

> ".. a persistently normal record is entirely compatible with an increase in the severity of epilepsy" (STROBOS and KARALLINIS 1968).

We recognize another detrimental effect of "seizure risk" in the unjustified claim of lab capacities, based on rationally unfounded "repetitions of recordings." All too often, we are confronted with the demand for short-term control recordings due to the erroneous and stubbornly held opinion that it is possible to objectively detect seizure risks at any time with an EEG.

The urgent need to correct assumptions about "seizure risk" is also evidenced in psychiatry with regard to differential diagnoses. A typical question asked by the physician from the EEG clinician could be: Is it possible that a patient with an uncertain epilepsy anamnesis who currently is showing an atypical psychopathological syndrome actually is displaying an epileptic equivalent? It is understandable that especially colleagues still in training and lacking experience, tend to avoid the responsibility of diagnosing the severity of epilepsy, if possible. Generally, the EEG lab is used for this purpose, with the erroneous expectation of an objective, equipment-backed diagnosis. In an era in which progress in medicine is measured by the degree to which the fallible subject is neglected, it has almost become a matter of civil disobedience to confess adherence to the still valid view that the diagnosis of epilepsy must be based first and foremost on clinical anamnesis. The contribution of the EEG to the diagnosis of epilepsy will differ from case to case but will never be of decisive importance: "The EEG is a limited diagnostic tool for making a positive diagnosis of epilepsy or for resolving unequivocally the differential diagnosis between an epileptic vs. a non-epileptic condition" (GLOOR 1977). Sounding the same note was MATTHEWS (1973): "Where clinical doubt exists, the EEG will not help." A model calculation by GOODIN and AMINOFF (1984) that took the sensitivity and specificity of the EEG with regard to epilepsy into account showed that it is the prevalence of epilepsies in the respective population that decides whether the EEG will contribute to the diagnosis or not. The authors based their work on the prevalence of 0.5 % found in the general population and on the condition of their own neurological-psychiatric patients. Paroxysmal potentials were found in 4 % of seizure-free patients and in 52 % of patients with seizures. For a model population of n=1000 this results in the following frequency distribution:

Table 1. Frequency distributions of patients with and without paroxysmal potentials in the resting EEG depending on the presence or absence of epilepsy. Above: epilepsy prevalence 0.5 %, below: epilepsy prevalence 50 %. A specificity of 96 % and a sensitivity of 52 % were assumed for the paroxysmal potentials.

		Epilepsy		
		Yes	No	
Paroxsysmal potentials in the resting EEG	Yes	3	40	Epilepsy prevalence: 0.5 %, n=1000
	No	2	995	
	Yes	260	20	Epilepsy prevalence: 50 %, n=1000
	No	240	480	

According to the table, 43 carriers of the characteristic are expected with an epilepsy prevalence of 0.5 %. 40 of those carriers would be without a seizure disorder, i.e. they would be false-positive. Considering such an unfavorable relation between real-positive people (n=3, corresponding to 7 % of those with the characteristic) and false-positive people (n=40, corresponding to 93 % of the carriers), it would be extremely risky to base the diagnosis on the EEG. However, if we assume a prevalence of 50 % of seizure patients - an assumption that seems realistic for the clientele sent to an epilepsy ambulatory for diagnosis - the diagnostic value of the EEG appears in a totally different light. Assuming the same specificity and sensitivity, there would be only 20 (7 %) of the patients without seizure disorder, i. e. false-positive cases, out of the expected 280 carriers of the characteristic, if n=1000. 260 (93 %) of the carriers would also be epileptics and therefore real-positive. Weighing the usefulness against the risk, the usefulness clearly dominates. The question of primary interest regarding differential-diagnostic significance of paroxysmal potentials for psychiatry can therefore be answered through the

determination of the epilepsy prevalence in the respective psychiatric population. For our institution, which deals primarily with acute psychiatry, we took the data gathered over a ten-year period between 1981-1991 as basis, considering all patients with an initial diagnosis of epilepsy (ICD 9: 345.0, 345.1, 345.4, 345.5). This resulted in an epilepsy prevalence of 0.39 %. If we considered only epileptics with primarily psychiatric symptoms, the prevalence declined to a mere 0.32 %. If we view these numbers as representative of an in-patient institution for acute psychiatry, we can conclude that paroxysmal EEG activity is insignificant for the psychiatric differential diagnosis. One must be more concerned that if the biometric premises are ignored, the risk of false-positive diagnoses is significant. Of course, the premises demonstrated here in the example of the resting EEG are equally true in EEGs recorded under provocative methods as well as for the long-term EEG record from the moving patient who carries a cassette. The usefulness of the EEG is then always indisputable when the paroxysmal activity can actually be related to observable epileptic behavior with sufficient certainty (s. a. 4.4.) This means that examination intending to confirm or exclude psychiatric manifestations of epilepsy make sense only if they are conducted in close cooperation between the EEG lab, the treating physicians and the nursing staff. Each case requires an individual examination plan. The prospects of success increase if during the examination the frequently detectable seizure-triggering circumstances are taken into account.

In review, the popular, albeit errant opinion that EEG allows an evaluation of the seizure risk touches upon psychiatric questions and, therefore, the psychiatric EEG. "Seizure risk" is a term reserved for clinical descriptions. An interpretation of paroxysmal graphoelements cannot extend beyond "increased neuronal synchronization tendency" or "increased brain-electric excitation."

2.2.1.4. One Feature - Many Terms

One striking peculiarity of clinical electroencephalography is the proliferation of terminology. In general, the creation of a new term is justified only if a truly novel or important phenomenon needs to be defined, whether for practical or theoretical purposes. As can be proved from numerous examples, these conditions are fulfilled only very rarely. The clinical electroencephalography dominated by the production of terms leads one to believe that we are dealing with some kind of substitute activity for the required, but due to lack of suitable concepts unattainable, essential research.

It is, for instance, hard to claim that definition and research of gamma-, kappa, lambda-, my-, rho-, pi-, psi-, sigma-, and zeta- waves (overviews in DUTERTE 1978 and KUGLER 1981) resulted in an essential expansion of knowledge. This also holds true for a multitude of other features that we do not desire to list here in their entirety. As can be demonstrated with each example, such terms regularly develop in phases. The initial description is followed by the creation of a profile of symptoms.

Further confirmations follow. Now, however, disappointment sets in. Independent and, compared to earlier methods, superior research shows the total clinical insignificance of the feature. From then on it only leaves a footnote as some form of historical reminiscence. Pars pro toto we only want to mention here the 14 and 6/s positive spike pattern that was used for no less than 30 different clinical syndromes as pathognomonic, before it was found that it can be proved in every fourth healthy young man (LONG and JOHNSON 1968).

A critical evaluation of the facts reveals that, to our dismay, the stock of knowledge upon which clinical electroencephalography is based consists to a large degree of such footnote ballast. While the aforementioned terms can only be blamed for wasted research potential and time lost for meaningful activity, there exist terms that are true impediments to the acquisition of knowledge. In addition to those mentioned in the previous chapter, these are all the terms which are more or less used as synonyms for the same phenomenon. Among the many examples, we take particular note of the grouped, fronto-central high-amplitude and rhythmic slow waves pertaining to the subalpha-, theta-, and delta-range (intermittent bilateral anterior = IBA, s. a. 3.1.) This salient phenomenon naturally attracted attention early on. SMITH (1938) coined the term "rhythmic theta bursts of drowsiness." Numerous authors in later years were of the opinion that the supposed variation they had observed had not been described in the same way and therefore required the creation of a new term. Table 2 provides a list of terms that, in our opinion, all refer to the same phenomenon in the adult EEG.

Table 2. Synopsis of terms that can be considered synonyms for the phenomenon of intermittent bilateral anterior (IBA), mostly high-amplitude and more or less rhythmic waves.

Term	Author
Rhythmic theta bursts of drowsiness	SMITH (1938)
Abnormal slow potential changes above the frontal region	KORNMÜLLER (1942)
Rhythmic slow discharges	COBB (1945)
Equilateral waves with 6 or 3-4 Hz frontal emphasis	DUENSING (1949)
Runs of bilateral 4-7 c/sec Activity	HILL (1952)

Hypnagogic hypersynchrony	KELLAWAY and FOX (1952)
Dysrhythmia	DALY et al. (1953)
Monorhythmic frontal delta	CORDEAU (1959)
Frontal intermittent rhythmical (FIRDA) delta activity	VAN DER DRIFT and MAGNUS (1961)
Frontal midline theta rhythms	CIGANEK (1961)
Paroxysmal slow activity	GIBBS and GIBBS (1964)
Paroxysmal dysrhythmia	HELMCHEN (1968)
Centro-temporal episodic 6/s rhythm	LIPMAN and HUGHES (1969)
Theta- and delta-parenrhythmia	PENIN (1971)
Anterior 6-7 Hz moderate amplitude activity	KELLAWAY (1979)
Periodic slow wave complexes	KUROIWA and CELESIA (1980)
Generalized bilaterally synchronous slow bursts	SCHAUL et al. (1981 a)
Bilateral paroxysmal slow waves	SCHAUL et al. (1981 b)
Episodic anterior drowsy theta in adults	JANATI et al. (1986)

The asymmetrical, generally left-sided variety of this phenomenon - intermittent left anterior groups of slow, more or less rhythmic waves (ILA, s.a. 3.1.) - was not included in Table 2, since asymmetries were always viewed as exclusively related to focal damages and therefore the intrinsic relationship between IBA and ILA was not recognized.

Morphologically, the patterns subsumed under IBA correspond to the patterns of drowsiness in children, as described by GIBBS and GIBBS (1950). The frequency of those patterns shifts in increasing age from the delta- to the theta-range. Another area, where inconsistently applied and partially overlapping terms cause confusion is the low-voltage EEG. One

and the same EEG is described as either "flat", "of unstable frequency", or "beta-typical", depending on the local "school." Whether the arbitrary determination of formal criteria such as 20 µV as the upper amplitude limit of the "flat" EEG (JUNG 1953) is of any help remains doubtful. In contrast, characteristics of the more importance but more difficult to operationalize received meager attention. One such characteristic used for differentiation is the temporary posterior alpha-activity, observed in the majority of low-voltage EEGs as a reaction to closing the eyelid (DAVIS and DAVIS 1936; REMOND and LESEVRE 1957; GASTAUT et al. 1960; COBB 1978). There, one can observe all gradations of easily overlooked single alpha-waves to spindle-shape modulated groups of alpha-activity. Compared to that, a truly flat EEG in the sense of a so-called variant of basic rhythm certainly is a rarity. Another phenomenon which can be used for differentiation is the hyperventilation effect. It has been demonstrated that a high percentage of low-voltage EEGs can be "resynchronized" by hyperventilation (GALLAIS et al. 1957; PICARD et al. 1957). Of further importance in our opinion are details about the spontaneous dynamics of the ongoing activity. It is a fact that often the appearance of the EEG during the first minute is greatly different from that of the tenth minute. That a meaningful definition of the terms requires the inclusion of such functional aspects is evidenced by the unresolved controversy about the psychophysiological evaluation of sequences of low-voltage activity. The opinion that low-voltage activity is associated with an "arousal"-caused desynchronization (s. a. BERGER 1933; JASPER et al. 1939) that was also propagated in the activation concept of LINDSLEY (1961) is prevalent.

This concept fails to explain the experimentally supported findings that the alpha-rhythm can persist unchanged even at high levels of attention (SHAW 1992). According to our experience with psychiatric patients, low-voltage activity in the resting EEG is generally not an expression of "arousal." Furthermore, it seems hardly possible to prove the "arousal" interpretation since attentiveness as well as anxious tension as subjective phenomena can at best be assumed but not objectified. EEG technicians often try to meet the demand for comprehensive behavior documentation during the EEG by recording tension of the patient in case of primarily low-voltage activity. Such a remark, however, is usually not the result of the observation of behavior but a petitio principii. Since it is considered to be true that psychological tension finds its expression in low-voltage activity, the presence of the latter is used to conclude the presence of the former. However, the physician who assesses the EEG will tend to relate the remark to actually observed behavior and therefore feel confirmed in his opinion. Incompatible with the "arousal" interpretation is also the increase in frequency and duration of lower-voltage desynchronized phases with the increasing duration of the EEG observed in the majority of our patients. The regularly observable alpha-activation through sensorial stimulation furthermore proves, without a doubt, that we are dealing here not with a manifestation of "arousal" but, on the contrary, with lowered vigilance. Only very rarely do we find an EEG which was initially desynchronized that shows the alpha-typical organization only at a later point in time. Furthermore, we can point to the findings in healthy subjects during long-term sleep deprivation. All authors agree that, after a progressive discontinuous disintegration of the background activity, around the third day of deprivation a low-voltage EEG occurs that is otherwise also described as norm variant (f. i. RODIN et al. 1962; BENTE 1969b). It says something about the power of longstanding

errors that despite all evidence, few dared to question the equation of low-voltage and arousal EEG. According to CHATRIAN (1976), anxious tension can explain only some low-voltage EEGs. Before him, ROTH (1961) had already noticed that any relationship between the frequent low-voltage EEGs in post-encephalitic and post-traumatic states on one hand and anxiety and emotional instability on the other hand was the exception rather than the rule. In the majority of cases, they are evidence for lowered vigilance. Also pointing against the "arousal"-interpretation are low-voltage EEGs that are typically associated with alcoholism.

According to the concept of LINDSLEY, the sensorially induced desynchronization and amplitude decrease go hand in hand with a more or less evident activation of fast beta-activity. In reality, however, we also find a fairly high proportion of fast beta-waves in desynchronized low-voltage activity that can unequivocally be related to a sub-vigil state (DAVIS et al. 1938; FROST 1963; BENTE 1964b; KUBICKI et al. 1987). Even using spectral analysis, desynchronized activity under "arousal", i.e. after opening the eyes, could not be distinguished from desynchronized activities occurring with closed eyes (DANIEL 1966; GENGERELLI and PARKER 1966). Therefore, it is equally impossible to use beta-activity to distinguish between "arousal" and lowered vigilance level. By relating EEGs with increased or dominant beta-proportion in certain cases to the so-called norm variants "beta-typical EEG" or "frequency-unstable EEG", the terminological chaos surrounding desynchronized low-voltage activity is complete. VOGEL (1970) was absolutely right when he pointed out that only a minority of beta-EEGs are genuine, i.e. constitutional variants.

Drawing some preliminary conclusions, we cannot deny that the thesaurus of electroencephalographic knowledge is nothing but an unstructured conglomerate of unconnected individual facts of dubious meaning. As DONDEY and GACHES (1977) remarked, the interpreter bases his assessment of the EEG on a hodgepodge of half-truths which, for most part, do not satisfy strict empirical or scientific standards. To put it more bluntly, this means that the clinical EEG lacks a rational foundation. However, such a rational foundation would be the condition not only for the integration of all those disconnected facts but for focused observation. It would eliminate the real reason for the limited intersubjective reliability of visual evaluation that is generally observed and deplored (VOLAVKA et al. 1973b, 1975; STRUVE et al. 1975; WILLIAMS et al. 1985). Contrary to popular opinion, this is not a problem of insufficient standardization. Always when a scientific discipline stagnates due to terminological difficulties the actual problem proves not to be the terminology. With some good will and a willingness to compromise, it could be standardized. But the terminological problems are the apparent expression of differing opinion about the essence, the possibilities and the limitations of the method. Terminology problems are, as JASPERS (1946) already knew, usually the consequence of the absence of a concept.

> "When a science seems to stagnate and, despite the best efforts of many people, does not seem to make any progress, one can notice that the cause for this is often found in a certain traditional way of thinking about things, in a terminology adopted at one time which

> the masses accepted and followed without further thought and which thinking people only in individual cases and only with great reluctance rejected in a few instances." (v. GOETHE 1790, transl. from German)

2.2.2. The EEG as a Morphological Discipline

For some time now, attempts to explain the EEG by the behavior of individual neurons have been abandoned. In the end, the "Doctrine of Microprecise Causality" (WEISS 1969) has failed here, too. The unavoidable acknowledgement that regularities, as we recognize them at the level of cortical macrorhythms cannot be associated with corresponding regularities at the level of isolated cortical neurons demands a change of paradigm.

> "The bulk of knowledge about synaptic transmission and ... confuses the coherent formulation of a valid model of EEG generation. Obviously an EEG model must handle statistical mass action and must be based on major principles, which may be greatly simplified." (SCHENK 1975)

Here, we would like to take physics as an example where microdeterminism was, if not replaced, at least complemented by macrodeterminism long ago. We consider macrodeterminism to be a systematic approach of study, using the term "system" as it was introduced in biology by P. WEISS and in systems physiology by W. R. HESS (1960). WEISS (1969) considered the system concept appropriate for the description of all those phenomena which could not be explained by micromechanical causative reaction chains alone. A systemic view is e.g., indicated by considering the EEG as the integral manifestation of cortical mass activity. This kind of definition is incompatible with the world view of analytic-reductionist orthodoxy. Since its protagonists can only accept microelements and their interaction, they must dread all forms of systemic thinking. However, it is very likely that FREEMAN'S (1975) mass-action paradigm supporting experiments has made a certain dent there. According to FREEMAN, the neuron which can only be anatomically isolated is by no means the functional unit as such. What must be considered as the functional unit would depend on the perspective of the examination or behavior to be examined. Viewing the EEG as a manifestation of neuronal mass activity implies that the tools and concepts for its interpretation cannot be those of classical neurophysiology. This was also acknowledged by authors such as LOPES DA SILVA et al. (1976) who described it as difficult "to bridge the gap between the two domains of neurophysiology."

A primary and basic difference between EEG and neurophysiology is that in the former, signals are primarily not measured but only recorded. During the second step, these records must be interpreted in a clinically relevant way. Here, we simultaneously encounter two tremendous difficulties which a natural scientist using exclusively objective measurements does not face. First, the recorded signals must always be evaluated visually, i.e. subjectively. Secondly, it has to be

determined and, if possible, explained, which characteristics are clinically significant. One might interject that these difficulties in no way touch the heart of the matter, that they are only evidence of the regrettable fact that electroencephalography has not yet reached its declared goal of being a completely objective physical measuring method. If, which is entirely imaginable, EEG potentials would be measured without detour via the judging eye, primarily as voltage and frequency values, the same problem would continue to exist. On one hand, it is hardly possible to express the total information contained in the EEG in sheer numbers. If, on the other hand, one tried to limit oneself to relevant information, one would encounter the same problems as in the original record. In any case, the decision about what is relevant is required from a subject such as a guideline-setting authority. One of the absurdities of clinical electroencephalography is that the discussion regarding psychophysiologically relevant target variables which is so desperately needed in order to give quantification a rational base has thus far been almost entirely neglected. One might get the impression that this core problem has been excluded because of a silent consensus in the scientific community. Despite missing theoretical or rational foundations, one relies on spectral-analytically determined frequency variables and leaves possible alternatives to the coincidental discoveries of new technologies.

In view of this background, KÜNKEL'S (1980) remark seems even more astounding: "We must ask ourselves whether the search for frequency bands is the right one after all ... or whether we must find something different. As long as we do not make any progress with this problem, the current stagnation of EEG analysis will continue to exist. We will have to face the fact that our models will have to be much more complex if we take into account the topographical differentiation and the temporal variability, i.e. the dynamics of the EEG. And as long as we are not able to do this we cannot claim to be talking about a model that can even remotely describe EEG activity" (transl. from German).

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> In our opinion, the intraindividual stability of mean power spectra found in resting EEGs which was discovered and not further interpreted by STASSEN (1980) might be the manifestation of intraindividual stability of morphodynamics or their underlying regulatory mechanisms.

While today at least the topographical aspect is taken into account by including a larger number of leads, the dynamic aspect remains neglected. But even when topography and dynamics are somehow put into parameters, the aspired to quantitative reconstruction of morphodynamics could never have the same acuity as that which can be attained visually.

However, since all empirical science is indebted to the maxim of intersubjective reliability we nonetheless are held to follow the path indicated by BENTE (1961) to develop the quantification of the EEG following the visual gestalt perception.

As mentioned previously, it was BENTE (1961, 1973a, b) who as one of the pioneers of EEG quantification emphasized early on the "primacy of visuo-morphological analysis" of the EEG as opposed to quantifying techniques. He explicitly excluded primary quantification. All quantification would have to be guided by visual gestalt perception. Quantification was, in his view, primarily an examination of visually discovered laws of order. The interpretation of quantitative parameters would only be possible within a framework established through visuomorphological analysis. The still undisturbedly deployed dynamics of primary quantification without concept finds an eloquent expression in the not exactly new but still current quote by NIEDERMEYER (1985): "The problem was that data analysis was suddenly en vogue and cohorts of EEGers joined the bandwagon. These methods became aimlessly overused and the true yield of the work was low. Many of these expensive apparatus gradually became idle and dust gathered on them."

In retrospect we must admit that BENTE'S demand has remained without major resonance, and a contributing factor to this is certainly that thinking in the categories of conventional neurophysiology the character of the EEG as a separate morphological discipline has been missed. This failure also explains the widespread association of the EEG with all other forms of neurological electrodiagnostics under the label of neurophysiology. Therefore, a way of thinking and working which is based on the methodological premises of experimental neurophysiology is expected from the clinical neurophysiologist. Of course, no electroencephalographic morphodynamics could exist without excitatory or inhibitory post synaptic potentials.

However, this fact is as unimportant for the description and clinical interpretation of an EEG as the knowledge of transistor technology for the TV critic or offset printing for the reader of a book. Of course, an independent scientific discipline also needs a specific language for observation that is appropriate for the observed subject. Since phenomena usually appear differently than they actually are and furthermore require interpretation, observational language also requires an additional theoretical language. The latter does not refer to phenomena of sensory perception but to the so-called theoretical constructs deduced from them (CARNAP 1968). A theoretical construct must meet two conditions. First, it must be deduced from observations. Second, through the formulation of work hypotheses, it must allow for new observations and discoveries. The more the second condition is met, the higher the construct validity. The EEG as a morphological discipline can be placed in the same category, methodologically, as those disciplines which are originally based on a dynamic understanding of morphology, including botany or zoology. All morphology requires minimal familiarity with the observed subject. Only through the lenghthy process of forming one's own ideas can a degree of familiarity be acquired which allows the recognition of intrinsic regularities of the subject.

> It certainly is not cheap polemics if we claim that the majority of researchers who excelled in the field of primary quantification did not go through such a lengthy process of forming their own ideas.

Paradigmatic for such regularities are patterns which define the so-called stages of vigilance (chapter 2.2.5.). BENTE strived to delimitate "formative tendencies" which are the constituents of the pattern morphology, thereby exceeding the mere classification of the stages already distinguished by LOOMIS et al. (1937). Thus, he created the foundation for the observational language of a psychophysiologically oriented electroencephalography. Each pattern or "höheres Strukturmerkmal" (higher structural characteristic) (BENTE 1961) can be reduced to a few "formative tendencies." Compared to linguistics, the "formative tendencies" can be equaled to morphemes and the regularities that determine the formation of "higher structural characteristics" to the syntax.

From the perspective of systems physiology, the "formative tendencies" can also be viewed as independent partial processes whose complex interaction results in the brain-electric mass activity were registered in the EEG.

Here, one could draw an analogy with the meteorological model. Meteorologists try to reconstruct the global weather to be predicted from the interaction of a limited number of dynamically varying factors such as atmospheric pressure, wind, temperature, humidity, etc.

Depending on the degree to which we succeed in relating "formative tendencies" and "higher structural characteristics" with behavior/perception, we can also view electroencephalography as a specific concretization of general semantics. However, we cannot expect one-on-one relationships between the EEG and behavior/perception (see 2.2.6.). Just as with natural languages, we must assume that the meaning of an EEG feature varies with the context. This must be impressed especially on those who think that they can practice psychophysiological electroencephalography on an exclusively empirical basis, i.e. without a theoretical framework. Confronted with a fundamentally ambiguous multitude of phenomena, one must follow an ordering concept, comparable to Ariadne's thread, to reach a predetermined goal.

Those who today, for progress's sake, demand a concept of electroencephalography as a primarily morphological discipline automatically provoke misunderstandings, confusion and rejection. We are fully aware of the fact that such a demand will be seen as even more offensive today as BENTE'S in the Sixties. Related to the aforementioned detrimental effects of the intrinsic dynamics of technology on scientific progress is an equally detrimental epistemological prejudice. According to it, a discipline is a science to the degree that originally sensorial perceptions have been replaced by physical measurements. For a morphological discipline, however, visual or subjective gestalt perception is the absolutely indispensable method. The tendency to research biological phenomena primarily through quantification, i.e. objectively, before any insights in their

structure have been gained through sensorial perception - is prevalent. For many, gestalt perception has the mystical flair of intuition. Therefore a scientist who admits openly that he allows himself to be influenced or maybe even guided in his research by gestalt perception is suspect to his colleagues. Strangely enough, visual perception is considered scientifically legitimate when it is used to read measuring equipment but not when it is used for the direct observation of the phenomenon to be researched. Equally paradoxical is that today it is the advocates of primary quantification of the EEG in particular who propagate visualization in the form of so-called EEG maps. In comparison to the originally registered time function, this is the result, in color graphics, of the original function altering and the dynamic information eliminating transformation. Therefore we consider "EEG-mapping" as a step back rather than progress. Where rationality is lacking, irrationality threatens to take over. Thus the clinical EEG is in permanent danger of deteriorating to a pseudoscience. The fascinated following of technological innovation is the expression of a lack of rational foundations. The question as to whether research should be guided by certain methods or by theories has unfortunately rarely been asked in clinical electroencephalography. At least from the time of the first quantitative frequency analyses at the end of the Fifties, "progress" has been defined almost exclusively by the currently popular technologies.

We would like to refer the interested reader to the reviews by DUMERMUTH (1974) and KÜNKEL (1977).

This dependence on technology was and is so pronounced that even promising approaches - such as the assessment of the dynamics of amplitude variation (e.g. PERRIS 1980) - were abandoned midway after a more powerful technology had made power spectral analysis possible. As a matter of course, the frequency bands gained the status of relevant target variables. The rather coincidental fact that the Fourier algorithm was particularly well-suited to exhausting the possibilities of the computers then available had a major impact. This trend is not only as vigorous as ever but even seems to gain momentum. Many proofs exist that the wide-spread openness for new technologies, which certainly far exceeds the necessary degree, came and still comes at the cost of the development of concepts. Due to this, the expansion of knowledge was eventually also inhibited.

Although it sprouted from the perspective of the ethologist, (K. LORENZ 1959) the following quote can be used equally well as striking criticism of the research situation in electroencephalography: ".".. Research disciplines, whose topics are complexly structured global systems, pay homage to the false belief that it is possible to reach an understanding of the function without gaining insight in the structure" - and further: "This is accompanied by a deep contempt for those cognitive processes which inform us of the existence of structures" (transl. from German).

> LORENZ mentions three steps of inductive research of nature which would all be connected to gestalt perception; the collection of an induction base, its systematic sorting and the abstraction of regularities. The last step would allow the abstraction of superindividual regularities.

This order of events is particularly true for electroencephalography. Of course, the electroencephalographic morphologist must also know about the risks of gestalt perception. According to LORENZ this risk is in the stubborn insistence on pre-existing hypotheses or habits of seeing or regarding things. One also must beware of exaggerated pregnancy tendencies. Further, one has always to remember that gestalt perception is only a tool for discovery and that where its results contradict rational performance, one is held to believe the latter. Furthermore, a significant problem is the interindividually different development of the aptitude, since it can rarely be improved through study or training. As anyone involved in teaching will confirm, there are always some students who despite all efforts do not succeed in recognizing more complex electroencephalographic gestalten. Without fail they slide back time and again into the analysis of details and cannot see the forest for the trees. "Rationally and analytically gifted thinkers who rarely also possess outstanding perceptive abilities for complex gestalten consider those gifted in this area as fast talkers because they cannot recreate the way they arrived at their insights and also as uncritical because they do not consider the verification of the perceived as all that important" (LORENZ 1959, p. 154, transl. from German).

The publication of research results which were gathered through gestalt perception of course requires an operationalism of the evaluation criteria which is as far-reaching as possible. Here, we must take into account that the farther-reaching the rational operationalism, the less will remain of the original "ratiomorphic" gestalt perception. Experience tells us that differentiations through a catalogue of criteria created ex post facto are usually far less impressive than those based on a gestalt perception that is simply summarized in a general evaluation.

2.2.3. Non-linear Complexity Analysis - a Future Perspective of Primary Quantification?

Whether the essence of primarily quantifying non-linear complexity analyses presently tested in numerous methodical variations and with different problem positionings are an enrichment cannot be assessed for the time being. Contrary to spectral analysis, this kind of analysis takes the non-linearity of the EEG signal into account (RÖSCHKE and BASAR 1988; SOONG and STUART 1989; PRITCHARD and DUKE 1992). In it, the information about the phase suppressed in spectral analysis plays an important role (DEBUS and KÜNKEL 1991). The unfortunately mathematically cumbersome determination of the so-called correlation dimension D2 represents a measure for the complexity of the system or, in other words, for the number of independent partial processes or the degrees of freedom. Visually indistinguishable EEGS or

similar power spectra can correspond to completely different complexity measures.

> In non-linear complexity analysis, the time function is first transformed into a multi-dimensional geometrical figure, a so-called attractor in the phase space. The system state corresponds at any time to a specific point on this attractor. The correlations dimension D2 is the eventual result of a complicated "measuring process" of the attractor by means of the GRASSBERGER-PROCACCIA algorithm.

In the past, the majority of EEG-studies were devoted to sleep. There was a common consensus that parallel with the depth of sleep a decrease in D2 occurred (f. i. BABLOYANTZ and SALAZAR 1985; RÖSCHKE and BASAR 1989; RÖSCHKE and ALDENHOFF 1991). For patients with schizophrenic psychoses, contradictory results were found (RÖSCHKE and ALDENHOFF 1993; KOUKKOU et al. 1993). We ourselves found a decrease in D2 due to the effects of lithium (Ulrich et al. 1993).

2.2.4. EEG and Psychiatry

Over the years, a substantial number of publications have accumulated which deals with EEG-correlates of different psychological constructs such as fear, concentration, absentmindedness, excitement, insecurity, awakeness or wakefulness, to mention just a few (LOW 1987). But it was hardly ever possible to clarify whether the observed EEG-effects were related to the specific psychological activity or to an associated unspecific basic functional state. If today we assume, however, that the EEG of the scalp is the result of a partial synchronization of extended cortical substrates (s 2.2.5.) then it is very unlikely that specific psychological processes, not to mention specific contents, can be distinguished by this method. It seems much more plausible that the EEG allows the distinction of a limited amount of basic functional states that show a predilective but not invariant connection with certain psychological constructs such as those mentioned above. For psychiatry, we can conclude from this that for isolated psychopathological phenomena specific EEG-correlates cannot be expected. But the real question that preoccupies many researchers is whether the different psychiatric clinical pictures can be differentiated through electroencephalography. This question, however, can only be posed if a very specific pathophysiology can be associated with the psychiatric clinical pictures. Following KRAEPELIN's (1886) postulate of dementia praecox as a disease entity in the medical sense - the empirical proof is still outstanding - most researchers assume to this day that there exists real mental diseases that are just as real as for instance diabetes mellitus. However, the numbers of those who point to the decades- long inability to validate psychopathologically clearly distinct syndromes on a neurophysiologic or neurochemical basis and demand a reevaluation or a change of the research strategies are growing

(f. i. CARPENTER et al. 1979; BHROLCHAIN 1979; BOYLE 1990; JACKSON 1990; BENTALL 1990; VAN PRAAG 1990; WEXLER 1992; MAAS AND KATZ 1992). Such desperately needed new approaches are countered or sabotaged by the already criticized promises of an objective classification of disorders through the EEG. Without any proof or argument, it is stated apodictically:"...abnormality profiles are distinct for different disorders" (JOHN 1990). The "abnormality profile" is the result of a statistical comparison between an individual EEG-characteristic and the EEG-characteristic of a "large normative data base." Consequently, R. JOHN, the mathematician and experimental neurophysiologist of merit who was, however, never occupied with clinical psychiatrics, named his automatic classification system "neurometrics" which may be methodically incontestable but which is methodologically inappropriate. We have tried, in illustration 1, at the example of schizophrenic psychoses to show the psychiatric reality which differed from his view. The model claims to be valid also for all other psychiatric disorders.

As shown in illustration 1, the EEG-parameters to be determined for the 3 patients are always within the interindividual variation range of a healthy control population - even if there is a state-specific shift in the characteristic values.

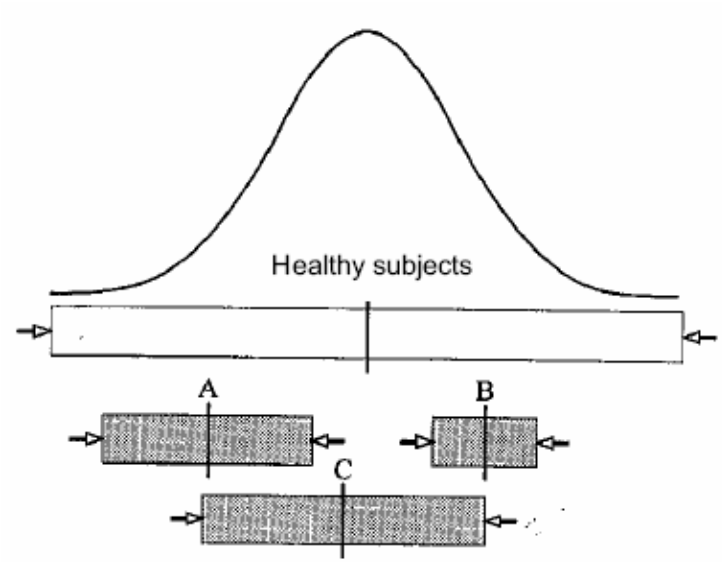


Illustration 1. The intraindividual electroencephalographic variation range of the 3 schizophrenic model patients A, B and C in relationship to the interindividual electroencephalographic variation range of a control population of healthy subjects ("normative data base").

This seems to preclude the diagnostic classification of an individual patient in relationship to a healthy control population. Since the interindividual variation range of a population of schizophrenic patients - not shown in illustration 1 - should be clearly greater than that of a population of healthy people (GARMEZY 1970) it seems quite possible to arrive at a statistical discrimination between the schizophrenics and the healthy people as groups. For the classification of individuals - the only classification that is of interest for clinical purposes - this fact is unimportant.

> "We have tried the 'specific disease, specific biology' approach for 40 years without much success. Let us consider a change. It is time to say 'The emperor has no clothes!'." (MAAS and KATZ 1992).

The new approach must begin with the definition of disease in the psychiatric sense. Contrary to symptoms, diseases are not phenomena which can be perceived with our senses and therefore, they are theoretical constructs (s. a. 2.2.2.). The latter, however, are derived or developed from the former. As mentioned earlier, the validity of a theoretical construct depends on how far it is really derived from an observable pattern and allows for new observations. Diseases show a great variety of grades with regard to their construct validity. As a general rule the construct validity is lower the more variable the disease appears in all its aspects. Therefore, diseases can be put in order according to their construct validity. On top there would be death-cup poisoning, in the medium range we would find lues cerebrospinalis and multiple sclerosis while the schizophrenias as well as the other psychiatric clinical pictures are to be placed further down. The name assigned to a disease can hide such differences. The self-deception involved is also called nominalism or reification (s. a. ULRICH and HEGERL 1989). Naming "diseases" - such as dementia praecox - gives them a life of their own with real-ontological status, just like the demons of which one once thought sick people to be possessed. Disease is something one either has or does not have, something that joins the healthy person and changes him or her. This is exactly the picture that characterizes our problem. It is not very surprising at all that clinical practitioners have not developed an awareness of the problem since this has no consequences for the therapeutic practice which is their primary occupation. For the researcher whose task it is not to fight symptoms but to arrive at an external validation of the theoretical constructs „diseases", however, it has disastrous consequences if he falls into the trap of nominalism.

In medicine, a certain set of symptoms is recognized as "disease" only when it appears in connection with an objectively and reliably measurable phenomenon. One of the reasons for the persistent interest of psychiatry in particular in the external validation of psychopathological diagnoses might be that it has had to fight from its early beginnings until today for its recognition as a medical discipline. It becomes increasingly clear that the construct validity of our diagnoses is simply too small to make the search for associated pathophysiological mechanisms seem potentially successful. The intensive efforts to define purely clinically homogeneous subgroups - like the positive/negative or acute/chronic dichotomies - have also yielded hardly any results. However, whether neurophysiologically or neurochemically defined subgroups can be

distinguished clinically remains to be investigated. Despite discouraging failures, today's research strategy still consists of comparing one inevitably heterogeneous group of "normal persons" to a psychopathologically homogeneous but in other aspects also inevitably heterogeneous group of psychiatric patients. Only recently, WEXLER (1992) talked about the "pathobiological heterogeneity" of psychopathologically homogeneous samples. Of a more recent date is an editorial by MAAS and KATZ (1992) stating that although RDC and DSM III have improved the diagnostic reliability, they have not contributed to the clarification of pathophysiology: "Perhaps we have been looking in the wrong places or in the wrong way." We also will have to take into account that differently diagnosed syndromes do not necessarily correspond to an equally different pathophysiology but that the differences in the clinical picture are caused by individually different compensation strategies. For why should endogenous psychoses be any different from exogenous or model psychoses where the relationship between the respective symptoms or syndromes and the premorbid personality has been recognized long since (BONHOEFFER 1912; SCHROEDER 1912; BIRNBAUM 1928; LEUNER 1962; WALTHER-BÜEL 1968)?

In their introduction to the German version of the Diagnostic and Statistical Manual (DSM III) of the American Psychiatric Society, KÖHLER and SASS (1984) expressed their confidence that the diagnostic precision guaranteed through DSM would become very important for therapy planning. We cannot share in their optimism. In a natural science oriented psychiatry, the search for somatic correlates of psychopathological syndromes must be central. Finding such correlates is the condition for a therapeutic intervention guided by rational principles. Since the revisions of psychiatric classification systems done at the conference table are based mainly on opinions and not on results of research - which continually increases the general confusion (VAN PRAAG 1989) - it is difficult to discover any positive aspects.

> VAN PRAAG (1992) characterized the DSM as a "premature codification of diagnostic concepts and terms" that causes more bad than good. ZIMMERMANN et al. (1989) criticized that in the DSM-system experts first allege a certain classification, and only then are researchers allowed to examine its validity.

DSM III confronts us with a renaissance of early-Kraepelinian, and actually long ago obsolete, conceptions. Excluding the basic problem of construct validity of psychiatric "diseases," the creators of DSM III postulate implicitly that a finer operationalism will suffice to arrive at valid disease categories. In the face of the hurried obedience at the introduction of the respective latest versions of psychiatric classification systems noticeable everywhere, HEIMANN (1986) sounds like the preacher in the desert when he warns that "the fixation of psychiatrists with nosologic specificity complicates a deeper understanding of the relationships between the psychopathological level and the pathophysiological foundations" (transl.

from German). The main problem psychiatry is grappling with lies in the difficulty of relating data of the behavior/perception level with neurophysiological/neurochemical data in a meaningful way [emphasis by the author]. The oft-heard talk about the breathtaking progress in modern psychiatry seems to be incompatible with a statement of such resignation. But if we take a closer look, we realize that all this lauded progress has nothing to do with HEIMANN'S basic problem. Although we have today an impressive multitude of data and knowledge in all kinds of partial areas, we cannot fool ourselves into thinking that we have learned much about the core problem, the pathophysiological validation of psychopathological syndromes. Even the concentration of the biological-psychiatric research efforts on the central-nervous biochemistry and especially on transmitter mechanisms did not make any change. For the transmitter-oriented researcher psychopathology is nothing but disturbed psychochemistry. Since certain symptoms or symptom complexes can be influenced by interfering with certain transmitter mechanisms, they can be reduced to quantitative deviations of the respective transmitter mechanisms, so goes the argument. Therefore, the pathophysiological validation of psychopathological syndromes can only occur through detailed research of the psychochemistry. Contrary to the current trend, this logic does not seem at all compelling to us but rather erroneous. As far as we can see not a single one of the different transmitter hypotheses could do any justice to the complexity of the psyche. Like wooden paths that start out wide and open, these approaches so far always ended in an impenetrable thicket. The reason for the continued attractiveness of the transmitter-psychiatry probably lies in the fact that contented with partial hypotheses and persevering in bustling modesty, it never raises its eyes to the complex whole that might cause feelings of insecurity. In addition to this, costly lab technology that even investigates the molecular field is still equaled to being truly scientific.

> From an historical perspective, transmitter-psychiatry is a modern variation of the old humoralpathology. For the humoralpathologists, medical thinking was equal to thinking in fluids. Disease was, as a matter of principle, considered a disturbance in the composition of fluids, a dyscrasia. All symptoms would be, as mere ephemeral occurrences, attributed to dyscrasia. Proof for a secret renaissance of this doctrine seems to us the almost compulsive reflex noticed in scientific discussions to switch from the clinical but also neurophysiologic level to the neurochemical level.

Contrary to the predominant paradigm, we consider the transmitters not as determinants of the psyche but only as mediators.

> ."..the amines, which are themselves servants, so to speak of other ongoing processes" (FREEDMAN 1992).

To us, psychopathology is the manifestation of the certain natural laws following disorganization of a highly integrated functional whole. This, of course, is something entirely different from, for instance, a changed synaptic sensitivity to

serotonin or even a whole complex of such partial disturbances which influenced each other. That in psychiatric syndromes a multitude of such partial disturbances can be determined is self-evident. Their proof depends solely on the availability of appropriate procedures and, therefore, on the general state of the technological-scientific development. However, its mere feasibility is far from being an indication for a progress in psychiatric knowledge! Today's still dominant micro-deterministic "bottom-up" strategy needs a "top-down" strategy that proceeds from the whole to become heuristically fecund. Such a "top- down" strategy must be grounded in an organismic biological theory in its real and deeper sense. This kind of theory is the condition sine qua non for a meaningful relating of psychopathological and somatic data.

Paradoxically, the "biological" psychiatry still believes itself able to do without such a theory. It is convinced of its ability to counter, despite all proclamations to the contrary, the undeniable disproportion between the expenditures and the actual gain in knowledge at the conference table by reviving obsolete nosological postulates. In this situation a reference to the French psychiatrist H. EY, thus far unacknowledged by the "biological" psychiatry, seems as much illuminating as contemporary. EY's doctrine, which he also called "organo-dynamic" (f. i. EY 1952) and to which we ourselves owe fundamental inspiration, is rooted in the truly biological way of thinking of the great HUGHLINGS JACKSON (TAYLOR 1958). According to EY (1952) the usual classification of mental diseases obscured their individual physiognomies instead of accentuating them. According to him, the distinction of "organic" vs. "endogenous" cannot be justified. EY criticized that psychiatry has become stuck in pure note-taking about diseases with an ever more detailed analysis of symptoms as the only progress that can be expected. If one wanted to arrange mental illnesses in a natural order one would have to consider them for what they are, i. e. pathological phenomena that correspond to a certain "dissolution level" (niveau de dissolution) or a certain level of "insufficient evolution" (évolution insuffisante or arrêt de développement). The disorganization process is always one and the same, independent of the etiology that can be toxic or infectious, exogenous or endogenous in nature. Mental diseases differ in the depth, duration and the rhythm of this disorganization process. Accordingly, one arrives at groupings that do not conform to any of the conventional diagnoses. The clinical differentiation between organic and endogenous mental diseases is unfounded, according to EY.

> As psychiatric history teaches, EY was not the first to question the distinction of organic vs. endogenous. HOCHE (1912) already called KRAEPELIN'S endeavors towards disease categories fruitless. Around the same time as EY, CONRAD (1959) stated that nosologic classifications in psychiatry are only pictures viewed with expert's eyes for which there exists no definition thus far. Entirely in the spirit of EY, GRIESINGER (1867) viewed the different clinical forms of mental disease as stages of one specific process. He based this opinion on observations of a regular progression from melancholia, mania, madness, confusion to idiocy. In this context the phenomenological regularity in the development of a schizophrenic bout, described by CONRAD in great detail, must also be mentioned. Numerous other authors provided convincing empirical proof that the separation of endogenous and exogenous

cannot be justified (f. i. SCHNEIDER 1929; BÜSSOW 1939, 1944; ALBERT 1950; BARAHONA-FERNANDEZ 1956; LLOPIS 1960; ZEH 1962).

EY concluded from JACKSON'S central idea: "illness does not create" that somatic correlates could not be "disease-specific." They could only be modifications of normal-physiologic functions. The focal point of interest for EY is here the transition from wakefulness to sleep. There, all dissolution levels observable in psychiatry can be watched in more or less fleeting states, like in statu nascendi. EY (1967) postulated furthermore a common time structure of "destruction of the field of consciousness" on the one hand and the subvigilant intermediary stages that can be delimitated in the EEG on the other. We consider this postulate the methodological premise for a psychiatric electroencephalography which satisfies scientific standards. However, apart from a few exceptions, the path pointed out by EY has been ignored. The reservations of clinical psychiatry mentioned earlier with respect to the EEG certainly are at least partially responsible for this. But also in this case, exceptions confirm the rule. In BENTE'S understanding of psychiatry, which was greatly influenced by EY'S neo-Jacksonianism, the EEG was far more than an auxiliary diagnostic tool. He considered it heuristically fecund as a vehicle for his psychiatric thinking and as an instrument indispensable for scientifically conducted psychiatry, as he once expressed it. The conceptual closeness to EY is particularly evident in a study about sleep deprivation (BENTE 1969b). This study conducted with healthy volunteers was aimed at the analysis of the "regularities of the psychophysiological dissolution of functions in the course of time", as it can be observed during a period of complete sleep deprivation of about 100 hours.

Based on the results BENTE concluded, thereby confirming EY, that sleep deprivation is an excellent physiogenic model for the study of psychopathological dissolution levels. The order of dissolution corresponded basically to the one found in an earlier study under central anticholinergica (BENTE et al. 1964a). HEINEMANN (1966) who, like BENTE, viewed long-term sleep deprivation as a "fitting method for causing psychiatric disturbances in an experimentally controlled way", arrived at similar results with regard to the dissolution order. His subjects showed a sequence of symptoms that reached from apathetic irritation, lack of initiative, subdued affections, uncooperative irritability and euphoria, typified by unfocused ideas accompanied annoyance, sinister mood, paranoid ideas, states of depersonalization to disturbed bodily sensations.

As EEG-correlates of sleep deprivation, BENTE'S study revealed an initial dynamic labilization in the form of a discontinuous breakdown of the background activity with an increase in frequency and duration of low-voltage subvigilant activity stages (s. a. 2.2.5.), corresponding to a stage B1. With increasing duration of sleep deprivation, more and more sequences of high- voltage slow waves were observed, corresponding to a subvigilant stage B3. Different from the resting EEG of a well-rested person, where such sequences appear only with increasing recording time, preceded by a disintegration of the alpha-rhythm, they were observed here already at the beginning of the EEG, originating immediately from the background activity. Such findings seem to verify explicitly the validity of EY'S conception. Therefore, further

systematic studies of a theory-based correlation of psychopathological dissolution levels and the EEG would have been equally justified and desirable. We are thinking here in particular about longitudinal examinations in psychiatric patients. That such studies directed at the dynamics of the underlying process - except for a few singular attempts (e. g. HELMCHEN 1968) - are still missing is certainly a severe shortcoming. A primary reason for the lack of impact of EY's ideas might be that the psychiatrist feels more comfortable with disease classifications that are oriented toward the medical model than with an approach that is rather far removed from the relatively pragmatic way of thinking of the physician. Furthermore, EY was published mostly in French, and getting a complete grasp of the contents sometimes requires a particularly great effort. EY probably would have met with greater resonance if he would have countered the "mere medical note-taking", criticized by him, with a systematic representation of dissolution levels

Illustration 2 is such a systematic presentation. It is based on observations of typical reversible exogenous psychoses. In contrast to the modular models that have regained popularity especially over the past few years (FODOR 1984), this is a dynamic-integrative model. This means that we can, for instance, talk about a decrease in drive only as long as the dissolution process is limited to superficial functional levels. Once deeper functional levels are affected, the decrease in drive will no longer be recognizable as such, although one can imagine it to be part of a delirant symptom. Despite its hierarchical order it would be a mistake to view this sequence as strictly successive.

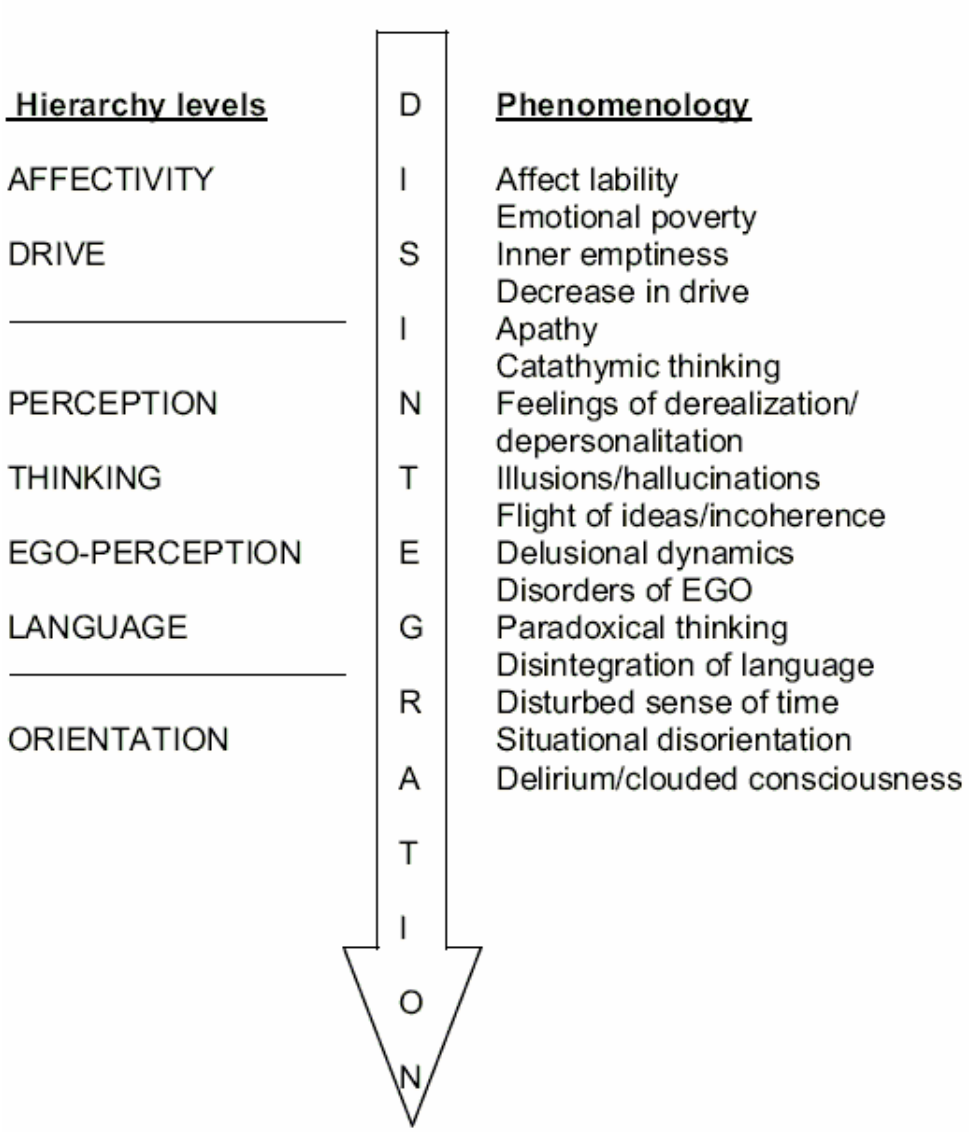


Illustration 2. Psychopathology as disintegration of the psyche.

Since psychopathological syndromes are complex dynamic structures, we must assume that symptoms associated with different dissolution levels can also appear simultaneously. But because of the proportionally different distinctiveness of the symptoms, a characterization and consequently an assignment to a specific dissolution level is usually possible. However, this does not say anything about the possibility of distinguishing between endogenous and exogenous. With respect to this, BONHOEFFER'S frequently confirmed dictum "that a clear and complete symptomatologic distinction of the exogenous symptom pictures from the psychological one, otherwise known as endogenous, is not fully feasible" (transl. from German) is still valid.

The quintessential conclusion of the above which determines our research strategy is that it is not very promising to use clinical diagnoses to look for EEG-correlates - a procedure propagated for instance by SMALL (1987) in close relationship with DSM III. Even the argument that different studies conducted about the same topic are comparable only if unified psychopathological classification conventions are observed is not compelling to us. A comparability of clinical pictures by no means indicates the comparability of the associated pathophysiological processes. The argument of comparability, however, presumes a one-on-one classification of clinical picture and process. Since this condition has been proved to be wrong, the research strategy based upon it cannot be correct either. In total agreement with the denosologization of biological psychiatry demanded lately by VAN PRAAG, we must consider the full range of variations of psychiatric disturbances and conscientiously keep the diagnostic criteria for inclusion or categories open and flexible. In a following step an attempt must be made to arrive at pathobiological groupings, possibly through the EEG. Through those patients who at a certain point in time show a specific clinical-electroencephalographic constellation of characteristics, one must attempt to arrive at statements of general importance. These also will help a more rational approach to therapy since rigid medication patterns cannot do justice to the dynamic variability of the underlying pathophysiological process (ULRICH and GAEBEL 1987).

The fact that research which complies with the methodological requirements established here is so rare may have its basis in the popular practice that the results of research are published only if they conform to the presently popular classification conventions (see above).

The correlation of clinical dynamic course and electroencephalographic features is complicated by the fact that as a matter of principle all state-related varying EEG-features ("state"-indicators) also can occur state-invariant, i. e. constitution-related ("trait"-indicators) (s. a. 2.2.5. and 3.1.). State-invariant features which are different from the physiomorphological picture in the adult can be viewed as indicators of a brain-functional maturation deficit if they correspond to a certain infantile or juvenile stage of development. We also will have to remember constantly that the distinction between state and trait characteristics is only a model-schematic one. Naturally even "trait" characteristics vary more or less clearly within certain

limits and from case to case depending on the actual functional state. Thus certain "trait"-characteristics which are kept in latency by means of compensatory mechanisms only become apparent after passing a certain threshold of functional deterioration. Finally, we have to consider the possibility that certain trait-characteristics indicating a maturational deficit disappear belatedly.

In summary, we can state that the development of the psychiatric EEG involves much more than the specific adjustment of a long-known tool to clinical-psychiatric necessities. Insofar as psychiatry must be adjusted to the EEG we are confronted at the same time with a genuine psychiatric undertaking. The fact that until today it has not been possible to introduce the possibility of a psychiatric EEG into general awareness probably has its reasons to a significant extent in the fact that the EEG has been and still is considered by clinical psychiatry more as an insignificant auxiliary tool borrowed from neurology for the exclusion of neurological disturbances than as the essential psychiatric tool for research for which it was originally introduced in psychiatry.

2.2.5. The EEG as Indicator of Vigilance and Maturation

A first step towards a theoretically founded electroencephalography was taken by LAIRY and DELL (1957). The HEAD construct of "vigilance" (HEAD 1923) played a decisive role in their work. Another clearly distinguishable influence is H. JACKSON and the proximity of the authors to EY. The electroencephalographic pattern dynamics were considered by LAIRY and DELL as an expression of the global functional state as well as of the maturity state. The global functional state (état fonctionnel global) is to be considered the equivalent of H. HEAD'S "vigilance." The authors point to certain passages of HEAD'S original work which are a clear indication that this term did not stand for psychological facts such as a behavioral state or a behavioral disposition. "Vigilance" had "une signification trés générale." The equation with alertness or wakefulness, tempting because of the word stem, was erroneous. Vigilance would be indicated by the spatio-temporal patterns which were discernible in the EEG under the usual resting conditions, i. e. the organization level and by the dynamics of transition between these levels, occurring spontaneously under the so-called resting conditions (see below).

The distinction between waking and sleeping conditions, therefore, seems to be of subordinate importance. D. BENTE adopted this approach, published exclusively in the French language, developed it and demonstrated its fecundity, especially in the field of pharmaco-electroencephalography (BENTE 1961, 1964a, 1964b, 1979, 1981, 1984). As explained by BENTE the pharmacogenous and the pathological "Form- und Funktionswandel" (change of morphology and function of the brain- electrical activity) is dominated by a certain order of succession that is superimposed to artificially isolated features. The respective order represents a modification of the physiological process of falling asleep or waking up. This is a clear rejection of the old practice of the arbitrarily isolating analysis of features that ignores the morphological context.

> "Since the EEG is a complex structure of a variety of features, all attempts to consider or measure the individual features without regard to its structural relationships harbor the risk of wrong conclusions that might have grave consequences" (BENTE 1961, transl. from German).

The condition for a psychophysiological electroencephalography was for BENTE an exact knowledge of the chronological sequence of transformations of brain-electrical activities regularly observable during the transition from wakefulness to sleep (BENTE 1981). Referring to LAIRY and DELL (1957) BENTE postulated a correspondence of this sequence with a decrease/increase of differentiation and availability of environment-related behavior.

This postulate represented for him the fundamental paradigm of a psychophysiologically oriented electroencephalography (BENTE 1984). Because for BENTE the crucial information resided in the spontaneous vigilance dynamics, the EEG taken under resting conditions (sitting comfortably, eyes closed, undisturbed in a quiet darkened room) was of central importance. The sleeping EEG as well as the EEG under defined cognitive load were only interesting methodological supplements for him.

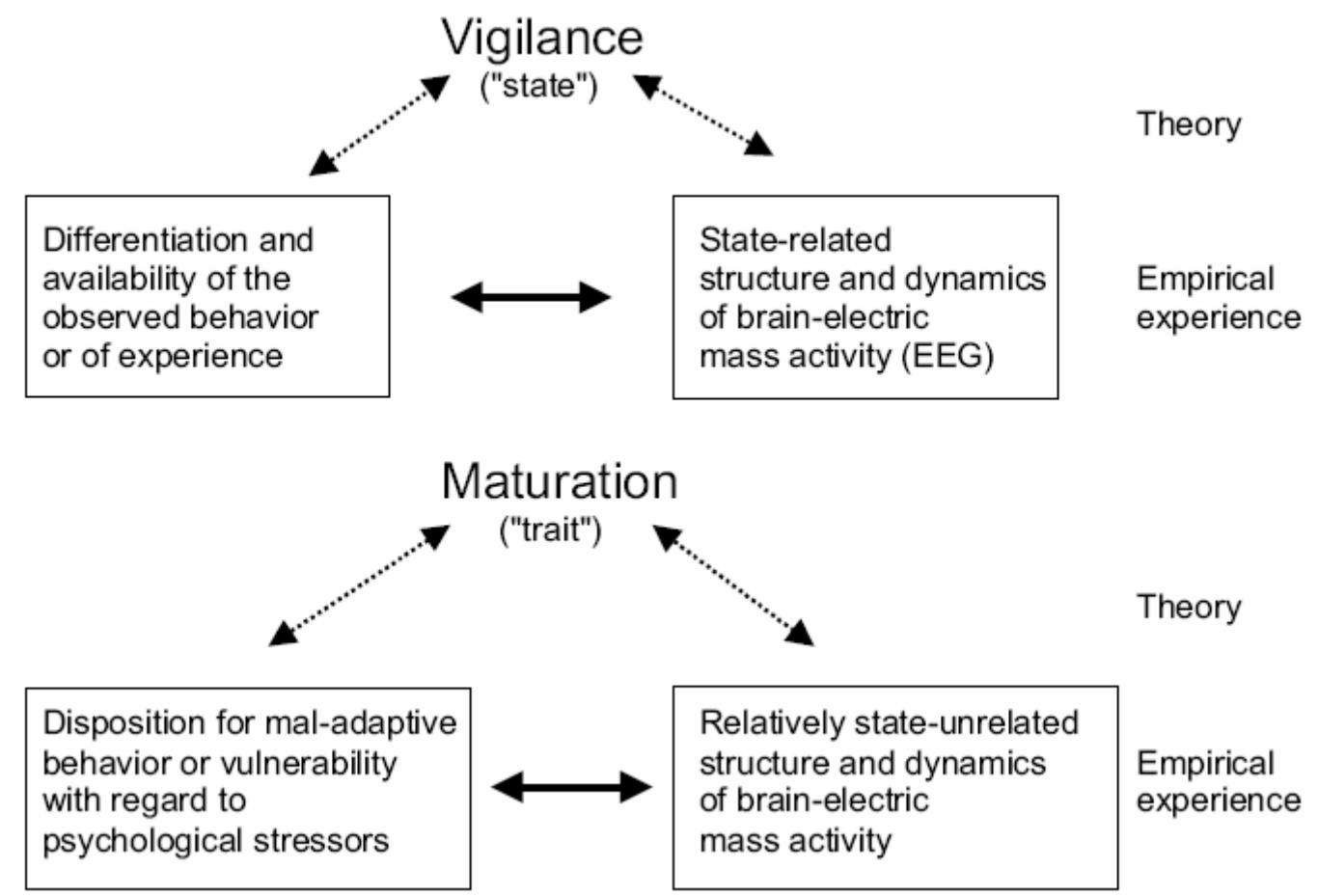


Illustration 3. The significance of the theoretical constructs vigilance and maturation for hypothesis-based empirical research.

"Higher structural characteristics" is what BENTE called the EEG-patterns at the center of interest - complex structures of grapho-elements in a certain arrangement, varying in time and topography. The appropriate instrument for their delineation would be primarily visual gestalt perception (2.2.2.). Dating back to the beginnings of electroencephalography is the

vigilance and sleep including visual classification into stages (stage A to E) by LOOMIS et al. (1937). Later the classification by DEMENT and KLEITMAN (1957) in which the focal point of interest shifted to the sleep (sleep stages II to IV as well as REM stage) gained wide-spread acceptance.

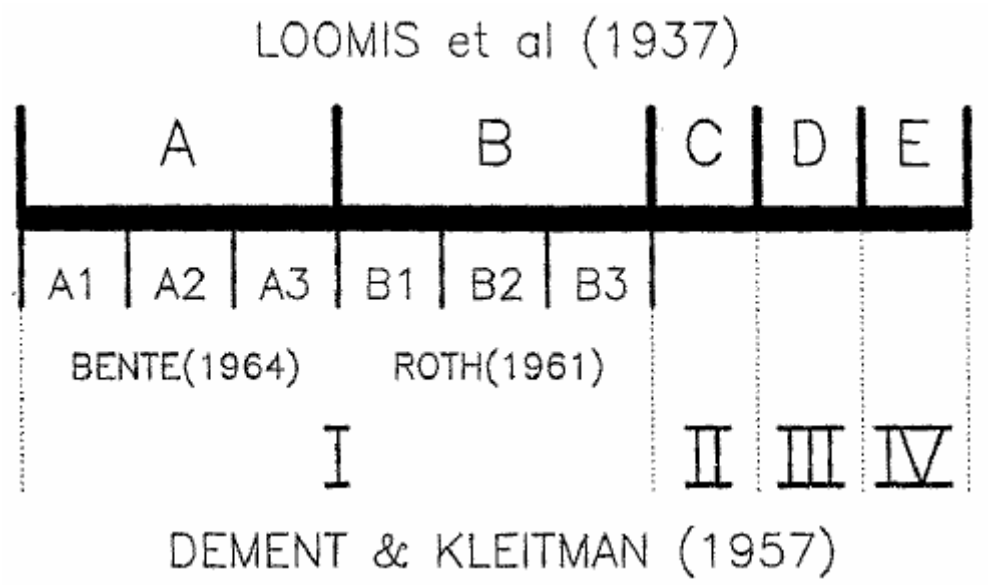


Illustration 4. Synopsis of commonly used visuo-morphologically defined classifications of the EEG-stages passed between relaxed wakefulness and deep sleep.

This development might have been inspired by the thought that sleep is physiologically a better defined state than wakefulness. But through the introduction of a certain framework of conditions the EEG of wakefulness can be equally well defined, a fact that motivated LIBERSON (1944) to propagate his "functional electroencephalography."

Illustrations 6-24 show the subvigilant intermediary stages which can be observed during wakefulness and have been more clearly defined by BENTE (1964b) and ROTH (1961), as well as at the sleep onset and light-sleep stages.

The international 10-20 system for the electrode placement in illustration 5 is intended for orientation purposes.

In comparison to the initial state - stage A1 - as it appears immediately after closing the eyes in a restful state (illustrations 6, 7) the basic rhythm, i. e. alpha-activity with posterior emphasis shows during the transition to stage A2 (illustration 8):

- a moderate increase in voltage
- a moderate increase in continuity (stability of course)
- a moderate decrease in frequency, more obvious in the anterior than in the posterior ("anterior-posterior frequency dissociation")
- a moderate increase in synchrony
- a moderate anteriorization of the alpha-activity in the mid and frontal regions (ear reference pictures!)

> The degree of anteriorization was originally related to the EEG taken against ipsilateral ear reference (BENTE 1964b). We retain this convention. As the following curve examples demonstrate there exists frequently a more or less distinct discrepancy between the reference and the source derivation with regard to the anteriorization. In the first case the anteriorization is considerably more pronounced in the majority of cases than in the latter. The opposite is hardly ever noted. Frequently we even also find a distinct anteriorization with reference recording and an equally distinct posteriorization with source recording. Such peculiarities indicate a high intraindividual stability. The furthermore existing distinct interindividual variability leads to the conclusion that the phenomenon of alpha-anteriorization resists the unequivocal neuroanatomical correspondence, i. e. it ignores brain lobe boundaries. While in most cases of anteriorization we are dealing with an ear electrode generated temporalization (TIIHONEN et al. 1991; LU et al. 1992) there certainly exist other cases where the anteriorization actually is more of a frontalization.

The fully developed stage A2 (illustration 10) is characterized by an accentuation of all these tendencies. The criterion for the delineation with respect to stage A1 is the degree of anteriorization with an anterior alpha-amplitude of about the same magnitude as the posterior.

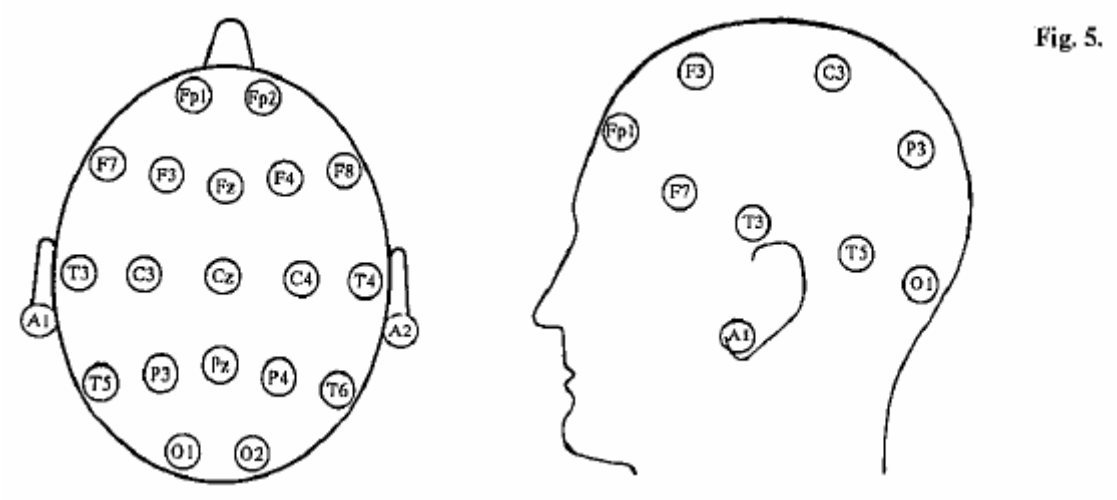


Fig. 5.

Illustration 5. Placement of electrodes according to the International 10-20 System.

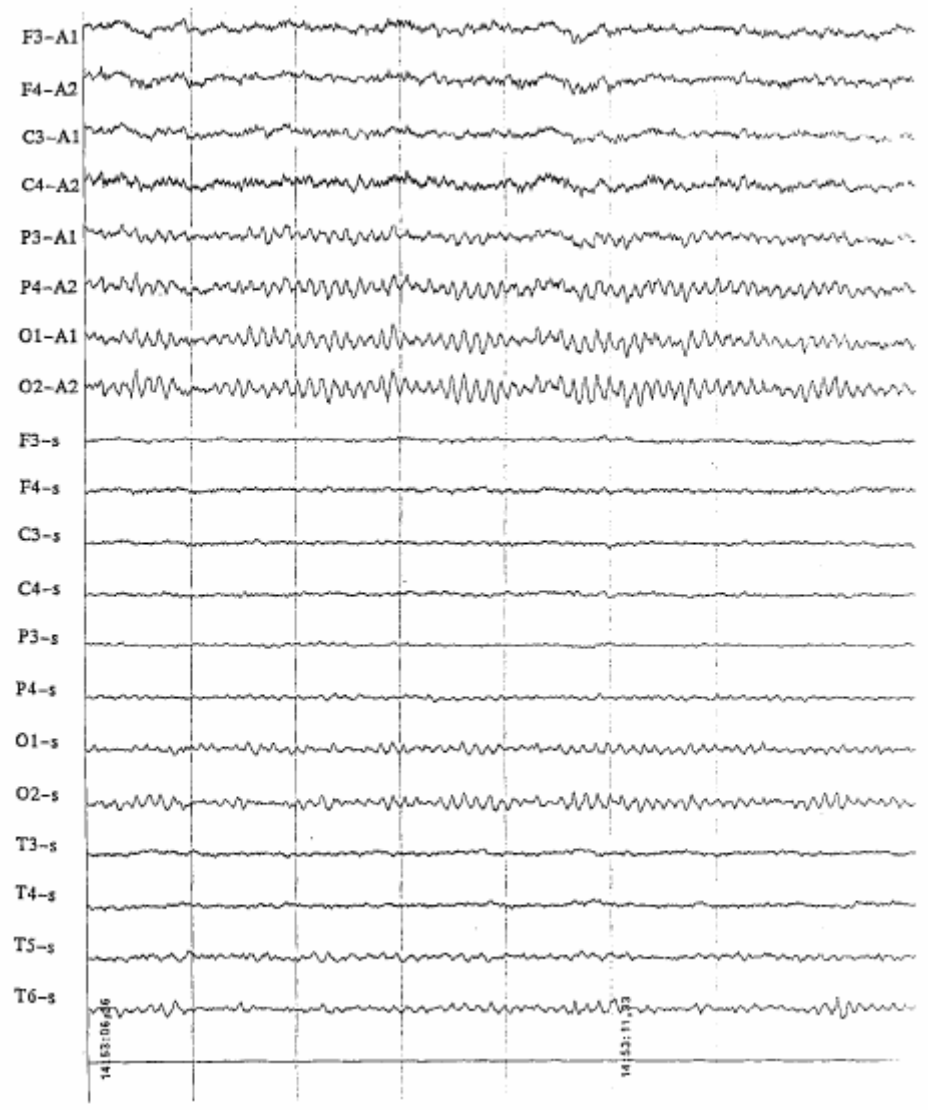


Illustration 6. Stage A1: 8.5/s-alpha-activity that is only represented as posterior (illustration 6-24: identical derivation schema)

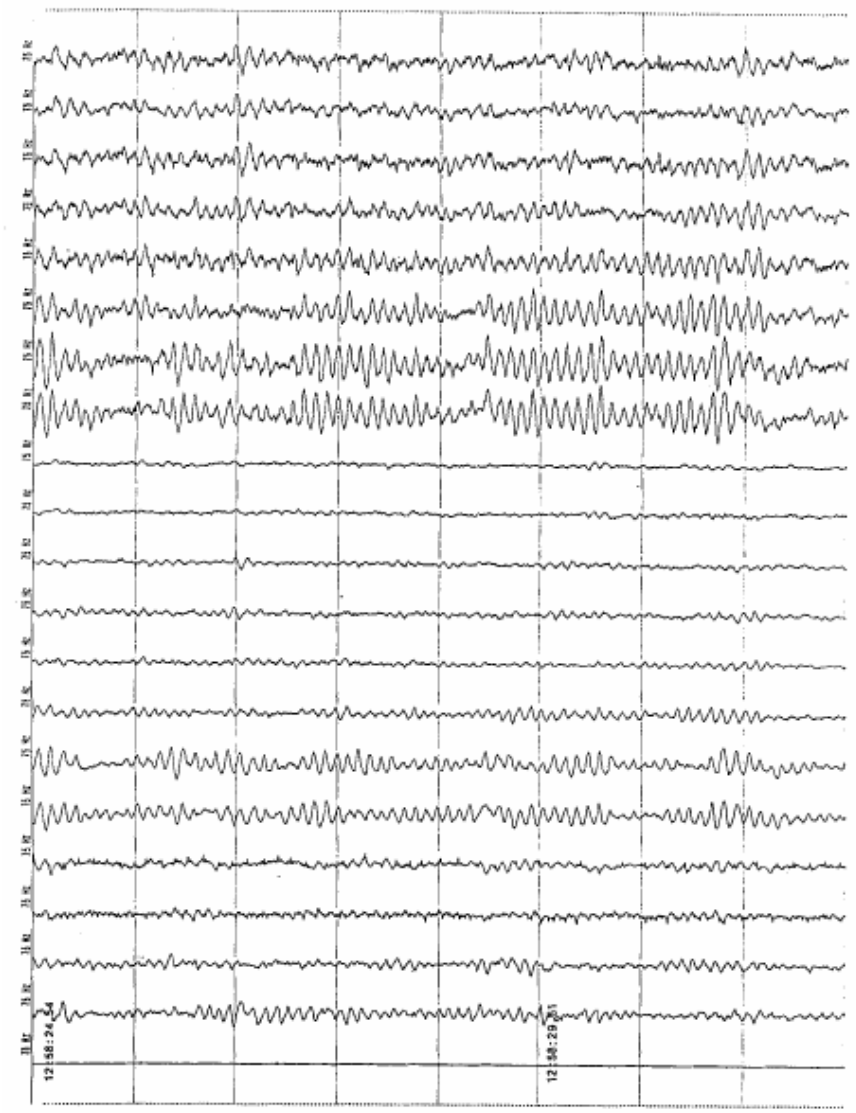


Illustration 7. Stage A1: slightly spindle-like modulated 9/s alpha-activity with posterior maximum. An alpha-rhythm can also be distinguished above the frontal and mid regions but at significantly lower amplitudes than above the posterior regions.

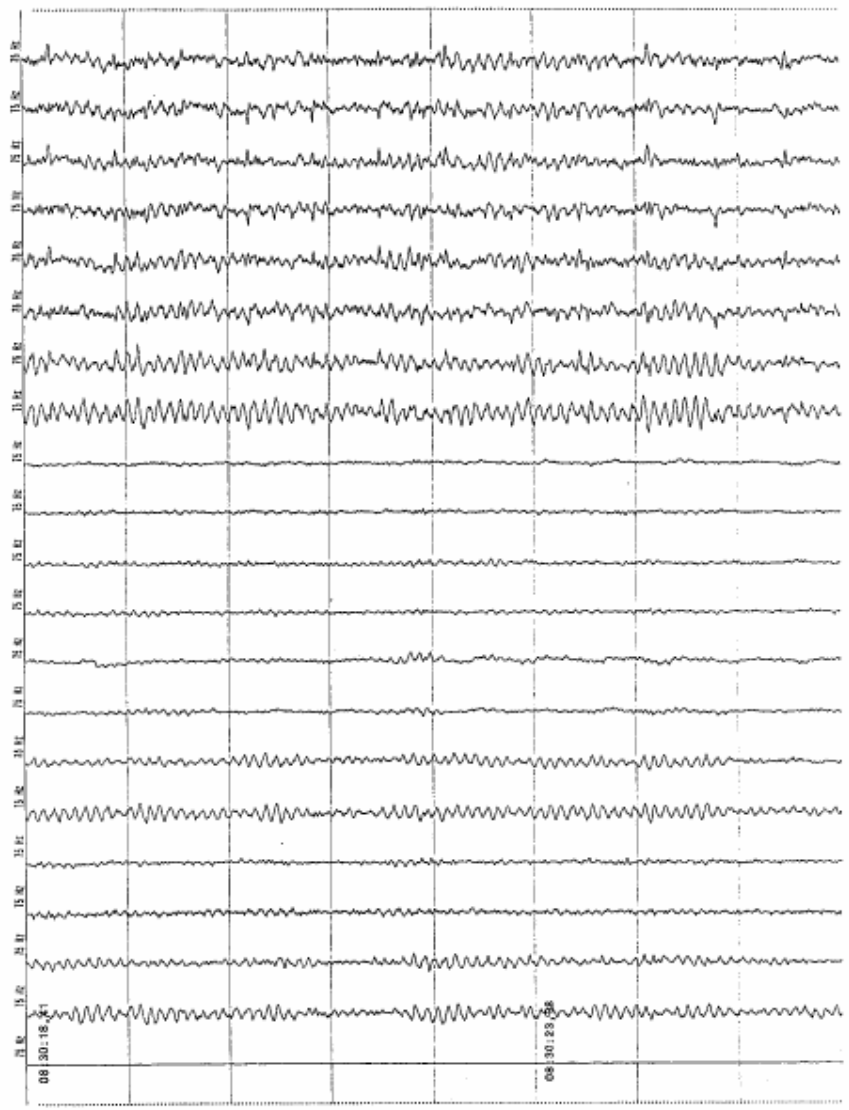


Illustration 8. Stage A1 > A2: 9.5 /s alpha-activity with posterior accentuation during the first 3 seconds showing a spreading to the front in the 5th second corresponding to a stage A2.

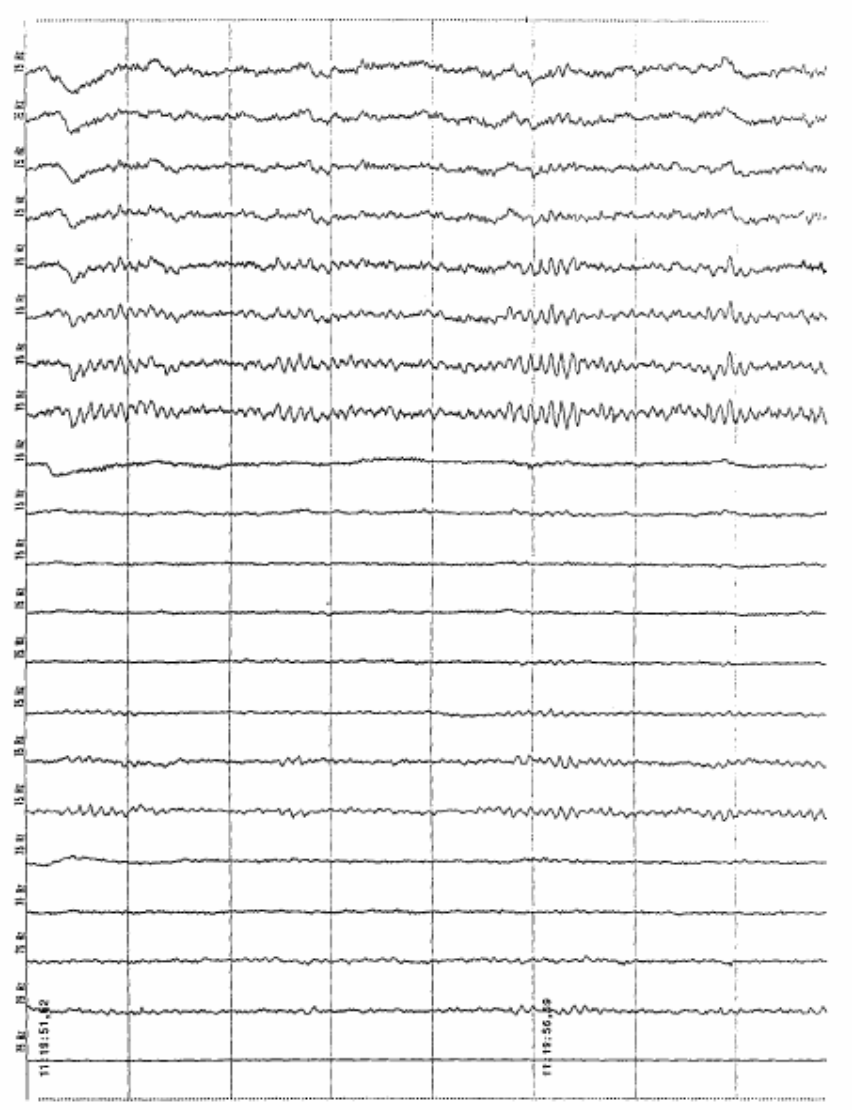


Illustration 9. Stage A1 > B1: discontinuous and posterior-accentuated alpha-rhythm at 9.5/s with transitions into short 1s desynchronized segments of lower voltage (2., 4., and 7. second) corresponding to a stage B1.

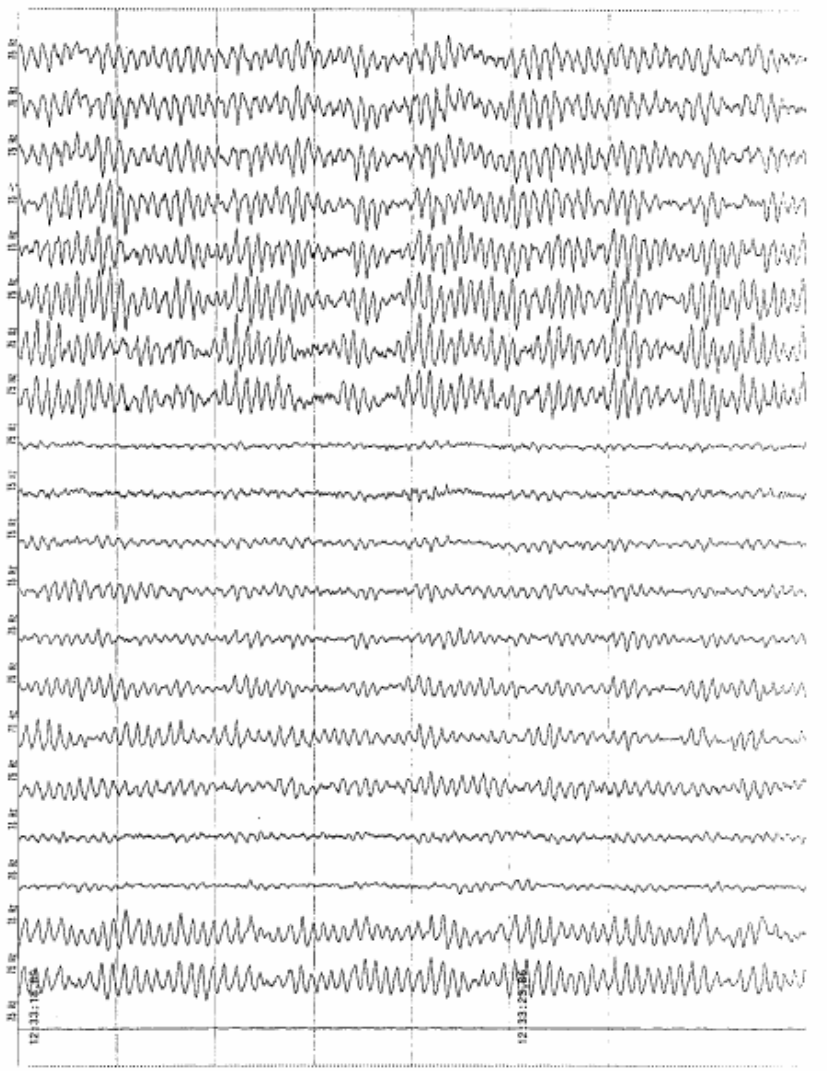


Illustration 10. Stage A2: consistently anteriorized, relatively monomorphous alpha-activity with an anterior-posterior frequency dissociation of about 1,5 Hz (posterior: 9,5/s, anterior: 8/s) exceeding the physiomorphic range. Whereas the anterior-posterior amplitude relation is almost balanced in the reference derivation, the anteriorization in the source derivations appears to be relatively smaller.

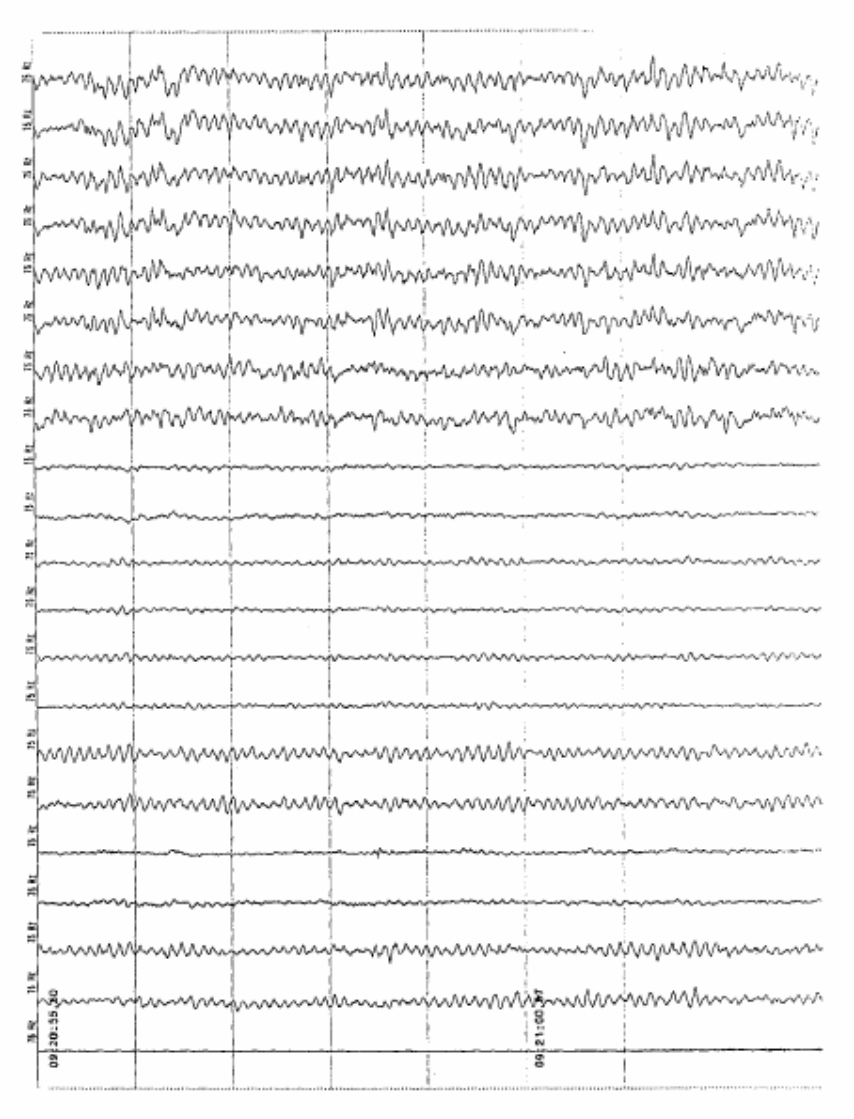


Illustration 11. Stage A2/A3: from the 2nd second continuously anteriorized, frequency-variable 9/s alpha-activity, already showing a slight anterior amplitude dominance. The source derivation, on the other hand, shows a continuous obvious dominance of posterior amplitudes.

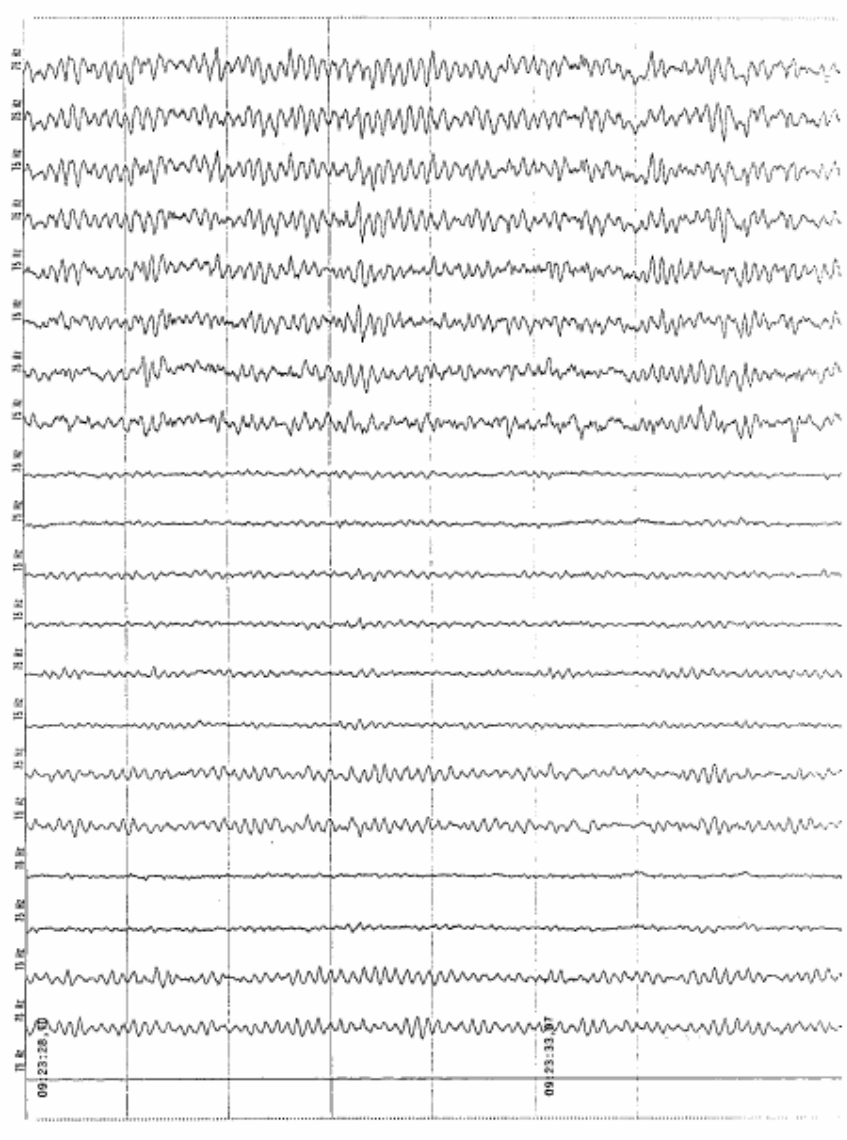


Illustration 12. Stage A3 > A2: obvious anterior amplitude dominance of a 9/s alpha-activity from the 1st to 6th second (not in the source derivations!), followed by a transitional A2 stage.

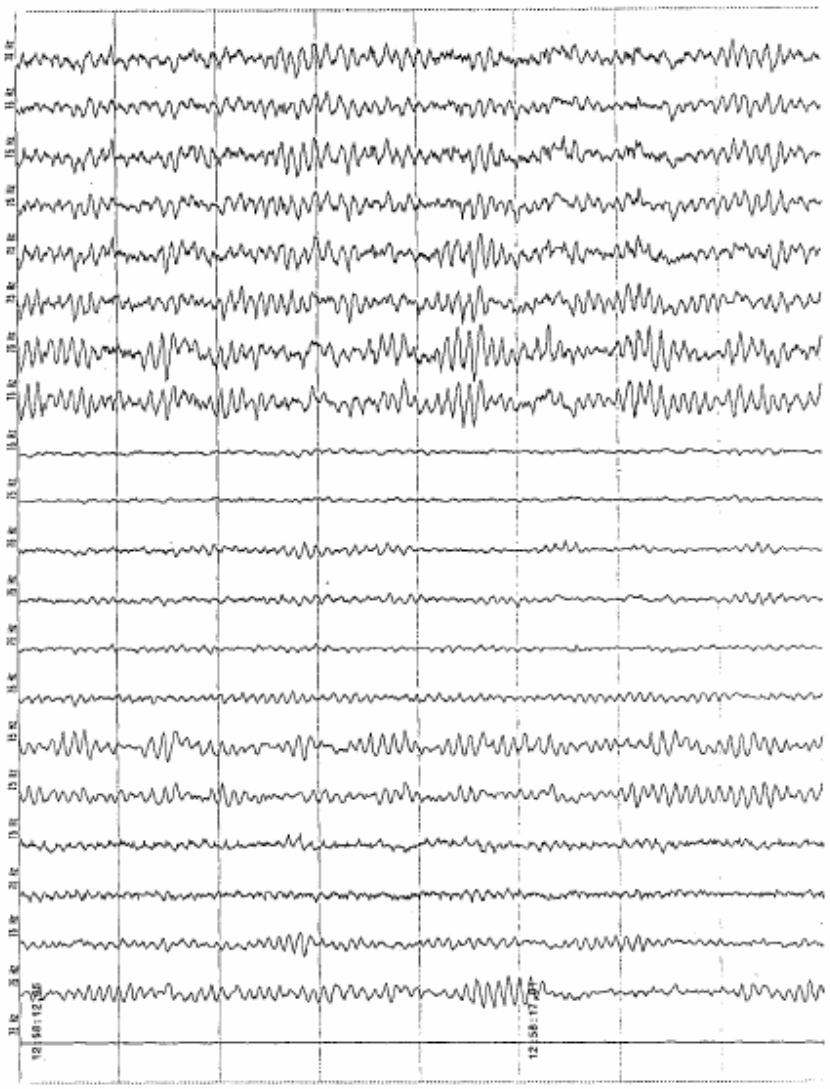


Illustration 13. Stage A1 > A2 > A3: A clearly posterior-accentuated 10/s alpha-activity (A1) spreads in the 2nd and 3rd second to anterior (left-emphasized) with a temporary passing of stage A3 in the transition from the 3rd to the 4th second. From the 5th to the 7th second, there is again a posterior-accentuated alpha-activity, corresponding to a stage A1, followed by another anterior increase in the 8th second (stage A2). The source derivations reflect the topographic changes only vaguely.

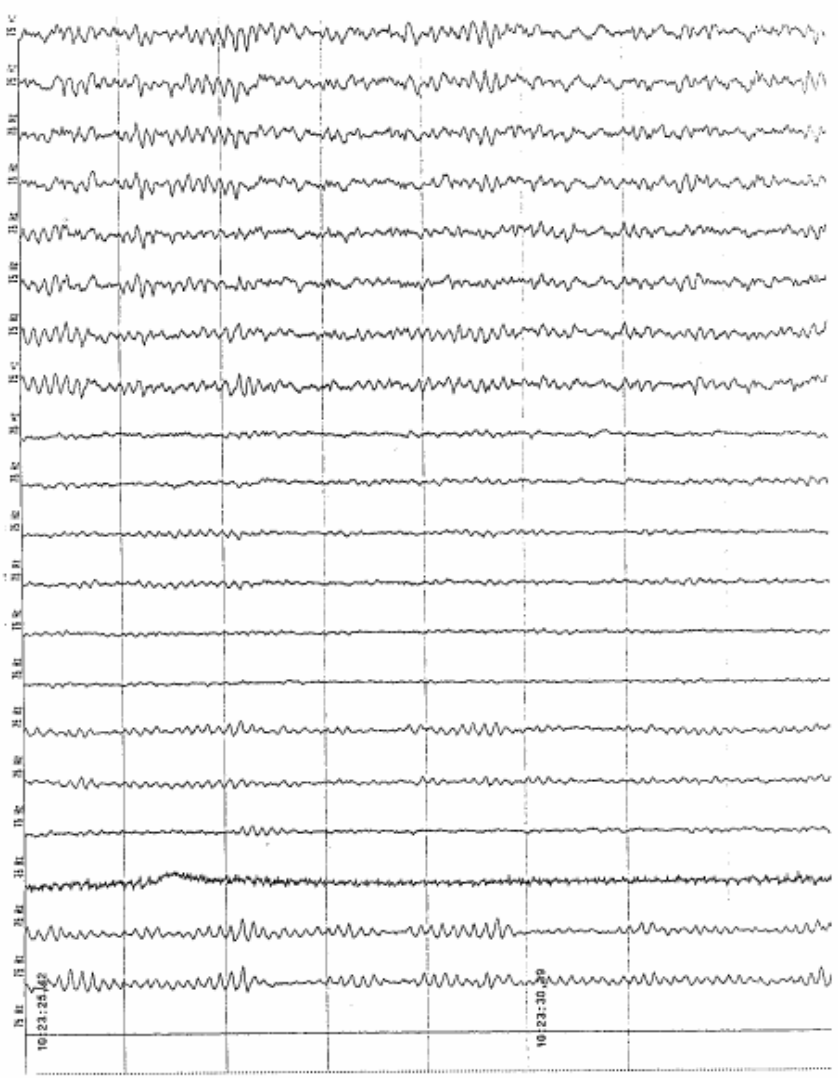


Illustration 14. Stage A2 > A3 .>B1 > B2: the progressive anteriorization with a 9/s alpha-activity (A2-A3) in the first two seconds is followed by the transition to a lower-voltage desynchronized stage of 1,5 seconds, corresponding to a stage B1. An anterior-accentuated alpha-activity in the 5th second temporarily is followed by an irregular theta-activity in the 6th to 8th second (B2).

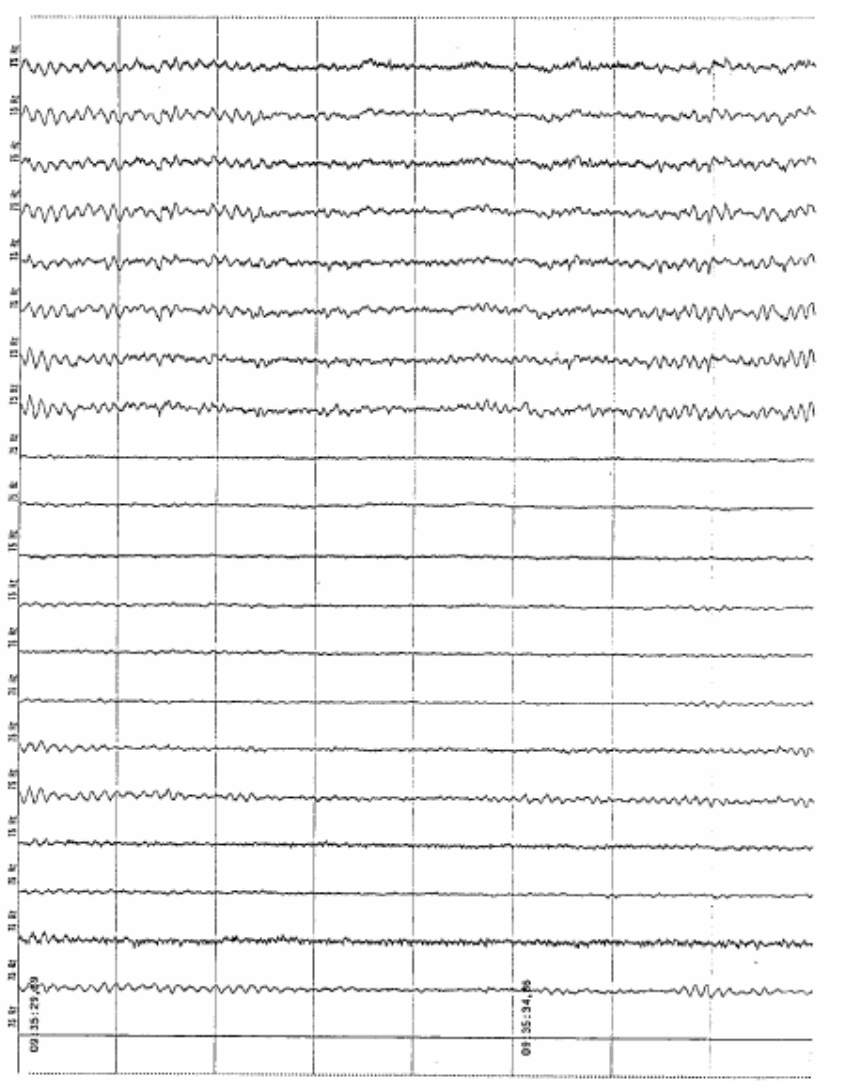


Illustration 15. Stage A2 > A3 > B1 > A1: increasing anteriorization of an 8/s alpha-activity from the 1st to 3rd second (A2, A3), followed by a low-voltage desynchronized stage of activity (B1). In the final two seconds the restitution of a posterior-dominated 9/s alpha-rhythm occurs.

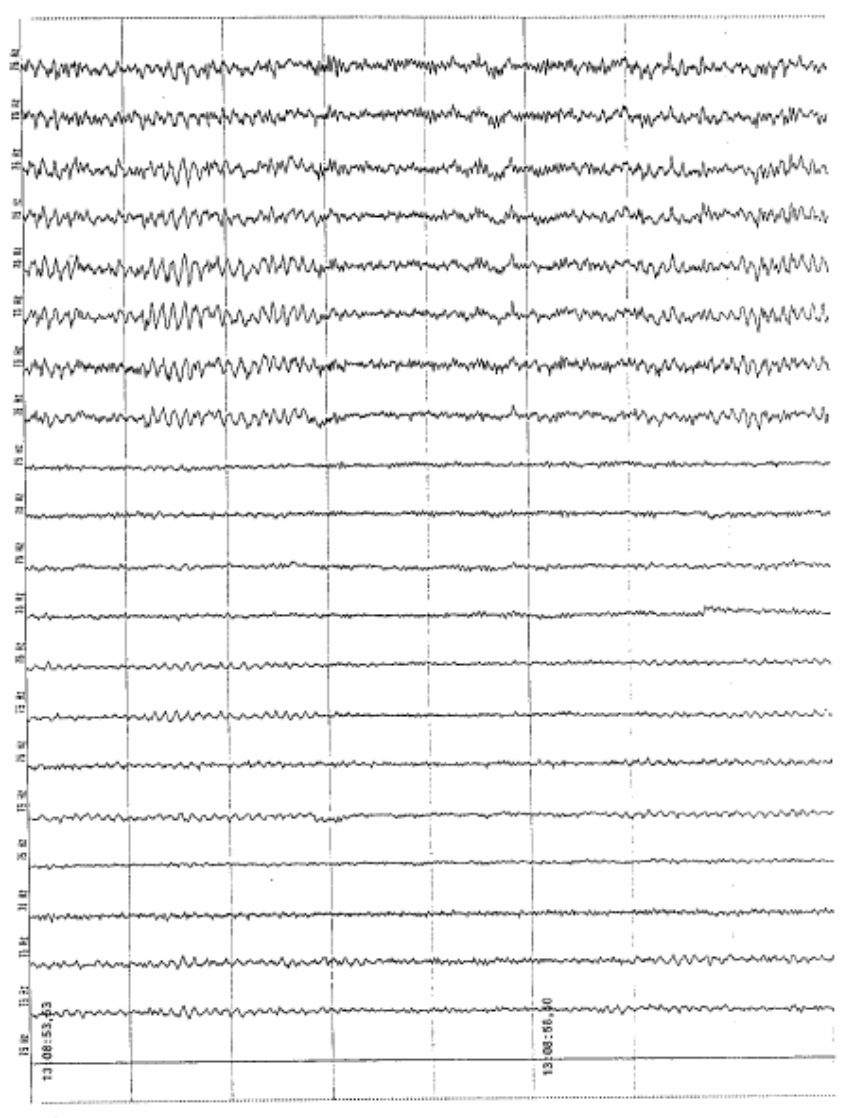


Illustration 16. Stage A2 > B1: A moderately anteriorized 9/s alpha-activity switches abruptly in the 4th second to a low-voltage and desynchronized stage with predominant "sub-vigilant" beta-activity of approximately 20/s. In the 7th and 8th second, the restitution of a posterior-accentuated 9,5/s alpha-activity occurs.

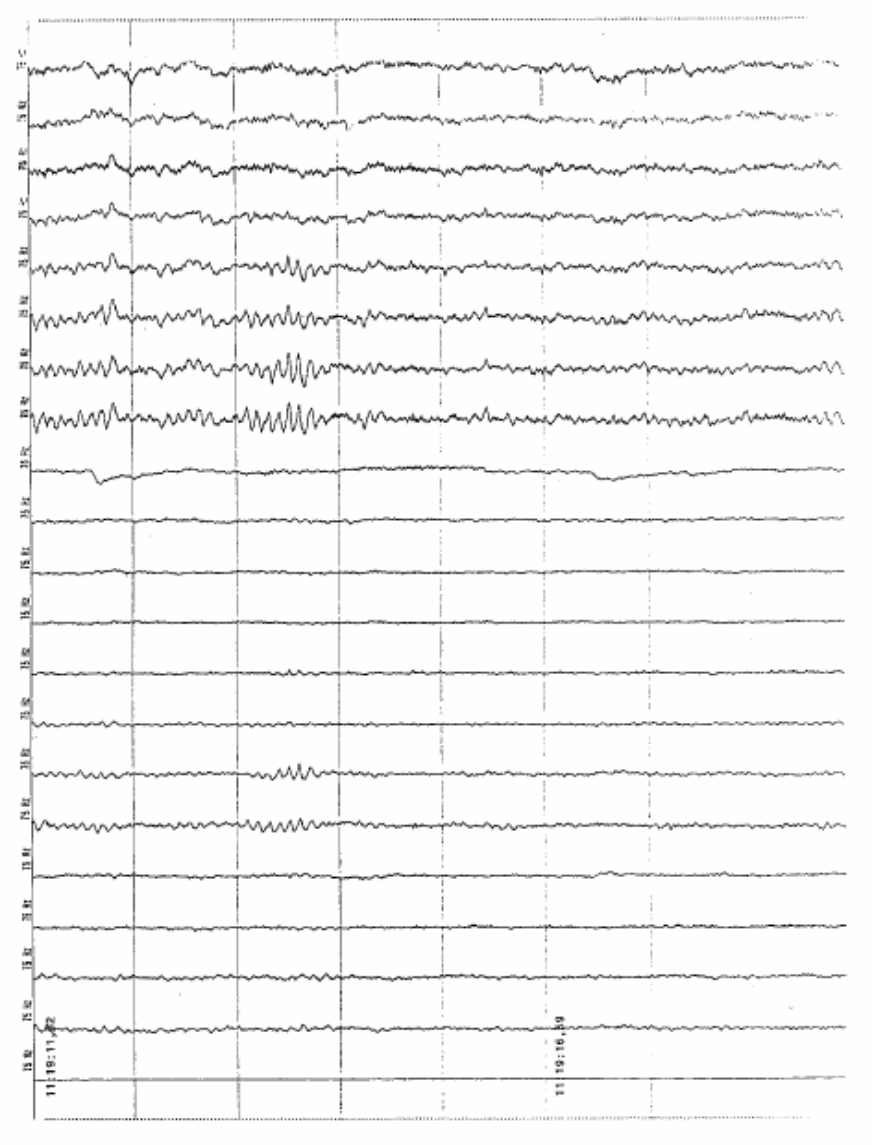


Illustration 17. Stage A1 > B1/B2: abrupt transition, without intermediary mid and late A-stages, of a posterior 9/s alpha-activity (A1) into a low-voltage desynchronized activity with interspersed irregular theta-waves (B1/B2).

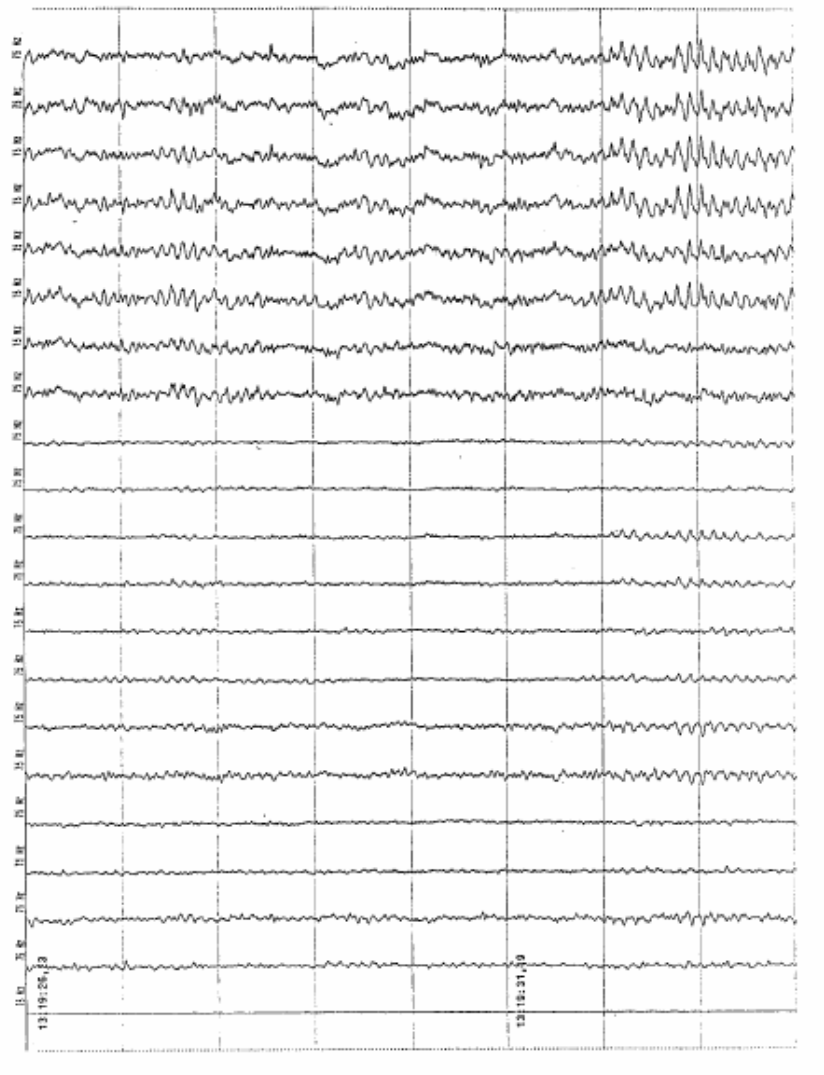


Illustration 18. Stage B1/B2 > A3: After a desynchronized phase of activity with interspersed irregular theta-waves (B1-B2), an abrupt transition to a clearly anteriorized 9/s activity, corresponding to a stage A3, occurs in the 7th second. This anteriorization can also be seen in the source derivations.

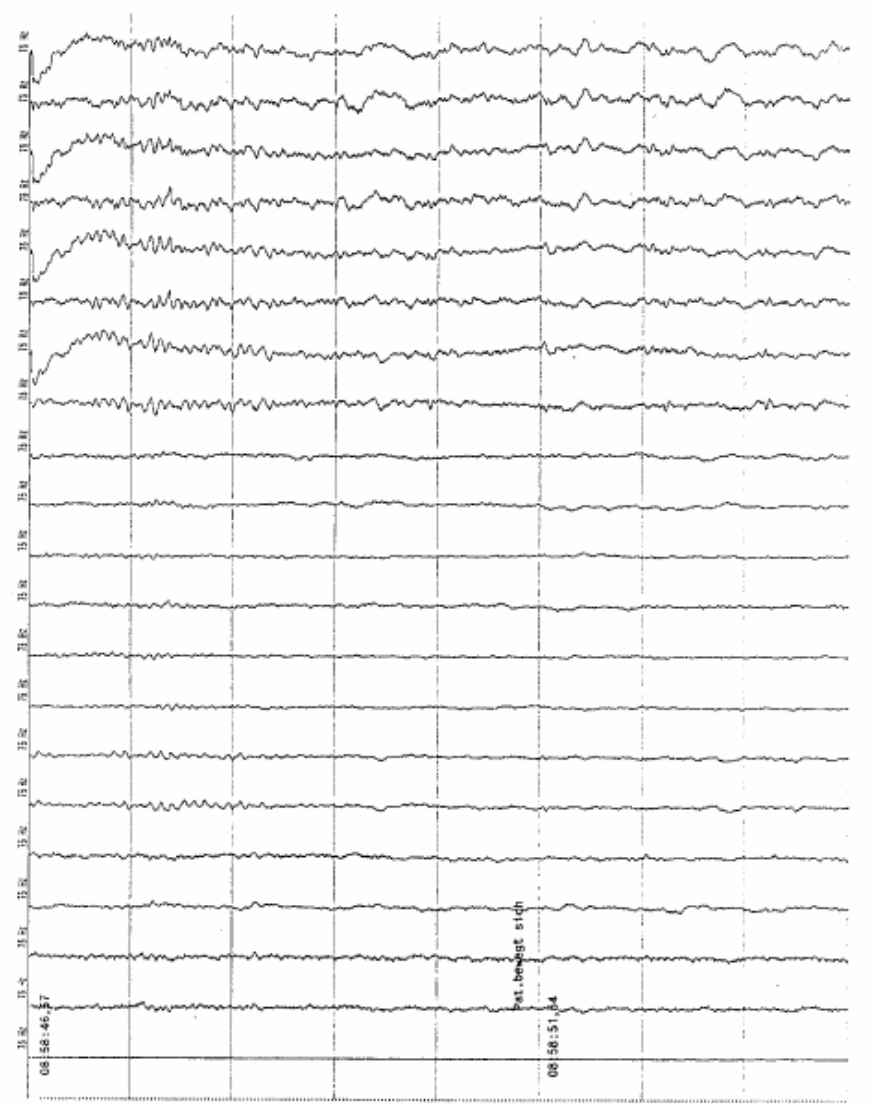


Illustration 19. Stage A2 > B1 > B2 > B3: A moderately anteriorized 9/s alpha-activity (A2) changes in the 3rd second to a desynchronized stage (B1) into which, from the 3rd second theta (B2) and anterior-accentuated delta-waves (B3) are interspersed.

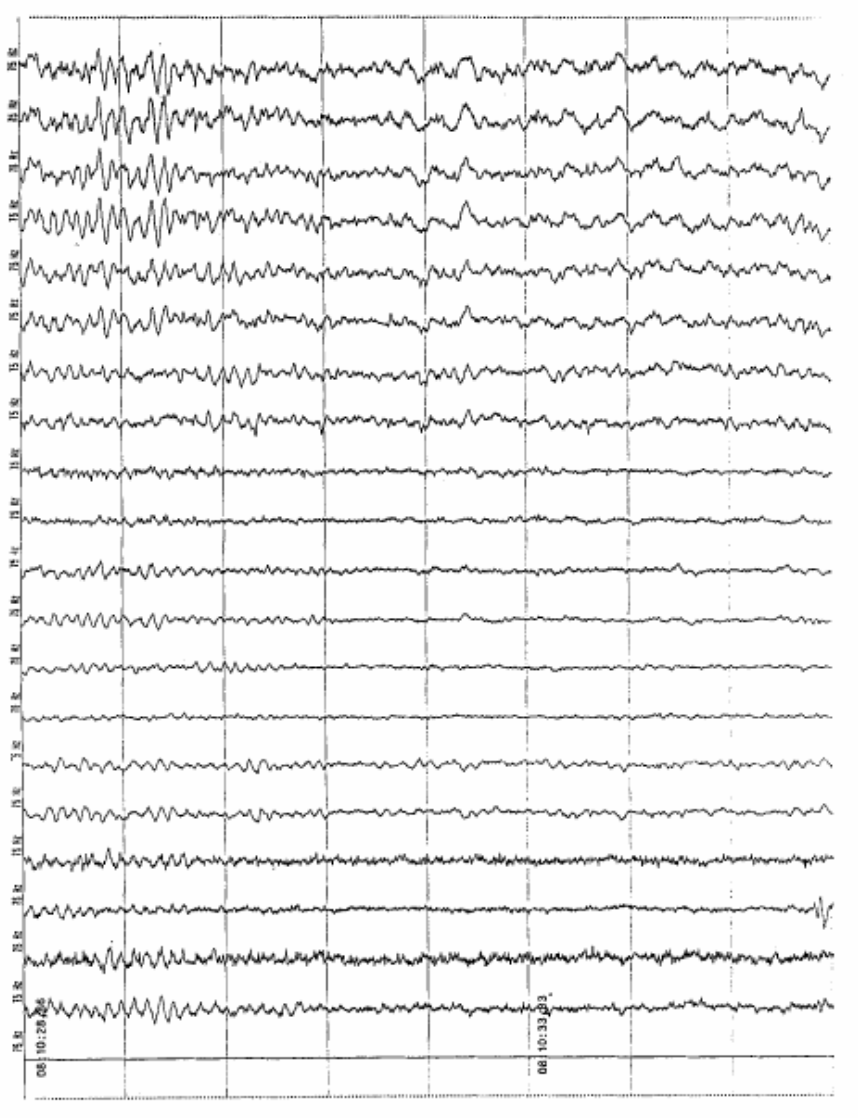


Illustration 20. Stage A3 > B1 > B3: A relatively slow anterior-accentuated 7-8/s activity (A3) changes in the 3rd to 4th second via a temporary stage of desynchronized activity (B1) into an anterior-accentuated irregular delta-activity (B3).

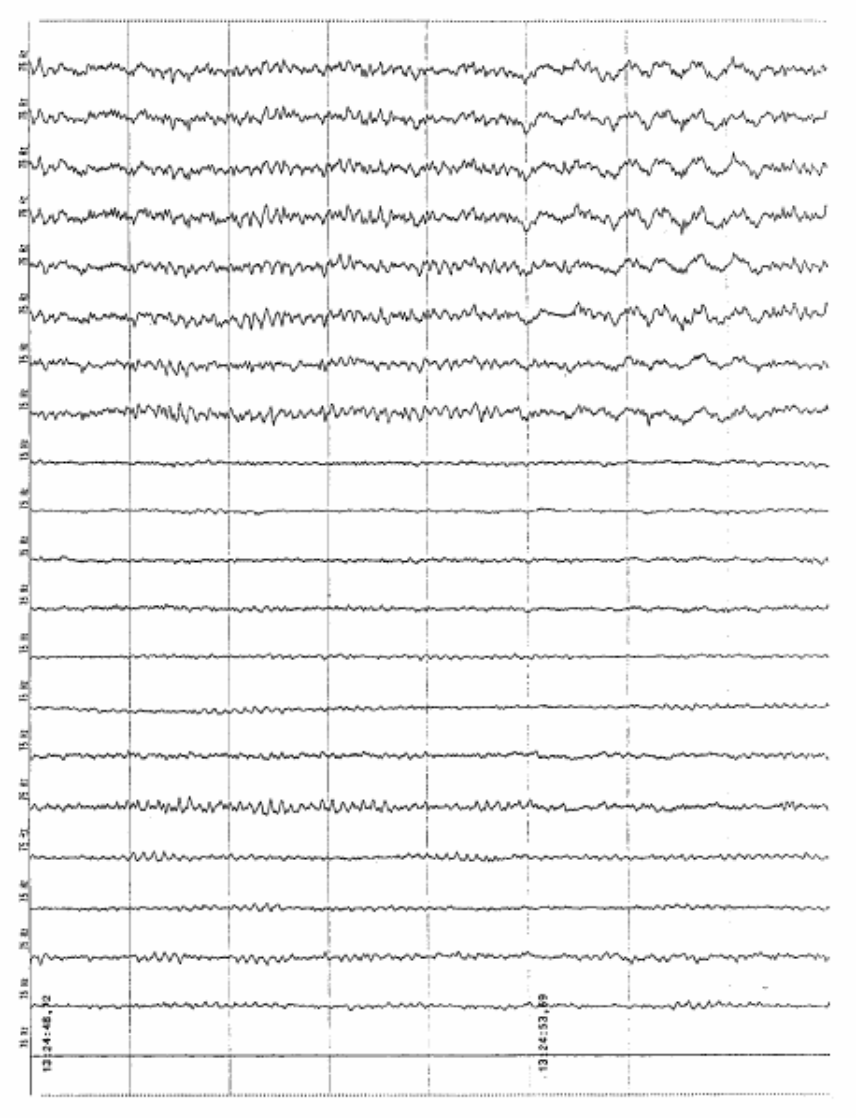


Illustration 21. Stage A2 > B1 > B3: A medium-level anteriorized 9/s alpha-activity (A2) changes in the 6th second via a desynchronized stage of 1 second (B1) into an anterior-accentuated 2-3/s delta-activity (B3). These dynamics cannot be observed in the source derivations.

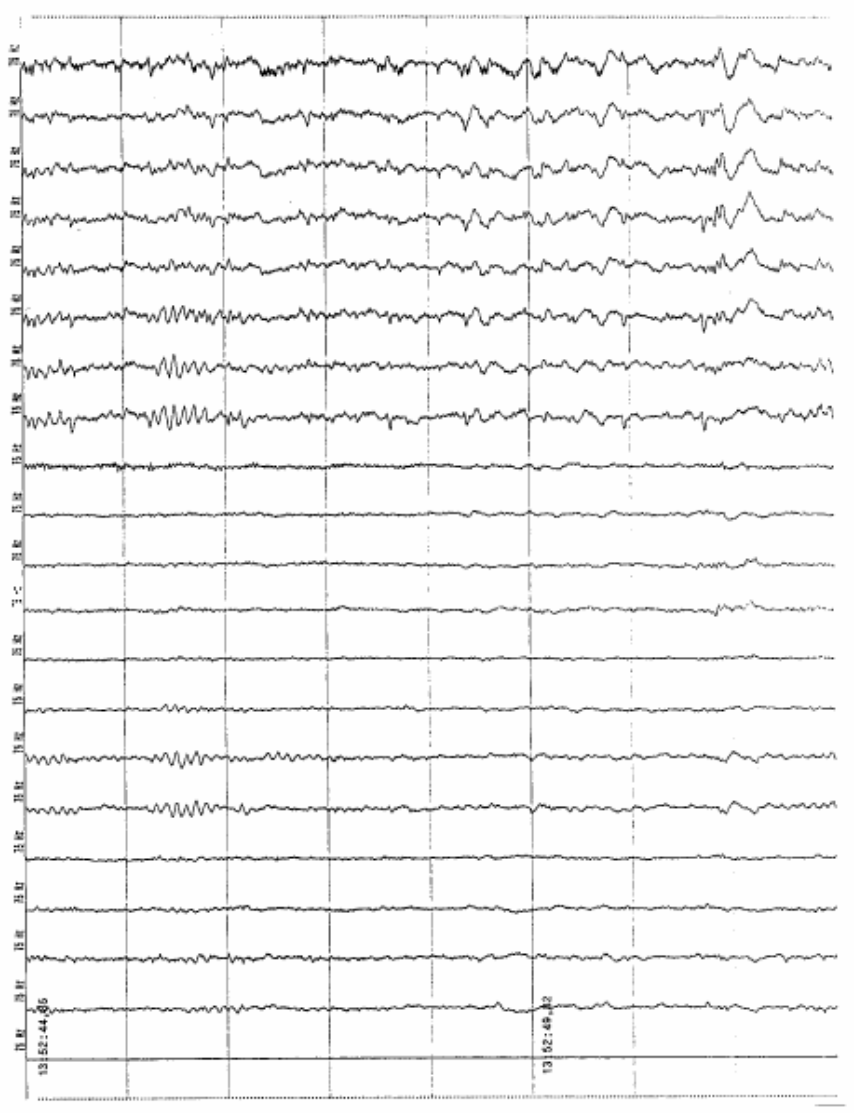


Illustration 22. Stage A1 > B1/B2 > B3 > C: A posterior 10/s alpha-activity changes in the 3rd second into a desynchronized activity, corresponding to a stage B1-B2. In the 5th and 6th second anterior-accentuated irregular delta-waves (B3) take prevalence,with a transition into an atypical K-complex, i. e. 14/s beta-activity simultaneously with a so-called vertex potential (C)

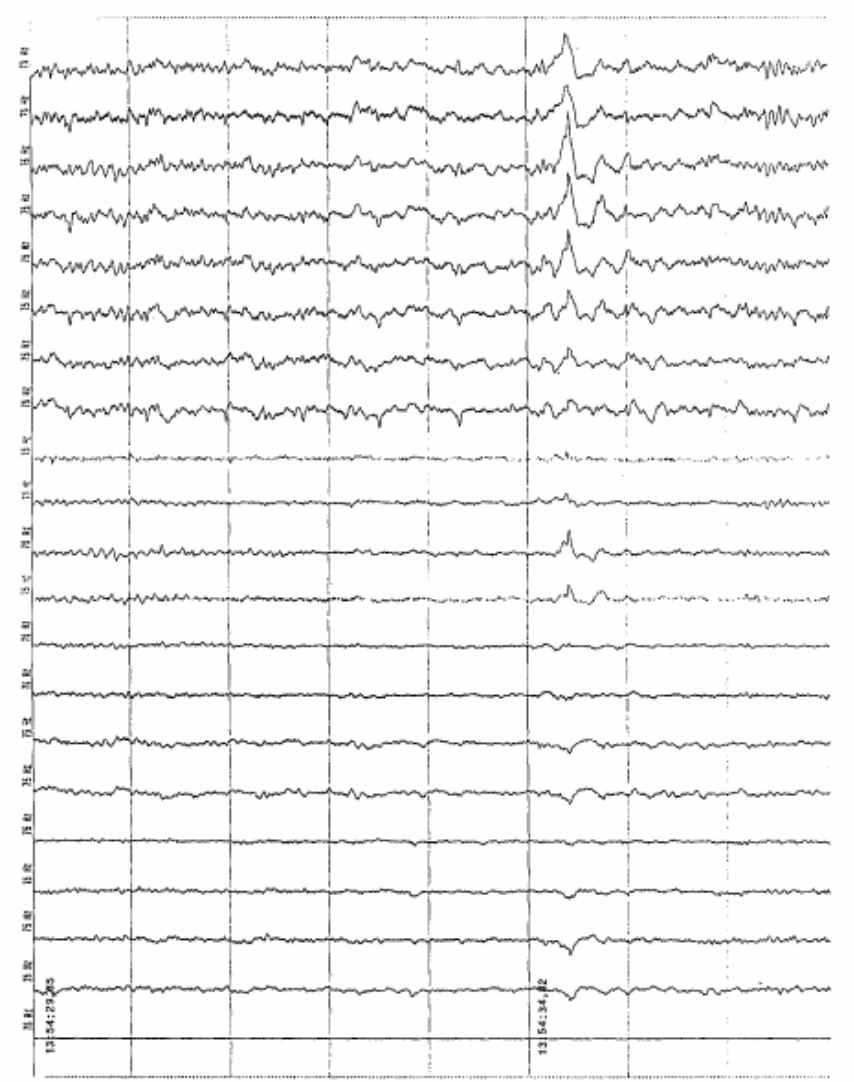


Illustration 23. Stage B1 > B2/B3 > C: From a desynchronized activity in the 2nd and 3rd second (B1) develops in the 4th and 5th second through interspersing with irregular theta- and delta-waves a stage B2/B3, followed in the 6th to 8th second by a stage C (K-complex, 14/s beta-spindle).

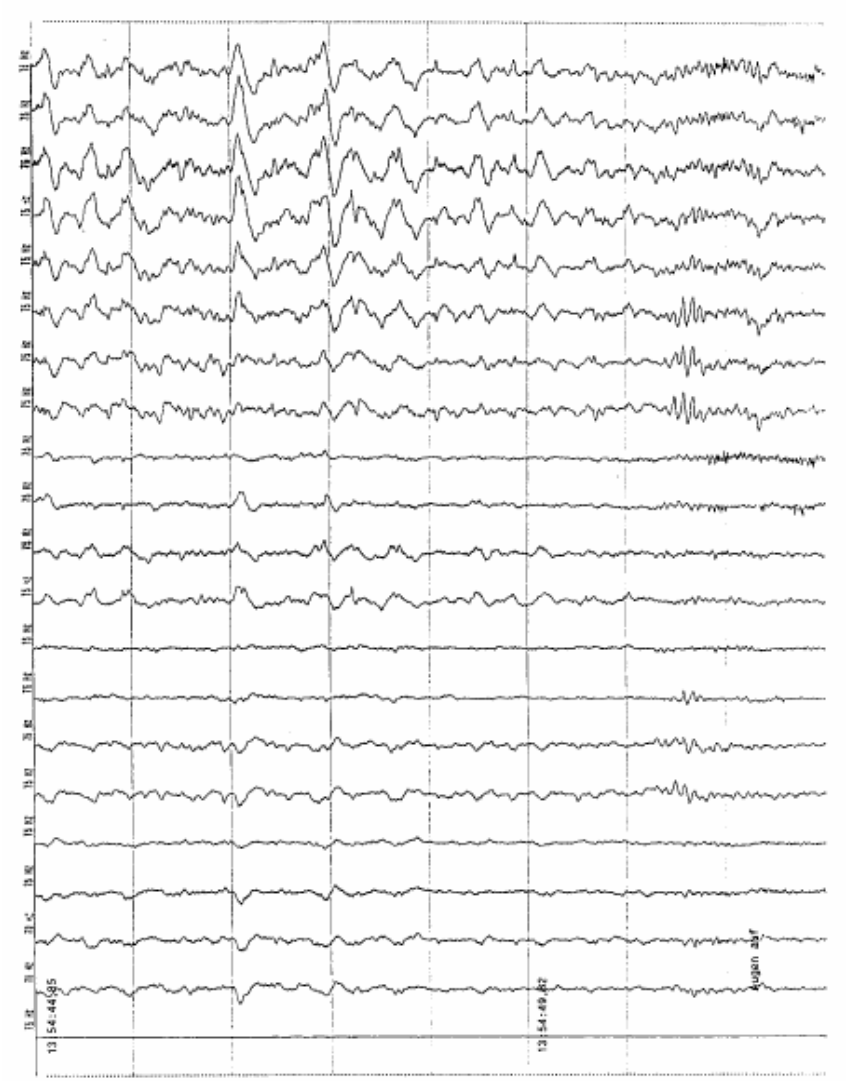


Illustration 24. Stage C: During the first 6 seconds anterior-accentuated 2-3/s delta-waves prevail, in connection with sharp, likewise anterior-accentuated waves (so-called vertex potentials) and a touch of 14/s beta-waves. In the 7th second, a posterior 10/s alpha-activity reappears together with anterior beta-activity of approximately 14/s.

In stage A3 a shift of the voltage maxima to the frontal regions occurs (illustrations 11,12). The transition to stage B1 is marked by a discontinuous dissolution of the increasingly shorter spindle-like modulated anterior alpha-activities (illustration 14, 15, 18). Stage B1 shows a desynchronized low-voltage activity (illustration 17). The interspersing with quick 20-30/s beta-waves is facultative. In stage B2 relatively low-voltage irregular theta-waves occur (illustration 19), in stage B3 high-voltage 3-4/s delta-waves, typically with emphasis above the frontal and mid regions (illustration 19, 20, 21), can be observed. The appearance of 12-14/s spindles finally marks the transition to stage C (illustration 24, stage II according to DEMENT and KLEITMAN 1957). Accompanied by the dissolution of the spindles and the evolution of irregular high-amplitude 1-3/s delta-waves the transition to deep sleep takes place (stage D and E or III and IV). In younger healthy persons there is an increase of segments corresponding to early B-stages from about the 5th minute of the recording. Late B-stages can be expected after about 10 minutes. Reaching stage C (or stage II) is under the described conditions rather the exception. Until today there is disagreement as to which pattern exactly marks the beginning of sleep. Many authors consider the lower-voltage desynchronized activity, corresponding to our stage B1 as the beginning of sleep. This empirically unsupported assumption can be traced back to LOOMIS et al. (1937). There is much more evidence for equating the beginning of sleep with stage C or stage II. As will have to be explained in more detail, we are not faced with a sharp boundary but with a wide transitional zone. The answer to the question - which kind of staging conforms better to our view - clearly favors that of LOOMIS et al. since it allows a considerably better differentiation of the EEG derived in a state of wakefulness.

Whereas the delineation of these stages in persons with prevalent alpha-rhythm is entirely without problems the low-voltage or flat EEGs with only sporadically detectable alpha-rhythm or only singular alpha-waves not at all rare in healthy people have provided plenty of matter for discussion. Some claimed that such EEGs, which were also termed "norm-variant," defy any staging. Of material importance for this opinion, and rejected by us, has probably been the research done by VOGEL (1970) that seemed to prove an autosomally dominant hereditary line of the characteristic "low-voltage." In addition to the decidedly rare EEGs without any rhythmic alpha-activity VOGEL also classified under this category the much more frequent EEGs regularly showing a temporary alpha-rhythm as reaction to the closing of the eyelid as well as those in which an alpha- rhythm becomes evident only under hyperventilation. If we agree to accept the accuracy of the genetic basis of VOGEL'S claims we are confronted with the question of what exactly is hereditary. It does not seem very plausible to us that there could exist a certain hereditary predisposition for a characteristic that is so crucially dependent on derivation technique like the amplitude of cortical potential variations. Much more plausible, compared to this, is the assumption that certain regulation characteristics are hereditary, possibly as a partial aspect of a certain psychobiological type (s. a. 4.7.).

A dynamic lability (DL) can be associated with the low-voltage EEG research by VOGEL as a regulation characteristic (s. a. 3.1. and 4.1.3.) In practically every EEG with dominating desynchronized low-voltage activity during the closure of the eyes

that has to be preceded by a short phase with open eyes a more or less temporary posterior alpha-rhythm can be provoked. Therefore, since the close-the-eyes-open-the-eyes-maneuver works as a stimulus the alpha-rhythm thus provoked can only be the manifestation of a temporary rise of the vigilance level. Therefore, we consider it necessary to associate a synchronized low-voltage activity with a subvigilant stage B1. This means that we must assume that in a minority of people because of their constitution and possibly also genetically determined under the usual conditions for relaxation there prevails not an alpha-rhythm, corresponding to a stage A but a desynchronized low-voltage activity, corresponding to a stage B1.

In literature, we find for observable patterns for the resting EEG of persons who are awake terms such as "états subvigiles" (SOUCACHET 1952), "transitional stages" (SIMON and EMMONS 1956) and "subvigilant intermediary stages" (BENTE 1964b). That these morphologically clearly distinguishable stages (s. a. illustrations 6-24) generally have met with very little acknowledgement possibly has one of its reasons in the fact that they were considered as mere transitional phenomena - attributable neither to a waking nor a sleeping stage. This made them appear to be some kind of negligible biological disturbing variance. Representative for this profound misunderstanding that until today hampered the development of a psychophysiologically oriented electroencephalography, we want to quote from a handbook article entitled: "EEG and Dynamic Psychological States":

"At this point, however, it might be mentioned that some attempts at least have been made to describe EEG patterns related to stages of vigilance. BENTE (1964) subdivides into 7 stages the original A and B stages of LOOMIS et al. (1938)...and further: ".we propose to limit the discussion of vigilance to those states that LINDSLEY associates with some degree of efficient behavior" (DONGIER 1977). Considering that this "vigilance" appears to be only an absolutely dispensable, superfluous name for alertness, vigility, wakefulness, attention, etc. A more strongly lowered "vigilance" therefore is equated to somnolence. But especially in pathological somnolence it is obvious that we are dealing with a relatively clearly delineated phenomenon or neurological symptom with a certain etiopathogenesis. Therefore, "somnolence" belongs to a different logical level than the ordering term "vigilance" related to the global functional level. "Vigilance" defined this way obviously cannot be equated with "arousal" or "activation". That such misunderstanding has almost become common knowledge is evidenced by the title of a monography "The EEG of Drowsiness" (SANTAMARIA and CHIAPPA 1987). Despite their attempt at comprehensiveness, no reference to LAIRY and DELL or BENTE can be found. However, with regard to the title of their work, the authors' claim: "The literature is largely quiet on this subject." and furthermore:". the analysis of sequencing drowsy stages has only scratched the surface of what we feel may be an interesting area". Such statements cannot fool us about the fact that the authors have no EEG-conception that includes or supersedes the partial aspect of "drowsiness." Contrary to HEAD'S original conception (see above), "vigilance" is today used almost exclusively in relation to behavior, like in the sense of "sustained attention." Several attempts to distinguish "vigilance" (sensu HEAD) as a term for the description of the functional state of a biological system from "vigilance" as a term for description of behavior/experience (PETERS 1976;

BENTE 1977; ULRICH and GSCHWILM 1988) were modestly received at best. Even the psychophysiologically oriented electroencephalography proffered no exception. Regardless of whether the EEG or behavior/experience are concerned, "vigilance" is used without making any discrimination. Inevitably, this leads to paradoxes. It has, for instance, been claimed that it could be methodically more advantageous to determine the vigilance level through electroencephalography rather than through self-assessment (MATOUSEK 1984). The critical question of whether psychological facts can be expressed by physiological facts or vice versa will be discussed in detail in the next chapter. The widely used definition of "vigilance" as a readiness of the organism to react adequately to a stimulus seems misleading (KOELLA 1984). "Readiness" is the designation of an attribute by the observer who is focused on the interaction of an organism with its environment but not an operational characteristic of the organism! "Adequate" is a subjective value judgment. Thus, KOELLA'S definition is fitting for living as well as dead systems. So what should keep us from defining "automobilance" as the readiness of the automobile to react to a specific stimulus such as pushing the accelerator with an adequate acceleration? According to this definition, an older car could be assigned a lower "automobilance" than a new car. In a less convoluted way, one could say that the old car does not function as well, just as a living organism with lower vigilance does not function as well. That leaves us with the question why HEAD nonetheless saw the need for a new term. HEAD'S writings indicate clearly that he derived his theoretical construct of "vigilance" from the observation of living systems and only wanted them to be associated with those. He explicitly equated "vigilance" with "vital activity." Differing from dead machines living organisms does not possess an initial state of functional rest. They change their functional state permanently in a cyclic process without even being required to fulfill a certain performance. This is a differentia specifica between living and dead systems, a phenomenon from which HEAD inferred the necessity to introduce "vigilance." In other words, the necessity of "vigilance" is derived from the impossibility of a one-on-one relation of phenomena from the domain of brain-physiology (EEG) with behavior/experience (s.a. 2.2.6.). Relating these two logically incommensurate description levels can only be justified by means of the theoretical construct "vigilance." As a theoretical construct, "vigilance" is independent from the description levels of empirical experiences.

Of course, "vigilance" as a technical term for the functionality of living systems cannot be subdivided into "local vigilances" (KOELLA 1984). Otherwise one would have to assign each of the cooperatively active neuronal assemblies its own vigilance. "Vigilance" can exist only in its entirety or not at all, just like an arch as a self-supporting edifice.

The concept of a psychophysiological electroencephalography that can be traced back to LAIRY and DELL (1957) as well as BENTE (1964b) is in full agreement with the findings of recent brain research. Accordingly, the EEG is the result of a network of cooperative neural elements which are coherent across the entire derivation area. The sensitivity and reactivity of each single neuron depend on the state of excitation of all other neurons (LOPES DA SILVA 1991). This results in an "integrated wholeness" (CREUTZFELD 1975) within which neuro-anatomical delineations are for the most part blurred. The

EEG appears as the manifestation of a "global function" (STORM VAN LEEUWEN 1978). Expedited by the rapid developments of the theory of non-linear systems (s. a. 2.2.3.) or synergetics this "holistic" view increasingly replaces or least completes the elementaristic paradigm of columnar cortical organization which is based on an imagined additive mosaic of elements that can be functionally isolated. Here, findings that cortico-cortical coherences or horizontal connectivity are considerably more pronounced than thalamo-cortical coherences or vertical connectivity play an important role (BASAR 1980).

In the language of non-linear systems theory, the EEG belongs to the class of cooperative or synergetic, self-organizing processes as they inevitably occur in systems with uniform, non-linear, interactive elements (HAKEN 1982; ROTH 1981; AN DER HEIDEN 1985). One talks about self-organization when a spontaneous formation of structures can be observed. "Spontaneous" means that a new structure was not imposed by external forces but originated because of the specific characteristics of the components involved. If a spontaneous repetition of similar structures, such as activity patterns is observed this is called a self-organizing process of cyclic order. This is exactly what happens in the EEG. Insofar as each state of the system is involved in the creation of the following one, the system can also be considered internal state-determined. This cycle is a highly complex process with a wide intra- and interindividual range of variation with regard to the proportioning and the dynamics of the course of the subvigilant intermediary stages. We must consider it less a system of rigid rules and more an ordering system which allows relating a multitude of individual phenomena in a certain way.

From the perspective of the chaos theory, the cyclically repeated activity patterns can also be regarded as dynamic attractors (s. a. 2.2.3.). According to recent findings, the EEG is most probably a deterministic chaos, i.e. a deterministic process whose course cannot be predicted despite the knowledge of the relevant parameters.

The global functional state of the system, i. e. its vigilance, is evidenced in its cyclic dynamics. A modification of the functional order, as under resting conditions, - pointedly termed "Funktionswandel" (functional change, CONRAD 1947) - can occur under physiological, pharmacological as well as pathological conditions. The ultimate physiological condition is sleep, with a very specific corresponding functional order. A pathological, functional change of lesser degree usually manifests itself in a change of proportioning and temporal sequencing of those patterns that constitute the subvigilant intermediary stages. This can mean increased dynamic rigidity as well as lability (s. a. 3.1.) However, a pathomorphical functional change of a lesser degree can also manifest itself in the intermittent occurrence of certain morphological variations of subvigilant patterns (s. a. 3.1.) without interfering with the cycle dynamics. In the case of more pronounced pathomorphical functional changes, as in diffuse dysrhythmia, a delineation of stages - and thus an evaluation of the dynamics - is no longer possible (s. a. 3.2.).

Since the structure and dynamics of brain-electrical activity are the product of a maturation process, each determination of vigilance level and vigilance dynamics requires the complementary specification with regard to the associated ontogenetic maturation level. Although the theoretical constructs of "vigilance" and "maturation" belong to different but complementary time grids, they are related to each other in the manner of orthogonal coordinates.

> Equally complementary are onto- and phylogenesis, emanation and evolution (GÜNTHER 1980), homeostasis and homeorrhesis (WADDINGTON 1966), synchronic and diachronic equilibration (PIAGET 1983) as well as simply the "state" and "trait" aspects.

As a theoretical construct, "maturation" is just as inaccessible for direct observation as "vigilance" (s.a. 2.2.5.). They can only be described by empirical indicators. The constructs provide the logical or theoretical justification for relating observed data, i.e. empirical construct indicators of different description levels.

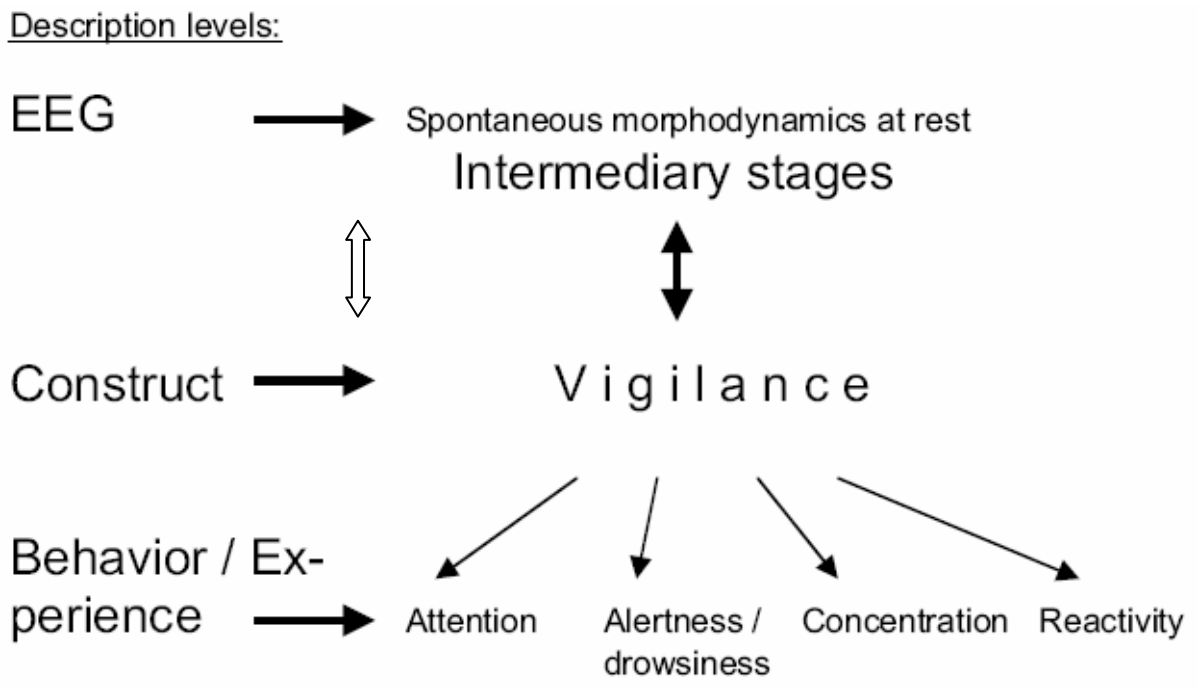


Illustration 25. Vigilance as theoretical construct.

While the electroencephalographic vigilance indicators find their immediate behavioral correlates in the differentiation and availability of the observed behavior or experience, we can only postulate for certain a disposition for usually mal-adaptive behavior patterns for the electroencephalographic immaturity indicators. However, since a disposition need not necessarily be realized under favorable circumstances, one has to expect results which are inconsistent, and probably only significant when calculating group statistics.

2.2.6. The EEG as a Tool in Psychophysiology

Psychophysiology presumes that all psychological processes have a physiological correlate. This basic concept does not require confirmation from empirical findings. It represents, so to speak, the signature of a world view coined by natural science and marks the boundary of convictions of spiritual-magic-mystical provenance.

The situation is completely different, however, if we discuss the nature of the relationships between psychological and physiological matters. Many might feel uncomfortable at the mere question since here, quite obviously, the "body-mind problem" which is regarded to be irrelevant for empirical research as well as unsolvable shines through. As evidenced by literature, psychiatric research limits itself to the presentation of statistical correlations between "biological" and psychopathological data. But if only a statistically significant correlation is available, such a finding is of questionable value as long as its meaning remains unsettled. All too often, more or less plausible post hoc hypotheses are offered. The problem of the psycho-physiological relationship can be concretized by asking whether and to what degree the subjectively felt alertness/drowsiness is reflected in the EEG. If we consult the literature, we encounter a strange contradiction which has been in place for many decades between popular opinion and empirically supported knowledge. Still dominant is the concept of a functional isomorphism between the subjective degree of drowsiness and the objective EEG. GRÜTTNER and BONKALO (1940) already pointed out half a century ago that the 14/s spindle-form activity usually associated with the light sleep stage C in more tired persons is absolutely compatible with cognitive activities such as mathematical calculations. FISCHGOLD et al. (1959) thought it remarkable that some subjects were able to keep contact with the experimenter, despite unequivocal sleeping patterns in the EEG. KUHLO and LEHMANN (1964) emphasized that lower-voltage desynchronized activity corresponding to a stage B1 is not a reliable indicator for subjectively experienced drowsiness. Other authors voiced similar opinions (f. i. LIBERSON and LIBERSON 1965; MAULSBY et al. 1968; SANTAMARIA and CHIAPPA 1987). As LIBERSON and LIBERSON noted, there also exists a subjectively felt drowsiness without any EEG-correlate.

In summary they state: ". a subjective impression of whether one is asleep or not may not be consistent with the apparent EEG pattern." According to RECHTSCHAFFEN and KALES (1968), the classification of sleep stages cannot be based on

the EEG alone. For a valid delineation, additional polygraphically acquired information about motor behavior of eye, pupil and limbs, EKG, blood pressure, etc. are necessary.

Based on the available evidence, the assumption of a one-on-one relationship between feelings of drowsiness and the EEG cannot be maintained. While there seems to be no doubt about the futility of finding EEG correlates to subjective experiences such as guilt feelings, illusions, etc., an electroencephalographic objectivation of the perceived quality of drowsiness is, for some strange reason, not only considered possible but is even taken for granted. This is evidenced through the fact that distinctions such as "typical alert," "slight drowsiness", and "pronounced drowsiness," are based solely on the EEG (MATOUSEK and PETERSEN 1979).

If we question the reasons for this epistemological lapse, it is initially tempting to hold an uncritical interpretation of statistical correlations responsible. Further, it might play a role that drowsiness in contrast to the other mentioned experienced qualities can be arranged on a bipolar continuum with one of the extreme poles clearly marked by the electroencephalographically object of sleep in its different stages. Based on a continuity of the subjective quality drowsiness, undeniable for the domain of inner experience the inadmissible analogical conclusion about an identical continuity in the EEG is made (MATOUSEK et al. 1984). Since continuous processes can be objectified through physical measuring methods, the demand for preference of quantitative methods is made, despite the visuo-morphological discontinuity of the subvigilant intermediary stages: "It may be concluded that the EEG method can be employed to measure the vigilance level, and that it has certain advantages over conventional self-rating, “and further: "The EEG method is not handicapped by subjective bias." Instead of taking into consideration the enormous variation range characteristical for all introspectively obtained statements MATOUSEK et al. (1984) consider it a methodical flaw. Consequently, they also view the dubious correspondence between the experience of drowsiness and the EEG - to them well-known - as a problem that is solely the result of an inadequate method and can therefore be solved methodically. Trying to eliminate from science the tool of introspection because of its supposed faking of reality, they must inevitably consider "psyche" or "psychology" in the proper sense and, thus, also psychophysiology, as dispensable, i.e. replaceable by physiology.

> The common epistemological position, which together with empirism will unfailingly lead to contradictions, rarely explicitly formulated or reflected in the field of psychiatry and psychophysiology, has also been named eliminative reductionism (WERNER 1988).

Here, a view of the world and of human beings that makes no distinction between living ("autopoietic") and non-living, man-made ("allopoietic") systems is reflected (MATURANA 1982). Only living systems possess subjectivity and, therefore, the capability of experiencing. In addition, they can be objectively described, just as non-living systems. Thus they can only be

understood in a biperspectival manner. Both perspectives have their own language, named the "mind language" and the "brain language" by LASZLO (1972). To avoid epistemological pitfalls it is of utmost importance to keep the terms belonging to "mind language" on the one hand and "brain language" on the other clearly separated. Someone observing both areas of description simultaneously has the impression that the physiology of the organism generates its behavior. Thus, a hierarchical multi-layer model is suggested to him. We must emphasize, however, that we are here dealing only with an impression of an operational causative connection created by the observer that by no means allows for a phenomenal reduction. Such a phenomenal reduction would ultimately justify an eliminative reductionism according to which the psychological can be completely replaced by the physiological. Contrary to living systems, only a monoperspectival objective analysis is possible for non-living systems. A translation of subjective into objective data and vice versa is impossible as a matter of principle because they originate from "logically incommensurable" description areas (RUSSEL and WHITEHEAD 1913). Another way to express this idea is that the point of view from which an observing subject makes statements about psychological matters - they can always only concern the own psyche - is as a matter of principle different from the point of view from which statements about physiological matters are made. The latter includes all external objects such as the own body (GÜNTHER 1978). Saying that drowsiness is nothing but the lack of a transmitter x at a spot a in the brain or a certain brain-electric structure in the EEG is logically out of question and thus nonsense.

Experiential states such as a certain degree of subjectively perceived drowsiness are always determined by a multitude of only partially recognizable and in many ways interactive contributing factors. The patterns which can be distinguished in the EEG represent in this context only one partial but essential aspect. Another important aspect is the eye movement (SANTAMARIA and CHIAPPA 1987). Of course, the current emotional state or its associated multifarious and complex physiological mechanisms also have an impact.

> From the above, we conclude that the assumption of a positive psychological effect of feedback-induced alpha-activity is not very plausible. As a matter of fact, the ineffectiveness of such techniques has been proved experimentally quite some time ago (SACKS et al. 1972; TRAVIS et al. 1975; PLOTKIN and COHEN 1976). PLOTKIN and COHEN further proved that for some pleasant feelings generated during alpha-induction, the alpha-induction as such is not responsible, but rather, unspecific situational external conditions are. According to EDELMAN'S (1989) research, there exists no connection between the frequency spectrum of the EEG and mental states. In particular, contrary to earlier assumptions EDELMAN found no connection between the theta component and specific behaviors and experiential states.

Even if it were possible to cover all objective determinants, their interactive process dynamics could not be accounted for. Biological systems can be described as deterministic-chaotic (SCHUSTER 1984), i.e., although they are strictly determined in the sense of natural science, their behavior cannot be predicted (s. a. 2.2.3.).

For the psychophysiology we can formulate a principle that a certain behavioral-experiential phenomenon can correspond to a variety of brain dysfunctions, just as one and the same brain dysfunction can correspond to a variety of experiential phenomena. This principle forms the framework for psychophysiological correlation research. Only if we are constantly aware of this principle is empirical correlation a useful tool for arriving at (limited) knowledge.

2.2.7. The Problem of Pure Empirism or the Contempt of Theory for Empirical Experience

The development of the psychiatric EEG entails more than just an electrodiagnostic service. In order to develop the EEG as a psychiatric research tool, it is inevitable that the clinical psychiatry be open-minded regarding such a development process. The cooperation of partners with research responsibilities shared by the hospital and the psychophysiological electroencephalography is desirable. To a large extent the methodological conditions necessary for this scenario must still be created. We are fully aware that the methodological consciousness in psychiatry - probably due to the pragmatic concerns of everyday clinical life - has traditionally never been very pronounced (s. a. JASPERS 1913). Evidence for this may be that it is common to call research work in a critical evaluation as "too heavy on theory" while we have never heard "too heavy on empirical experience." The equivalence of empirical experience and theory, generally proclaimed as desirable, indeed does not exist. Sometimes, one cannot avoid the impression that theory-abstinent empirism is considered a counterpoint to unbridled speculation or even as signature of a true science.

> This development also draws some, albeit very isolated, criticism: "In fact, many consider that we are presently fact rich and theory poor" (GOLDSTEIN 1983), and „It therefore seems more significant today to be raising questions than gathering data" (ANDREOLI 1992).

For pure empiricists - and there are many, especially among the "biological" psychiatrists - a researcher discredits himself through the use of terms such as "epistemology" or "theoretical construct." When UEXKÜLL and WESIACK (1988) rightly stated that medicine in the 20th century has remained a natural science of the 19th century, this is especially true for psychiatry. About 150 years ago, when psychiatry became a natural science, medicine adopted its methods. But medicine failed to follow when natural sciences radically changed their understanding of science. Still dominant as official doctrine is the machine model, conceived about 120 years ago by Emil DU BOIS-REYMOND and Hermann VON HELMHOLTZ. The sudden disrupture of the connection with the beginnings of biology as the science of living beings at this point of time, associated with names such as Johannes MÜLLLER and Karl Ernst von BAER, still determines today's conceptions. An important witness for the primate of theory over empirical experience in modern natural science is Albert EINSTEIN

according to whom it is our theories that determine what we see and describe. From a certain point on, new data would contribute no longer to clarify a situation but only confuse it.

W. FREEMAN (1992) recently summarized the problem in an editorial. His opinion is of special import because it was given from the perspective of the purely experiment-oriented brain researcher which is protecting against psychiatry-immanent tunnel vision. FREEMAN'S editorial ties into the annual meeting of the "Society of Biological Psychiatry" and the 458 presentations and posters presented there:

"The data were expensive to obtain and now not worth replicating or even retrieving, because there was little or no theory to specify what to measure, in what ancillary conditions, and with what expected outcomes. This is not the kind of chaos of which we can be proud."

One should, please, start by presenting findings. After that one might be able to talk theory. If we follow this recommendation, we must expect incomprehension and rejection for the simple reason that the theoretical explanations that justify leaving the beaten paths necessarily had to be cut short.

Further complicating matters is that electroencephalography and psychiatry, after the brief common initial phase for which we have to thank H. BERGER have moved continuously and, it seems, irreversibly, away from each other. Instead of being viewed as a genuine psychiatric research tool, the EEG today is considered by clinical psychiatry as a dispensable auxiliary tool that belongs in neurology. On the other hand, the administrators of the EEG, gathered in associations, who as neuroscientific electro-diagnosticians feel responsible for myo- and neurography too, generally lack any relation to the psychiatry. Thus we must ask the question who should be in charge of the development of the psychiatric EEG. In our opinion there can only be one answer: The psychiatric EEG can only be developed within psychiatry by psychiatrists with clinical qualifications. Clinical psychiatry must rediscover the EEG as its very own research tool!

3.

The Pathomorphological Changing of the EEG ("Pathomorpher Gestaltwandel")

3.1. From the Physiomorphological to the Diffuse Dysrhythmic EEG

At the example of the EEG in cases of incipient dementia, BENTE (1981) distinguished two paths of dissolution.

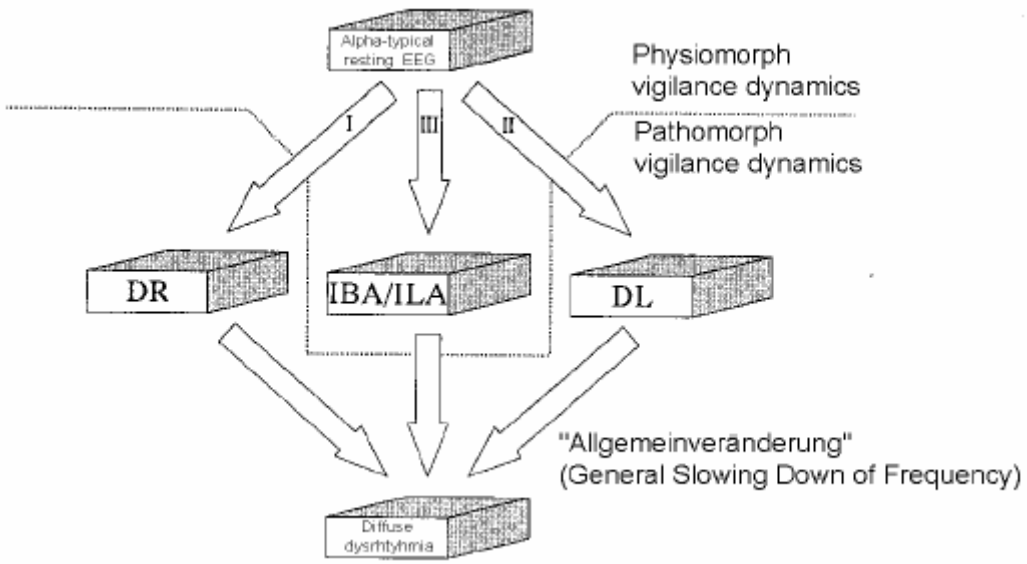


Illustration 26. The pathological gestalt change of the EEG (I).

In the first path - named dissolution via stage A - the resting EEG is dominated by the picture of a mid-stage A (stage A1 to A2) (illustration 26, left arrow I). The second path - the dissolution via stage B - is dominated by the picture of a stage B1 (illustration 26, right arrow II). The patterns themselves have physiomorph appearance but lack the physiomorph transition dynamics. They dominate the picture almost stationary. In both cases we are dealing with the manifestation of disturbed vigilance dynamics.

BENTE considered these two modi of functional dissolution (illustration 28, middle and below, illustration 29, 30) to be the "morphogenetische Matrix" (morphogenetic matrix) from which, with the progression of the underlying pathological process, the transition to a pathomorph organization occurs. This pathomorph organization results from the disproportion of the

diverse "formative tendencies" involved in the evolution of the physiomorph pattern (s. a. 2.2.5.). Because of the unphysiological persistence of the anterior extended basis activity, that usually continues past the 5th recording minute, we also call the dissolution via stage A dynamic rigidity (DR, illustration 27, middle and illustration 29). During dissolution, the formative tendency of the slowing of the frequency increasingly gains importance. Via a stage of more or less rhythmic theta- activity the picture of a diffuse dysrhythmia is eventually reached (illustration 31 to 35). During the dissolution via stage B, on the other hand, an increase in the discontinuity of the background activity with an increase in frequency and duration of low- voltage activity phases occurs, corresponding to a stage B1. In this case we talk about dynamic lability (DL, illustration 27, below, illustration 30). With continuing dissolution the formative tendency of the desynchronization gains importance.

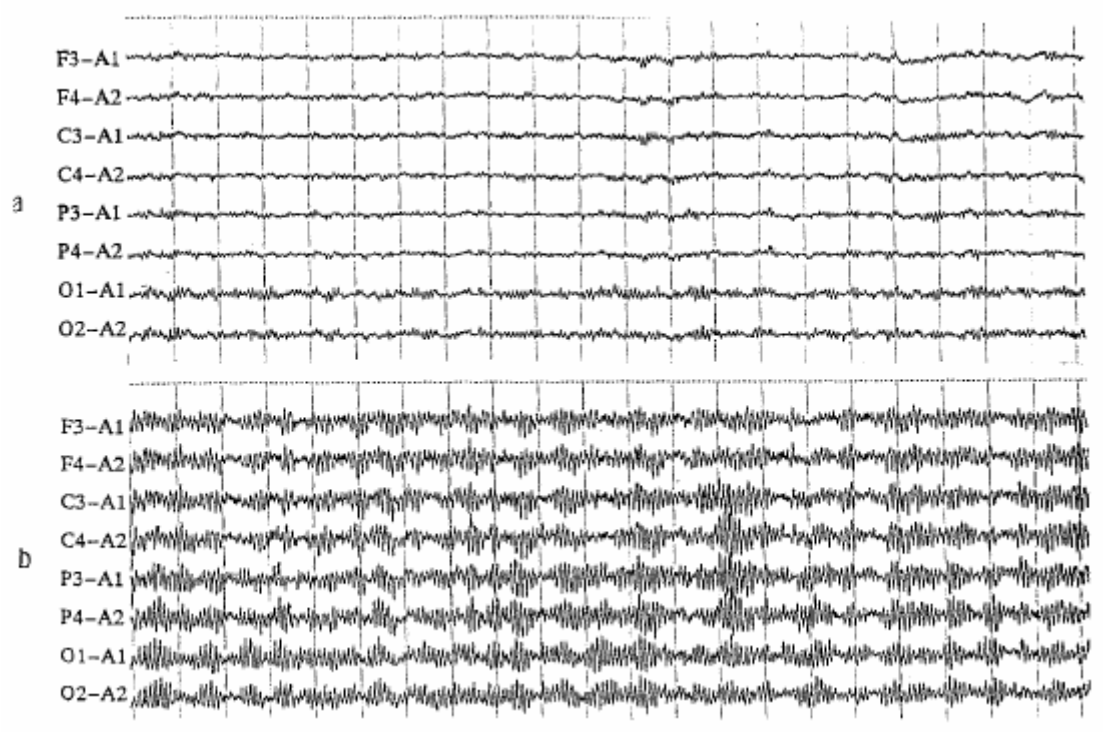
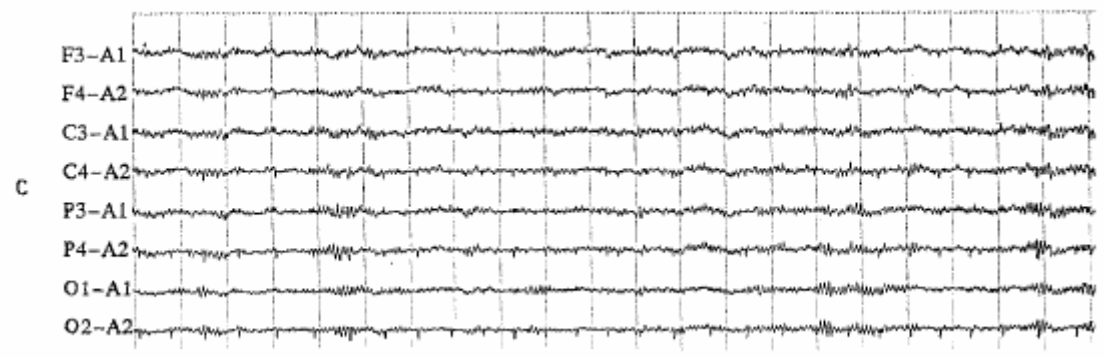


Illustration 27. Representative recording segments (0.8 cm = 1 s) from the first minute with reference to the ipsilateral ear.
a) Physiomorph dynamics: mostly continuous 9/s alpha-activity with posterior maximum, largely corresponding to a stage A1.
b) Dynamic rigidity: continuously anteriorized, relatively monomorph and slightly slowed down appearing 8.5/s activity, corresponding to a stage A2. This picture does not show any change during the 15 minute recording at rest.



c) Dynamic lability: discontinuous 9.5/s alpha-activity of varying degrees of anteriorization that can be delineated only in groups. Abrupt transitions to sometimes longer low-voltage desynchronized phases, corresponding to a stage B1. This picture does not show any significant change during recording either.

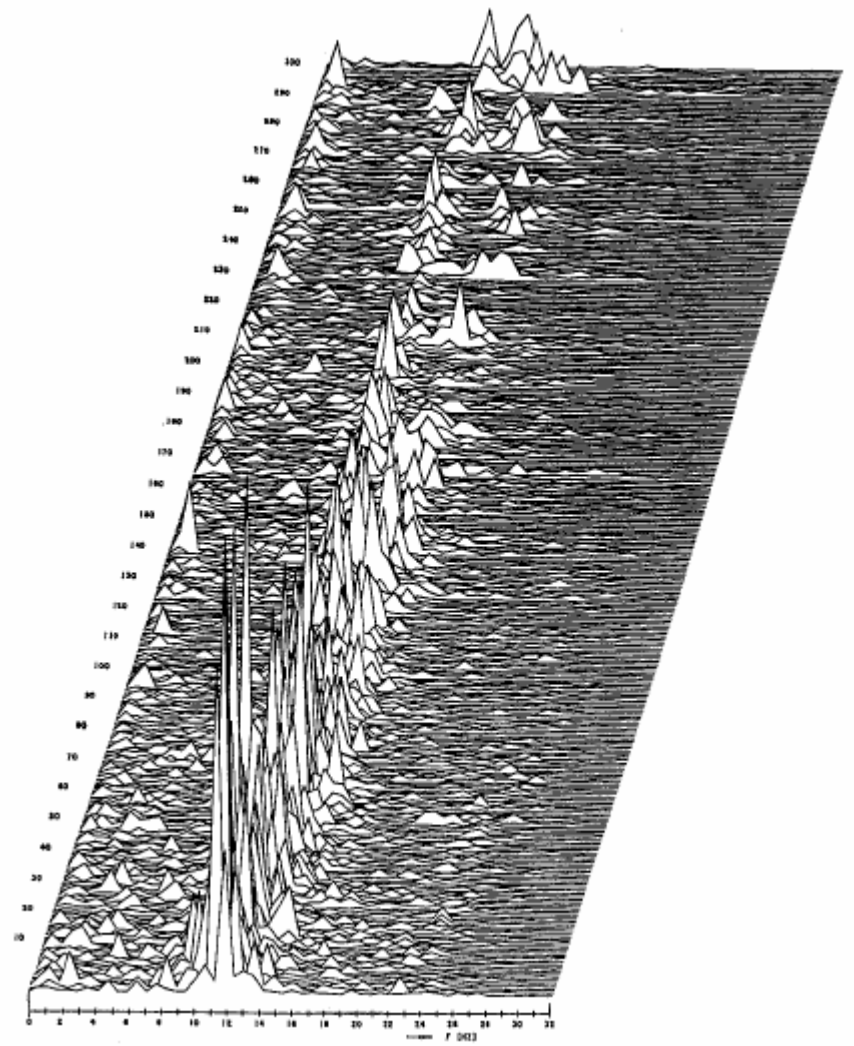


Illustration 28. Chronospectrogram of physiomorph vigilance dynamics (see top of illustration 27). In staggered formation, 300 FOURIER analysis obtained through power spectra (frequency range 0-32 Hz) are shown for consecutive 2-s epochs during a ten-minute resting record (lead: 02-A2). The spectral alpha-component of 11.5 Hz is most pronounced at the beginning of the derivation (stage A1) and remains at a high level until approximately segment 150 (i.e. until the 5th minute). After that we see a progressive alpha dissolution corresponding to an increase of subvigilant B-stages.

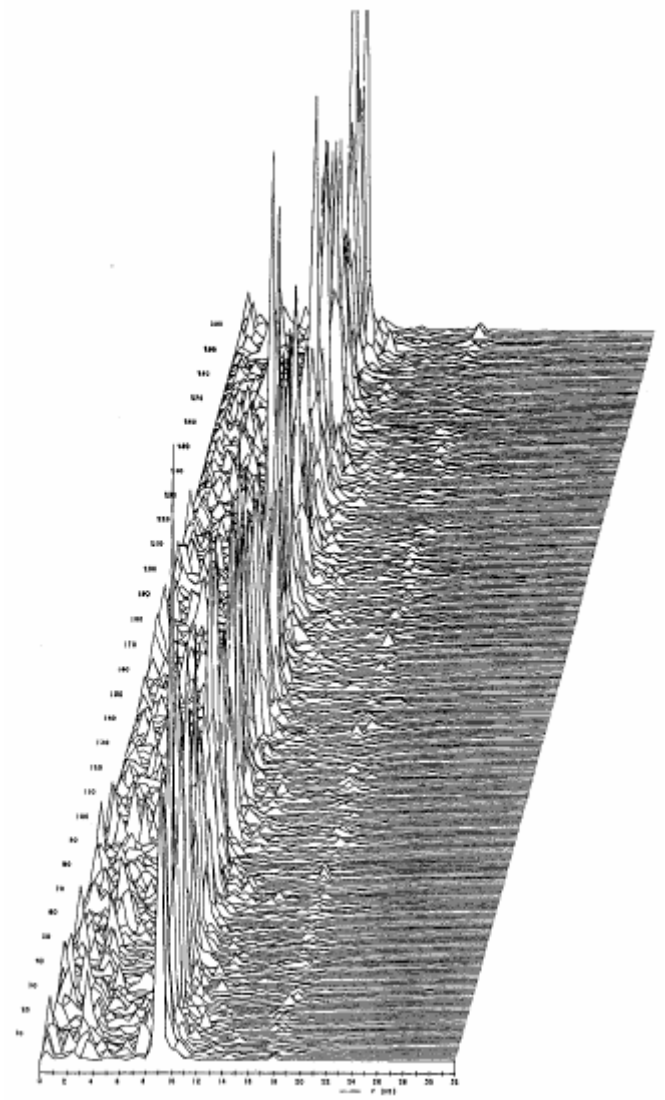


Illustration 29. Chronospectrogram of a dynamic rigidity (see middle of illustration 27). The pronounced alpha-activity of stabile frequency (lead: 02-A2) remains largely unchanged during the entire ten-minute resting record. The tendency of an increase of subvigilant B-stages, to be expected from the physiological perspective, is absent.

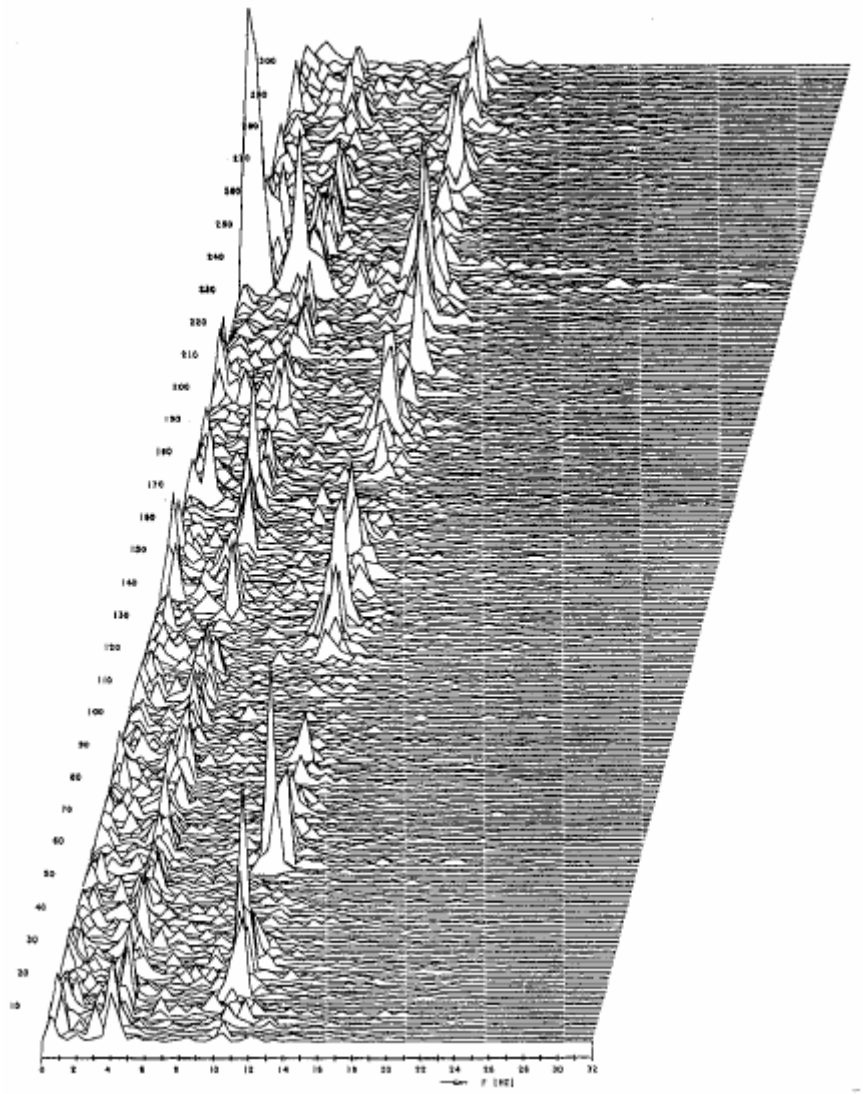


Illustration 30. Chronospectrogram of a dynamic lability (see bottom of illustration 27). An alpha-activity of higher variability of frequency of about 10-12/s shows a discontinuous abundance starting at the beginning of the recording. Any trend in the time course is absent.

Thus, the picture of a polyrhythmic frequency dissolution results, in most cases with a beta-component (s. a. 4.1. and illustration 36-38). Through the progressively increased proportion of slow activity, eventually, the picture of a diffuse dysrhythmia is reached. The diffuse dysrhythmia, always viewed as a typical correlate of more pronounced organic brain syndromes, also represents the final stretch of those two dissolution paths that start with the disturbance of the vigilance dynamics.

For us, however, there is no doubt that in addition to the two paths stressed by BENTE, there exists another one with initially largely untouched vigilance dynamics. This third dissolution path (illustration 26, arrow III, in the middle) manifests itself in the intermittent occurrence of pronounced sub-alpha-, theta- as well as delta-groups under mostly physiomorph vigilance dynamics. Attempts to find the most fitting terminology for this pattern, which occurs in many variations, have led to the already discussed terminological confusion (chapter 2.2.1.4., table 2).

> The long accepted belief, dating back to older authors such as DUENSING (1949) and FAURE et al. (1951), views the patterns considered by us as pathomorph variations of an A-stage to be pathognomonic for processes close to the midline of the diencephalon, the upper brain stem and the fossa posterior is regarded as obsolete today.

These patterns, subsummarized by us as IBA (Intermittent Bilateral Anterior) or as ILA (Intermittend Left Anterior) are the result of an increase in the voltage, deceleration, synchronization and anteriorization (mostly temporalization!) that are characteristic for the mid- and late A-stages. At the same time, a tendency for a discontinuous pattern dissolution - corresponding to stage A3 - can be observed. BENTE (1964b) considered the focal left anterior sub-alpha groups, encountered especially in older patients, to be a pathomorphic variation of the later A-stage (stage A4). Based on our observations and even more on certain experimental findings (see below) we deem it justifiable to also consider all those phenomena as pathomorph variations of a late A-stage that have a similar morphological basic pattern but a different frequency.

> KORNMÜLLER (1941) was able to show in the EEG of healthy volunteers under experimentally induced hypoxia - inhalation of a nitrogen-oxygen mixture equal to that at an altitude of 7500 meters - a characteristic sequence of stages. After only a few minutes, an increase in alpha-amplitude and alpha-continuity was observed that was more pronouncedly anterior temporal than posterior. This was followed by a stage characterized by groups and sequences of rhythmic anterior sub-alpha and later theta-waves with higher amplitudes. Signs of altitude sickness, that is, of an impairment of consciousness affecting the adaptive behavior eventually occurred in connection with initially still rhythmic 3-4/s-waves that grew increasingly irregular with augmented topographical generalization so that in the final stage the picture of a diffuse dysrhythmia resulted. With the reintroduction of fresh air, the EEG changes disappeared in reverse sequence and often very rapidly. As a result of an extended hypoxia, often an additional stage of low-voltage

> desynchronized activity preceding the reappearance of the posterior alpha-activity, could be observed. KORNMÜLLER'S findings were largely confirmed later by GÖTZE (1950) as well as by JUNG (1953). We consider this an excellent experimental model of a "pathologischer Funktionswandel" (pathological functional change). As in time-acceleration, the EEG demonstrates the sequence of all those phases we associate with psychiatric disturbances of specific clinical syndromes (see chapter 4).

Supporting the view that this indeed constitutes a dissolution path of its own are observations that under IBA classifiable peculiarities are rather frequently the only EEG modification in diffuse encephalopathies (SCHAUL et al. 1981 a, b).

Because of a frequently observed simultaneous incidence of intermittent bilateral anterior (IBA) and focal intermittent left anterior groups in the same EEG - especially in patients with involutional syndromes or under lithium prophylaxis - we wondered about a possible intrinsic relationship.

> Patients with mild-to-moderate dementia primarily exhibited a focal abnormal left temporal slow activity pattern, whereas patients with severe dementia exhibited a more diffuse slow activity pattern ..." Further, "These data suggest that focal, left anterior temporal EEG slow activity might be a sensitive indicator of the milder stages of SDAT" (Rice et al. 1990).

During earlier systematic examinations, we came across certain regularities (ULRICH et al. 1983). EEGs with ILA usually show at the beginning of the recording an asymmetrical voltage generation with a left-sided amplitude prevalence of the posterior alpha-activity. The anterior spreading of the background activity, corresponding to the stages A1 and A2, also shows a left side accentuation (illustration 39, 40). The formative tendency for frequency deceleration associated with the A- stage that is already physiologically more pronounced in the anterior than posterior - as well as for some part also the formative tendencies for voltage increase - lend the left anterior alpha-groups, with continuing decrease of the vigilance level, the semblance of circumscribed left anterior foci. These "foci," just as their bilateral variation (IBA), can have a rather diverse morphology depending on how the formative tendencies involved in their genesis are proportioned (illustration 39-45). The spectrum reaches from groups of focal left anterior rhythmic alpha- and sub-alpha-waves, high-amplitude rhythmic 6-7/s- waves and irregular 4-6/s-theta-waves to irregular delta-waves. If one disregards the morphogenetic context, then a misinterpretation indicating circumscribed brain damage is suggested. The popular practice to call these "foci," after rejecting a structural lesion, „functional" does not make much sense. Aside from the fact that such an interpretation does not provide any new insights one must remember that the functional diagram EEG as a matter of principle only represents the functional. To avoid misunderstandings, we prefer the following interpretive formulation in our findings records: "local manifestation of a global functional disturbance." It should be mentioned that, although rare, the mirror-image right-sided eqivalent to the ILA can also be observed (illustration 44).

> The predilection of the left brain half in particular for the alpha-anteriorization and the associated focal accentuation of slow waves is less of a mystery if we remember that the EEG, even from the physiological perspective, is in no way organized symmetrically and that this fact in all likelihood can be explained with the generally accepted neurodynamic inequality of both brain halves. We can, for instance, assume that the readiness for synchronization of the cortical neurons differs between the left and the right hemisphere. It has been known for some time that in genuine epilepsy left sided discharge foci are much more frequent than right sided discharge foci (TAKAHASHI et al. 1963). In 90% of the cases, Metrazol in epileptics with bilateral foci leads to a left sided prevalence of the paroxysmal activity (AJMONE-MARSAN and RALSTON 1957).

This interpretation is supported by observations that ILA, with the advancement of the pathophysiological process, shows a tendency for generalization, starting with a bilateralization (f. e. RICE et al. 1990). Thus ILA and IBA seem to be different degrees or stages of a uniform dissolution process. That the hypoxia experiments did not show any EEG-asymmetry might have its reason in the fact that during the experimental, time-accelerating pathological change of function intermediary stages remain inapparent. Possibly ILA can be associated with lesser dynamics or intensity of the underlying pathophysiological process compared to IBA. It is possible that compensatory mechanisms also play a role.

Our model of morphologically distinct dissolution paths signifies a fundamental departure from the usual procedure to utilize a single characteristic, such as a dominant frequency or a sum score formed by several single characteristics, as a quantitative indicator of the functional disturbance. In this case, one assumes, without any evidence, the existence of a linear relationship between the degree of the functional dissolution and the change of the index variable. But since the pathological gestalt modification of the EEG at best occurs linearly within the individual phases or dissolution stages, all attempts for an electroencephalographic validation of involutional decline of the mental performance level have to be viewed very skeptically. Indeed, there exist very few scientifically supported findings in this area.

An important question for which we do not yet have a definite answer is why, in one case, one, and, in the other case, the other dissolution path is chosen. Just as under the influence of psychotropic drugs (s. a. 4.5.), the preexisting conditions may have a significant impact on the kind of EEG-modifications that have to be expected.

Another question yet to be tackled is whether the distinct dissolution paths can also be associated with different psychopathological pictures. Assuming that the respective dissolution path is determined by the premorbid organization of the EEG and further assuming that this premorbid organization corresponds to specific behavior dispositions, such different psychopathological pictures certainly were to be expected.

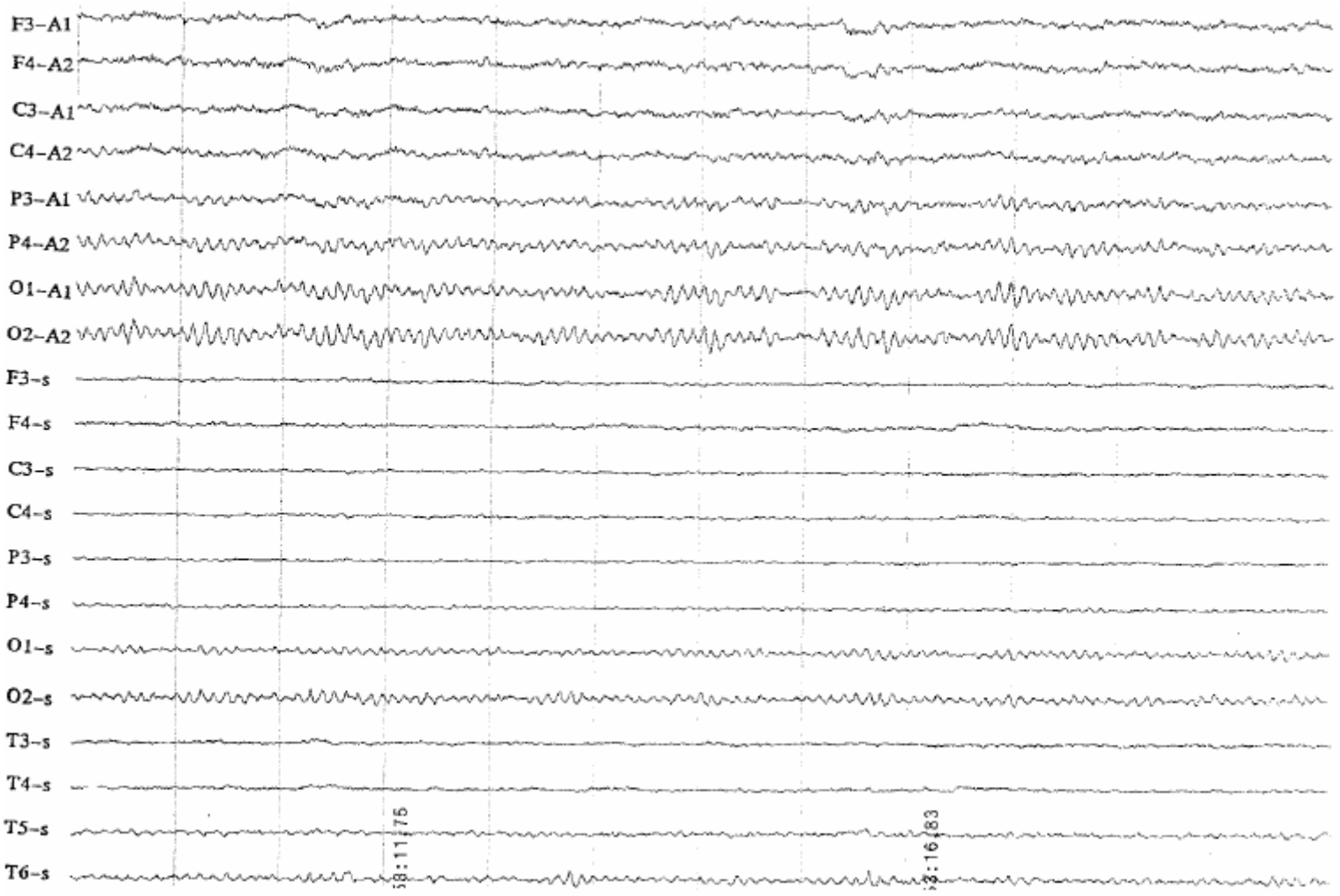


Illustration 31. Ideal-type organized EEG (5th minute) with a continuous, slightly spindle-form modulated and entirely posterior-accentuated 8.5/s alpha-activity (illustration 31-38 identical derivation schema).

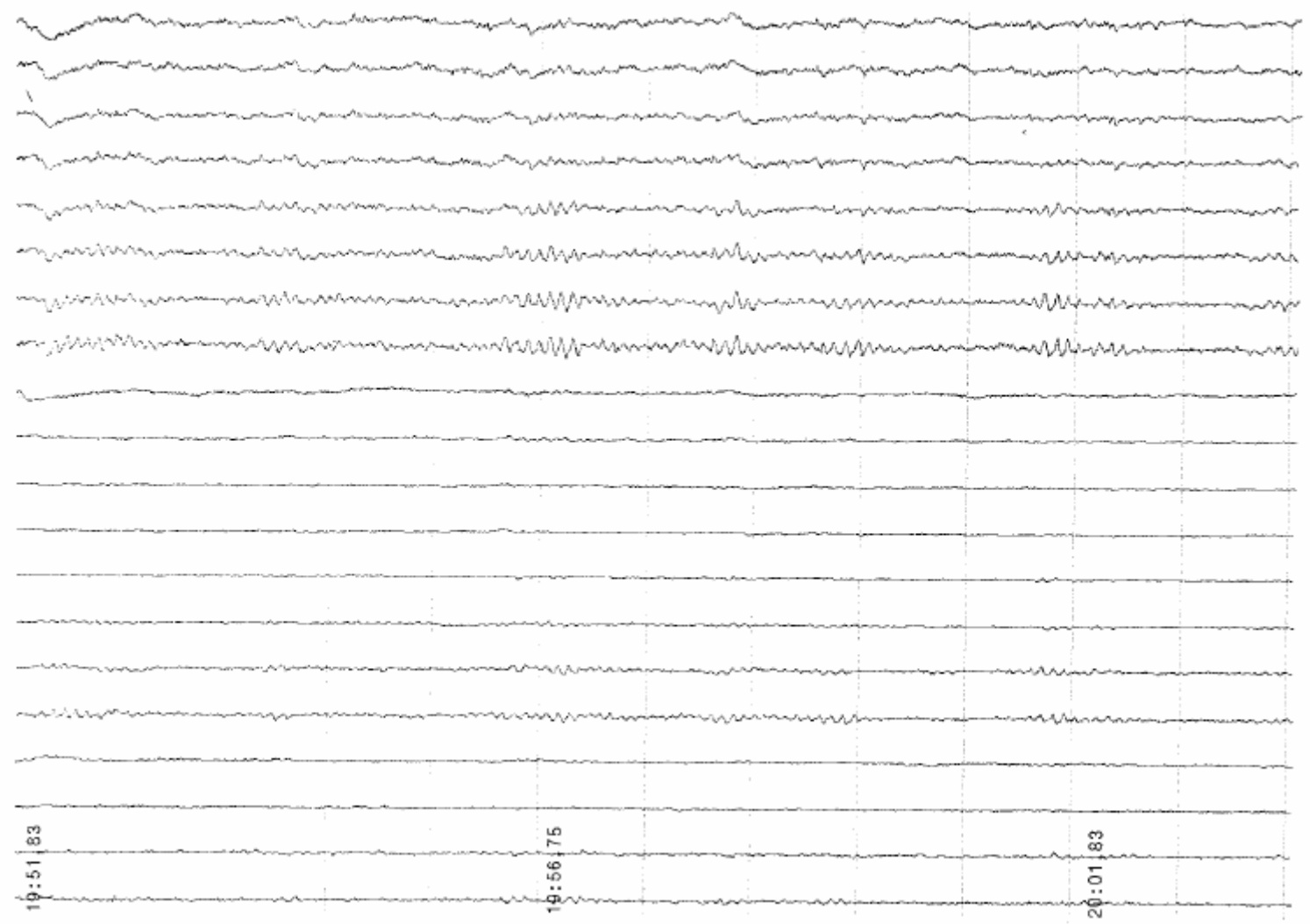


Illustration 32. Ideal-type organized EEG later on in the recording time (12th minute). Compared to the beginning of the recording increased discontinuity of the still posterior-accentuated alpha-activity, due to frequent transitions into low-voltage desynchronized activity, corresponding to a stage B1.

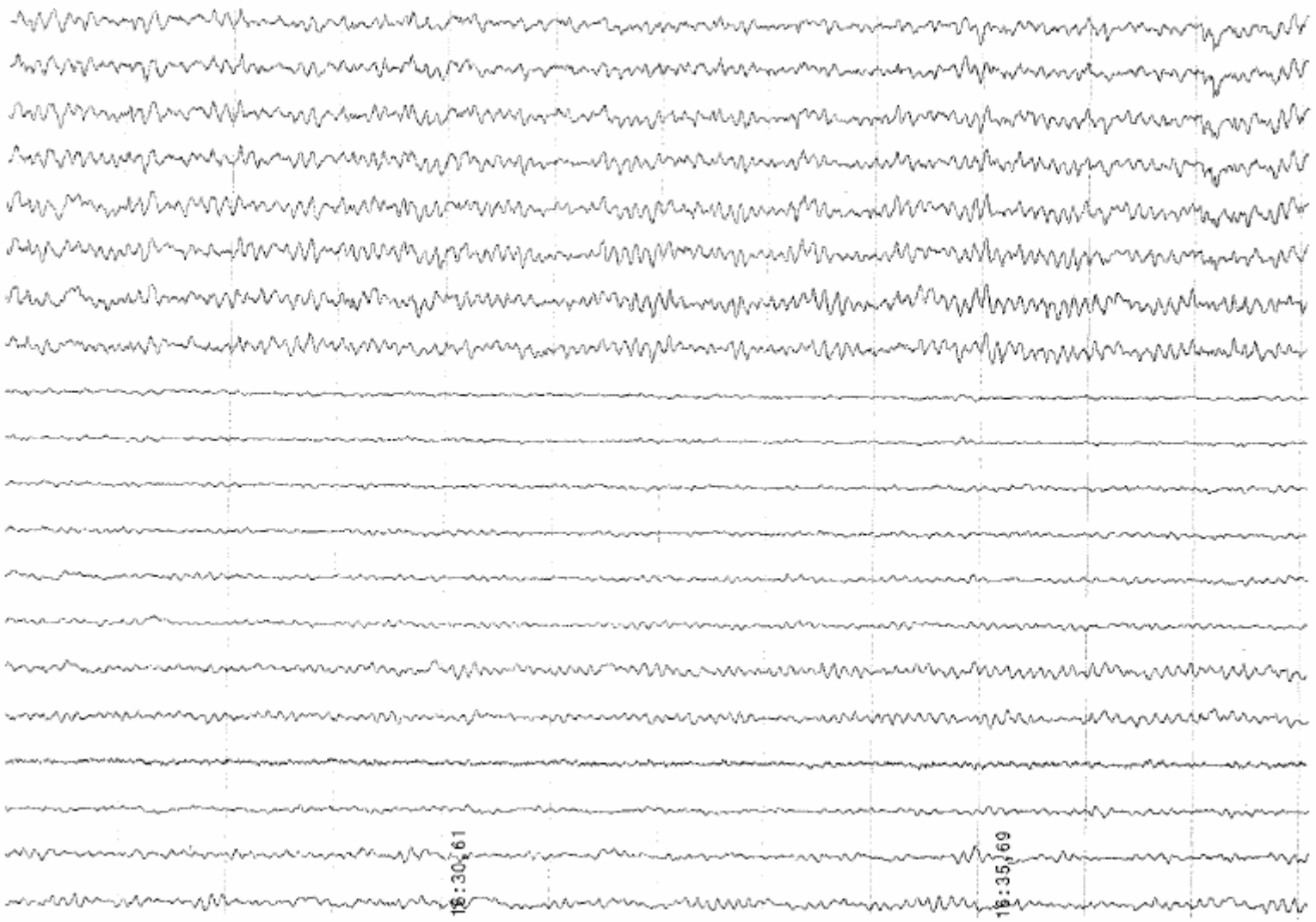


Illustration 33. Slight dynamic rigidity: Alpha-activity with frequency variations around 9.5/s with a medium-level non-consistent anteriorization, corresponding to a stage A1-A2.

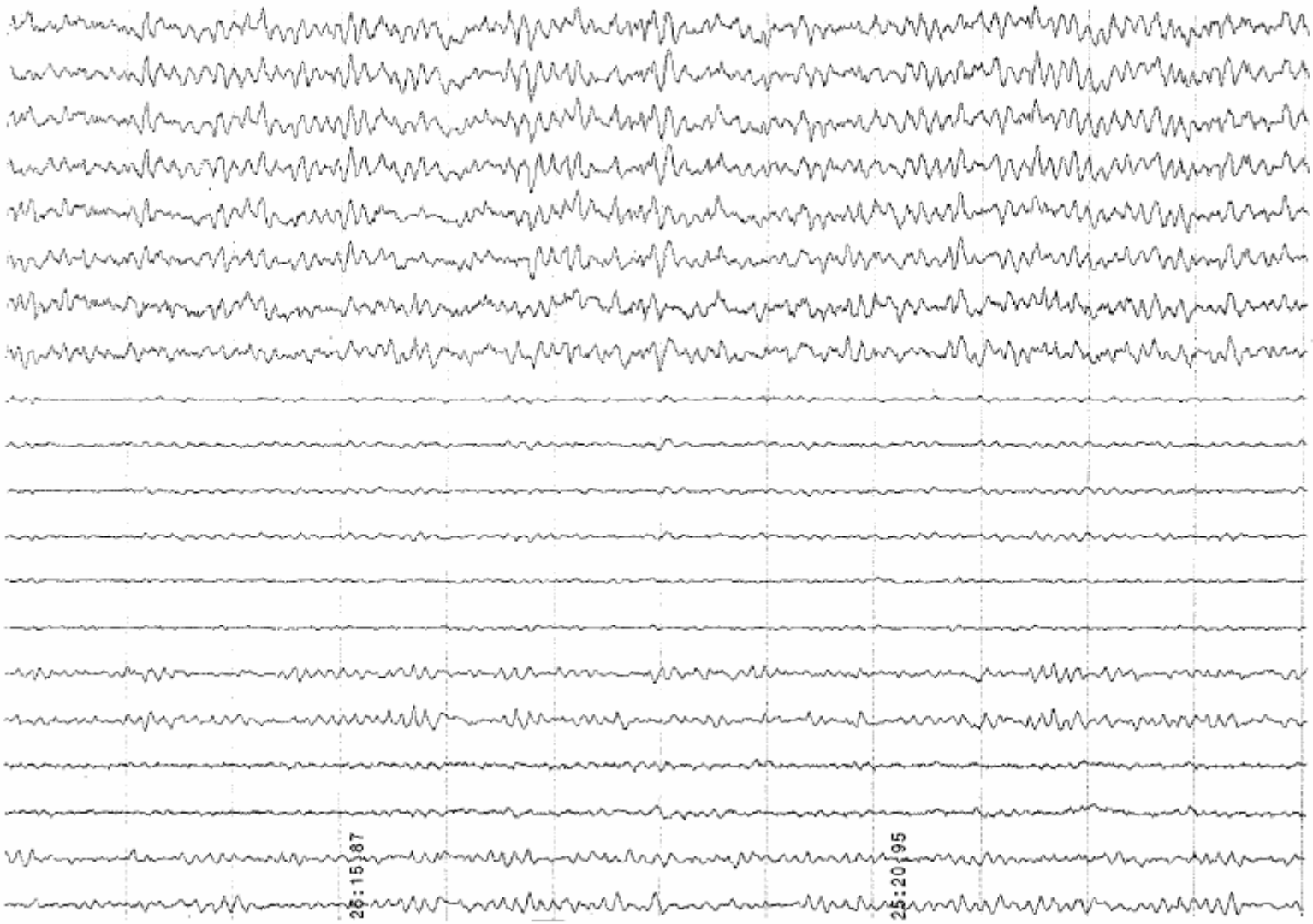


Illustration 34. More pronounced dynamic rigidity: Alpha-activity with frequency variations around 8/s with accentuation of the slower frequency components with anteriorization, corresponding to a stage A3.

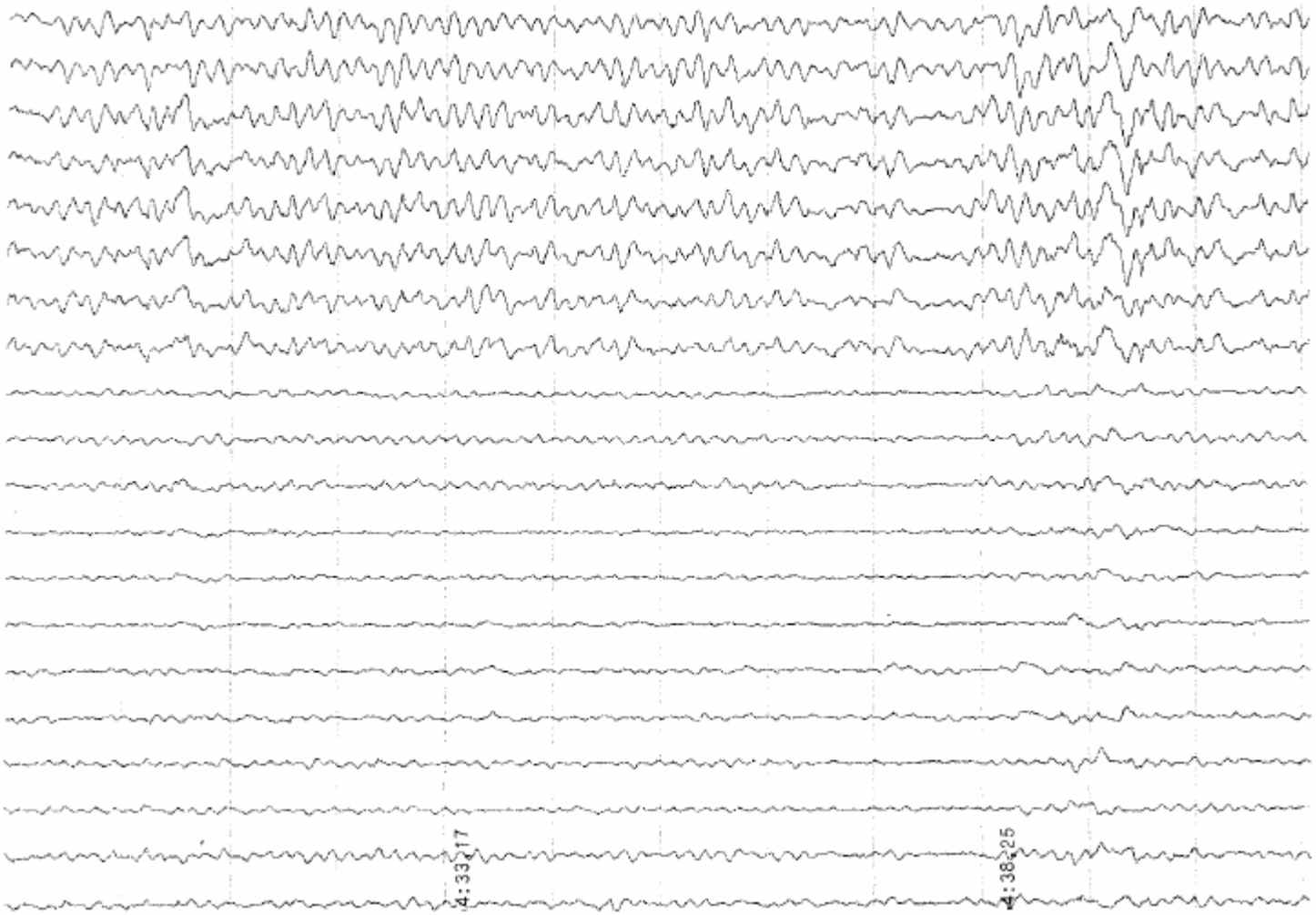


Illustration 35. Dynamic rigidity in transition to diffuse dysrhythmia. Groups and sequences of a rhythmic 6.5/s-activity of anterior accentuation (corresponding to a stage A4) alternate with irregular theta-/delta-activity.

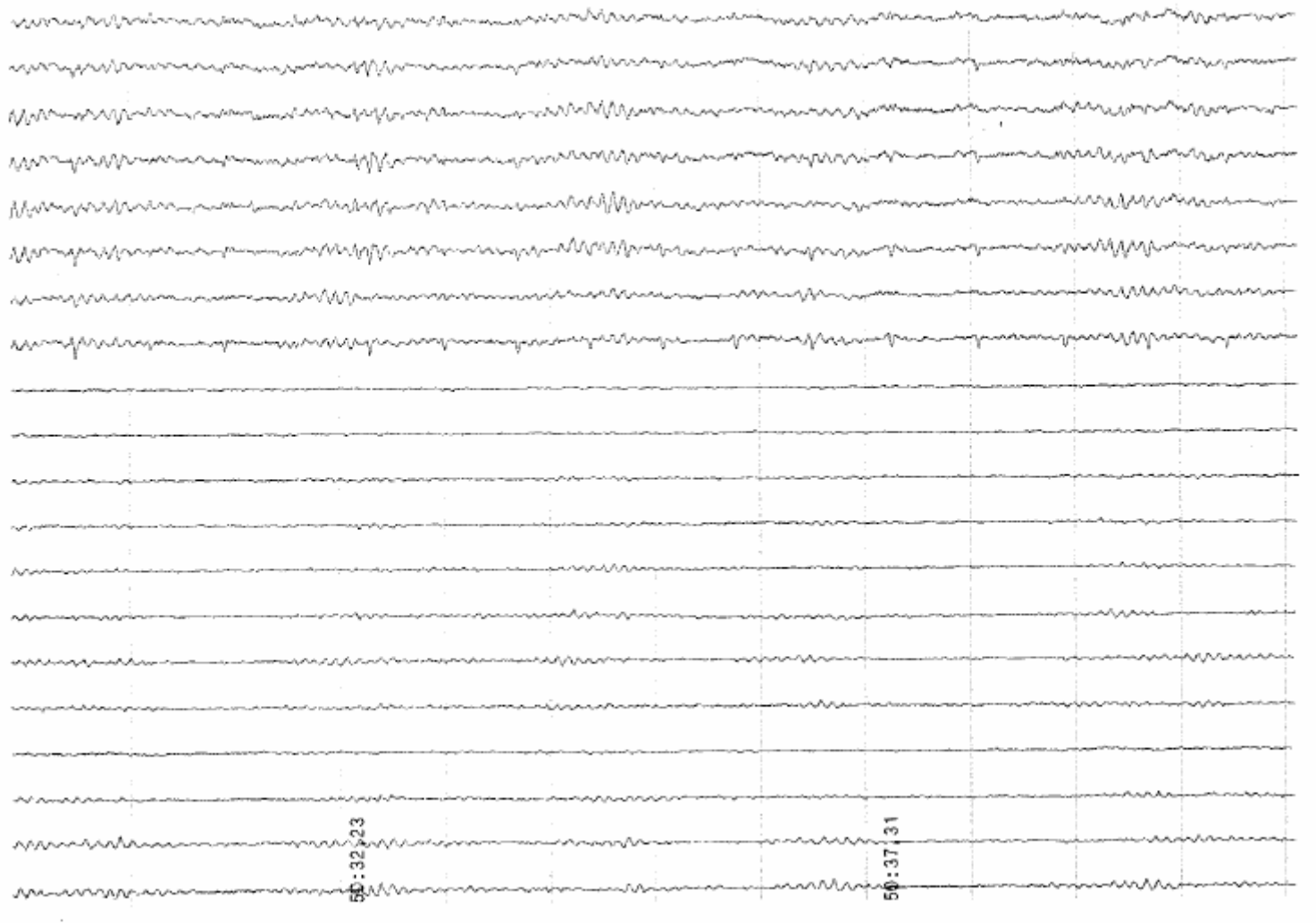


Illustration 36. Medium-degree dynamic lability. Already at the beginning of the recording (2nd minute), only discontinuous, 10/s alpha-activity differing in degree of anteriorization, only to be delineated in groups and sequences. Dominated by low-voltage desynchronized B1-stages.

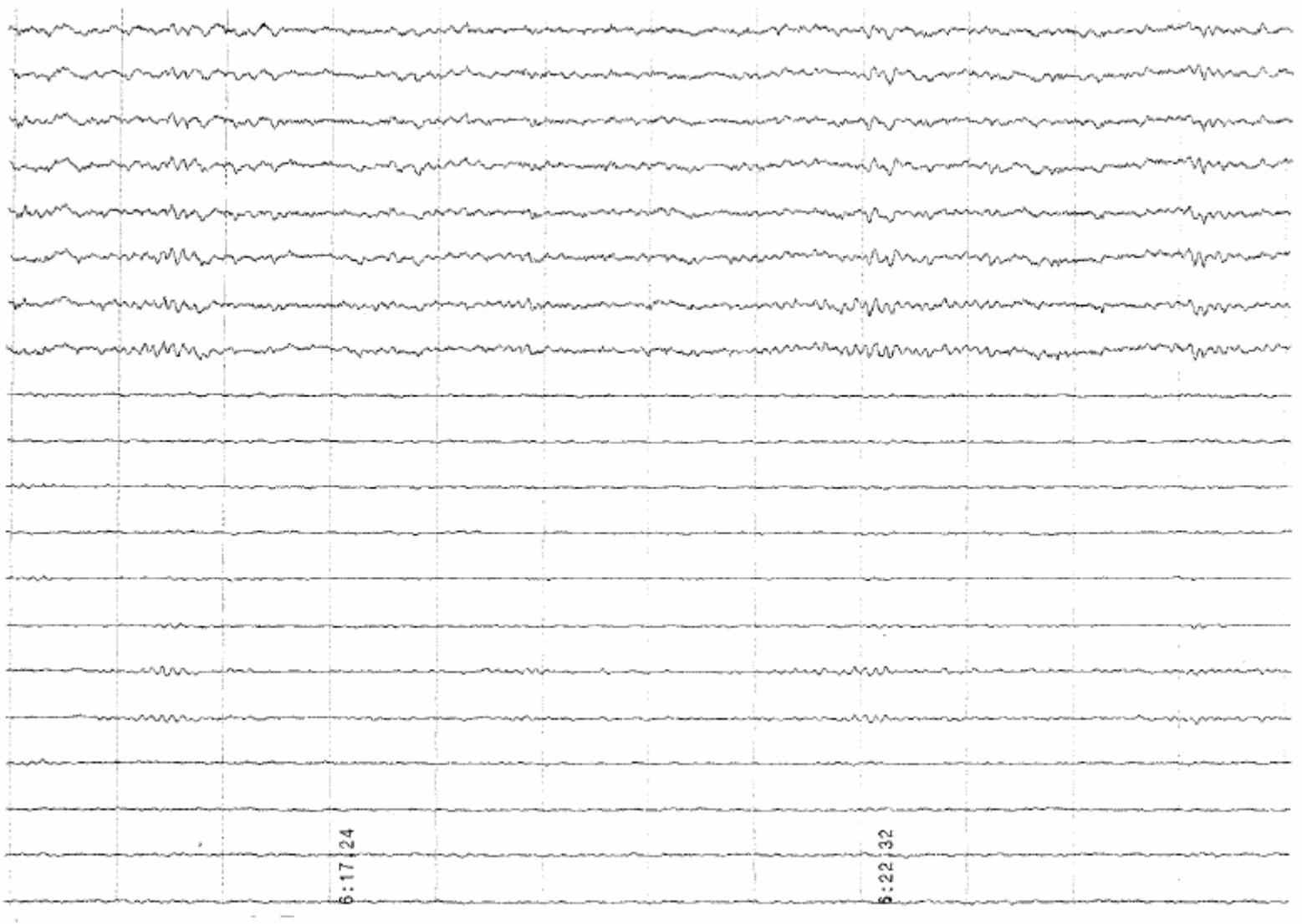


Illustration 37. More pronounced dynamic lability. Already at the beginning of the recording (2nd minute) lower-voltage desynchronized activity prevails, sometimes in connection with irregular theta activity, corresponding to stages B1-B2.

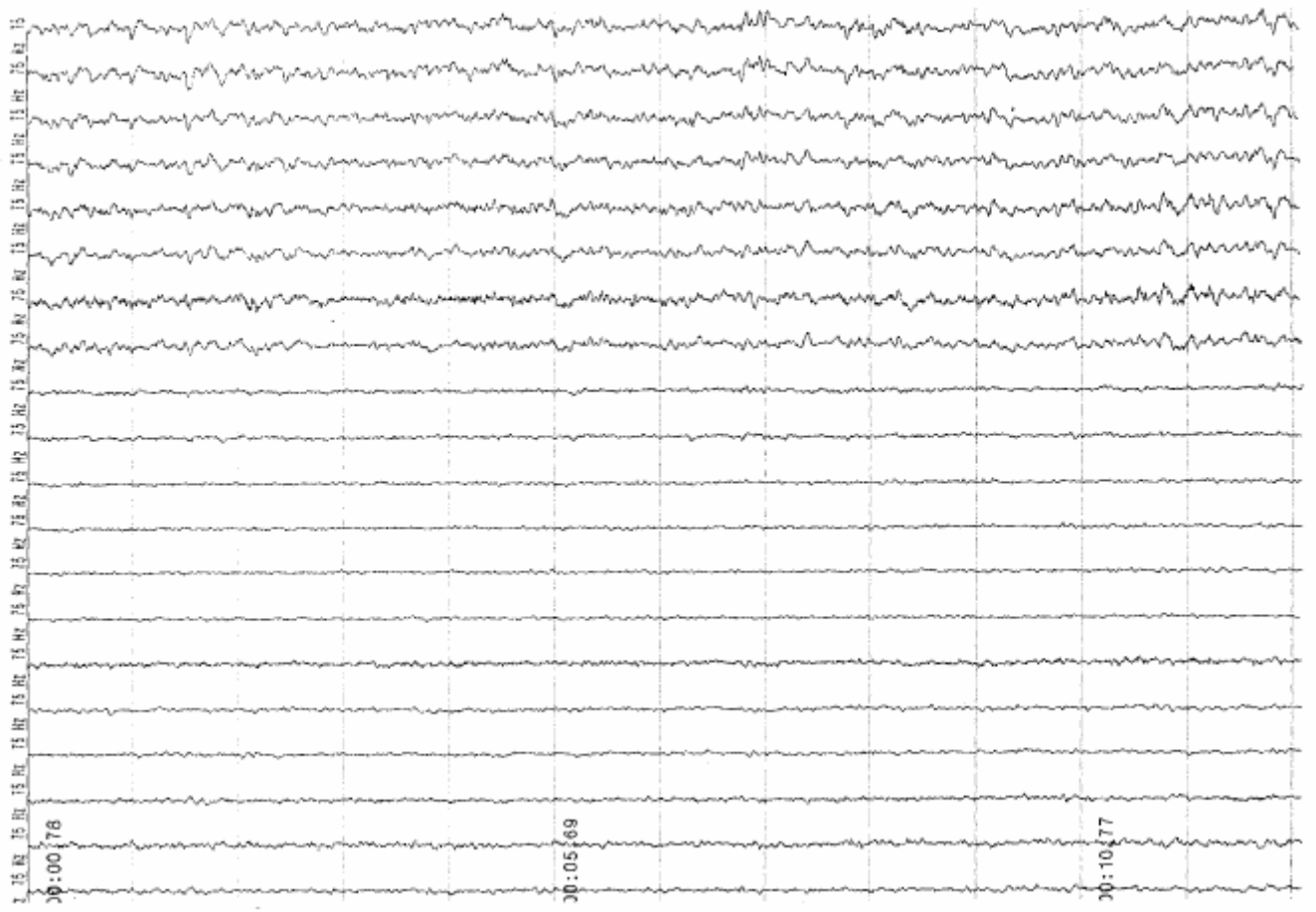


Illustration 38. Dynamic lability in transition to diffuse dysrhythmia. A relatively low-voltage activity is temporarily superseded by an irregular mixed theta-/delta-activity. It is almost impossible at this point to clearly delineate sub-vigilant intermediary stages, in contrast to illustration 37.

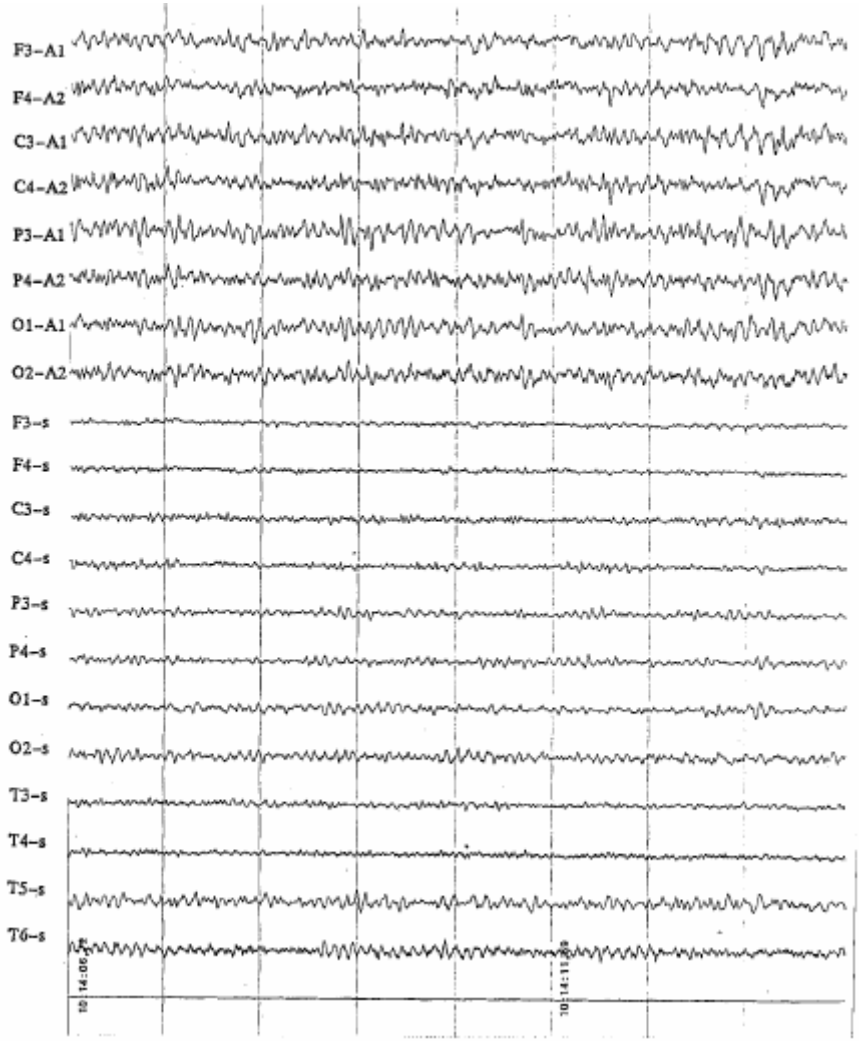


Illustration 39. Pathomorph variants of the A-stage (ILA/IBA). Frequency-variable alpha-activity around 8.5/s with a left-sided amplitude dominance - clearly recognizable during the first 4 seconds - which develops into a short group of focal 6/s-waves (ILA) with left-anterior dominance. (illustration 39-44 identical derivation schema)

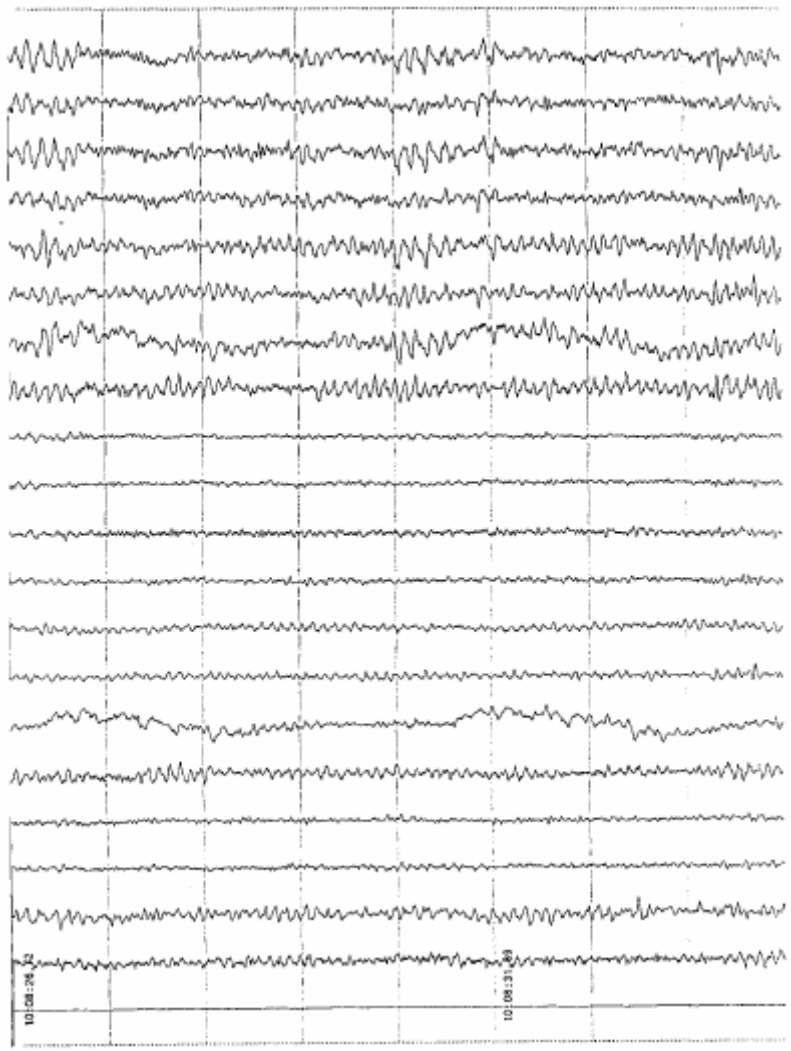


Illustration 40. Pathomorph variants of the A-stage (ILA/IBA). A group of rhythmic focal 7/s-waves with left-anterior dominance is followed in the 5th second by a group which also extends to the posterior regions.

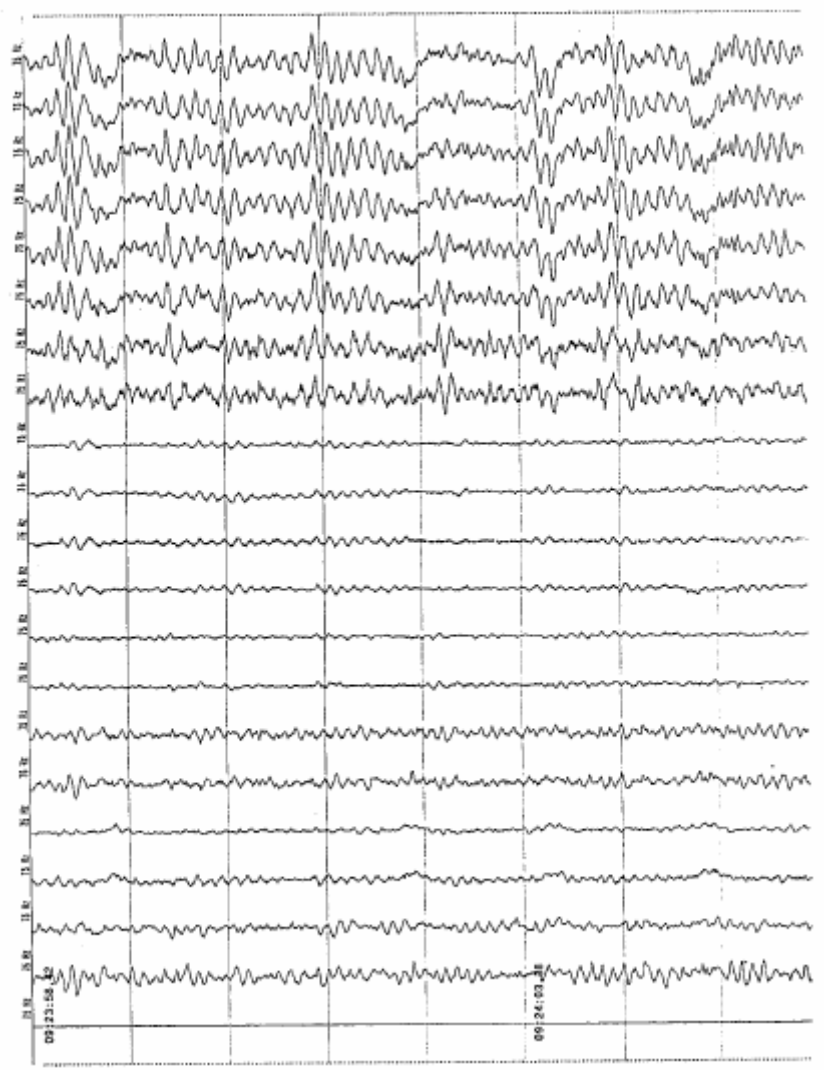


Illustration 41. Pathomorph variants of the A-stage (ILA/IBA). Groups and sequences of rhythmic, bilaterally symmetrical 7/s-waves (IBA). A 9-10/s alpha-activity largely hidden in the reference derivations can be detected in the source derivations above the posterior regions.

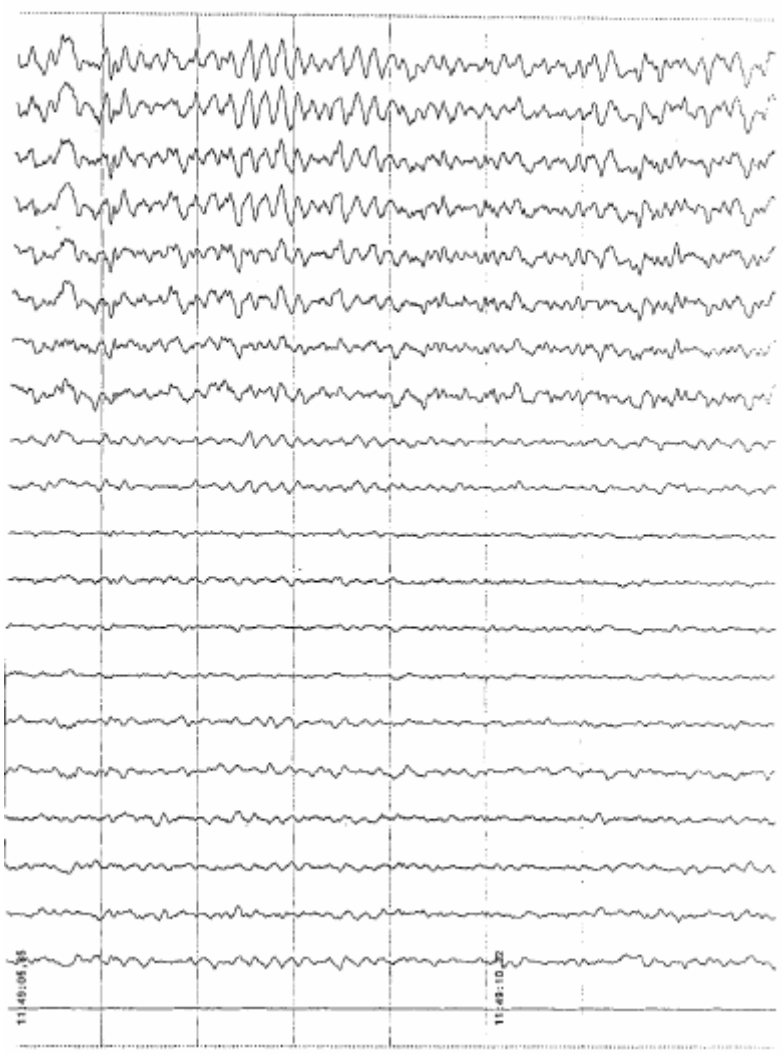


Illustration 42. Pathomorph variants of the A-stage (ILA/IBA). Intermittent groups and sequences of a moderately rhythmic bilaterally symmetrical 5/s activity (IBA) with transitions into diffuse-dysrhythmic activity. Alpha-activity cannot even be distinguished by suggestion. The example is taken from the same EEG as in illustration 39.

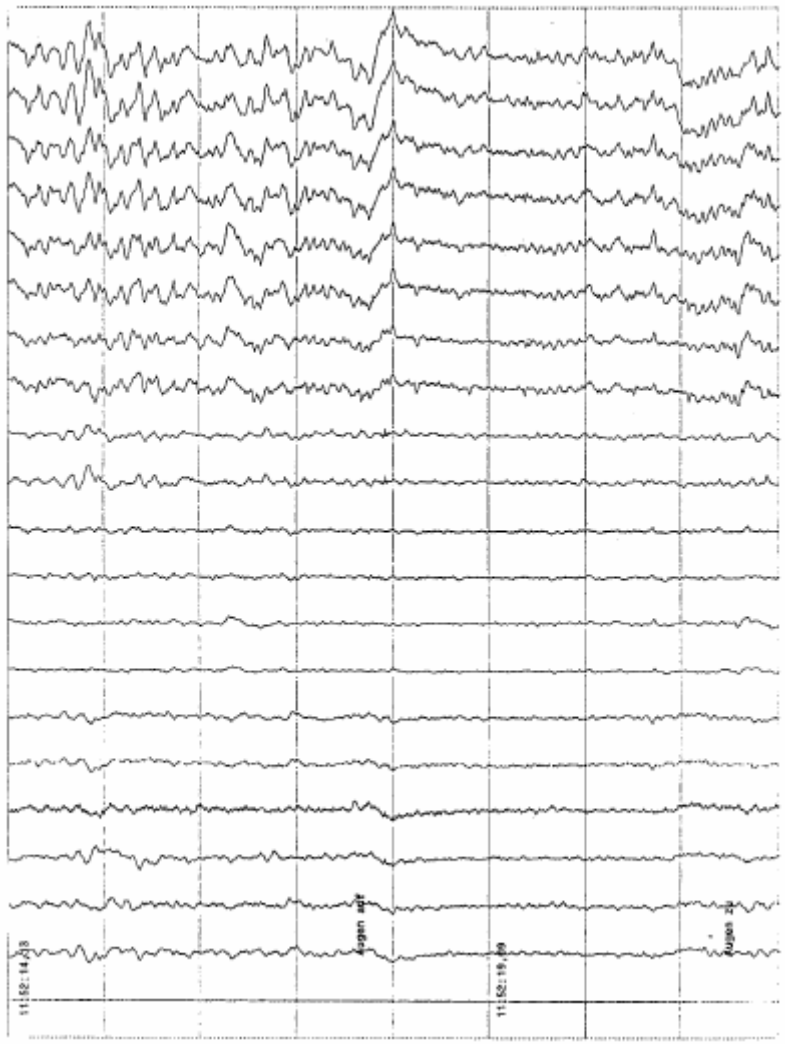


Illustration 43. Pathomorph variants of the A-stage (ILA/IBA). During the first 4 seconds, a transition from a moderately rhythmic higher amplitude anterior and bilaterally symmetrical 5/s activity (IBA) to a generalized diffuse-dysrhythmic activity that is blocked by the opening of the eyes is evidenced. Two seconds after the opening of the eyes, a passing 0.5 second posterior 9/s alpha-rhtyhm is shown. The example is taken from the same EEG as illustration 42 and 39.

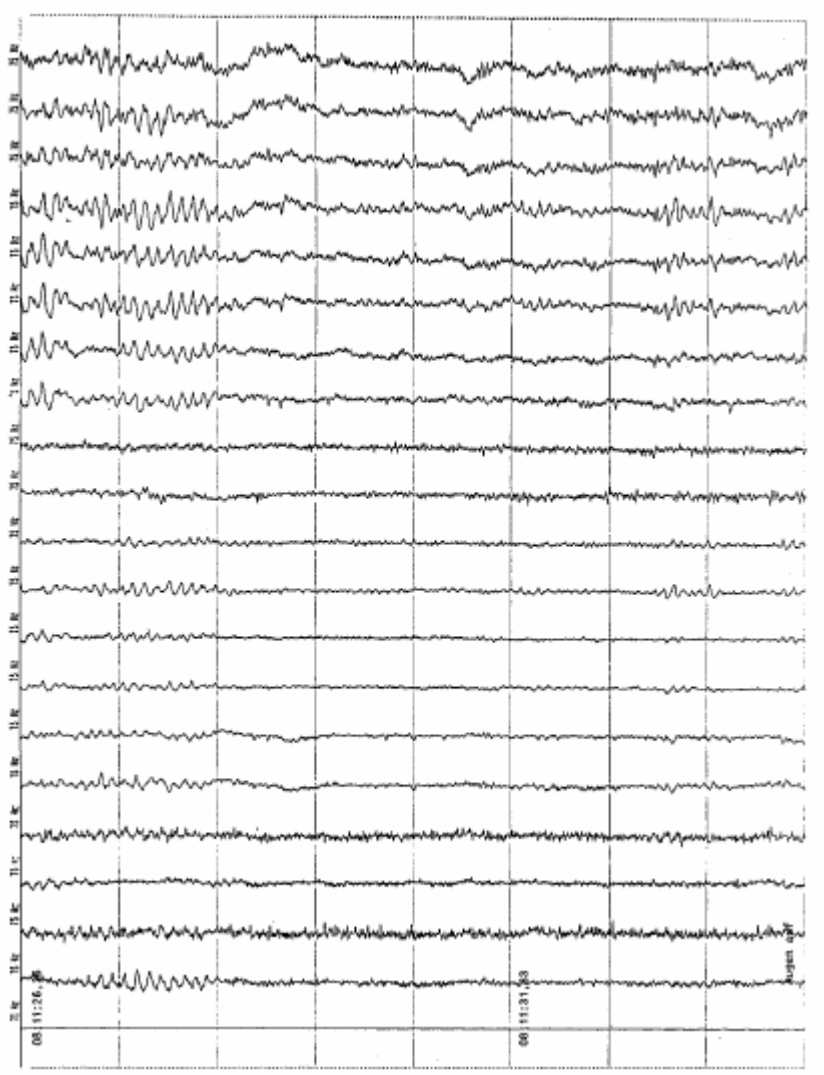


Illustration 44. Pathomorph variants of the A-stage (ILA/IBA). Frequency-variable rhythmic activity around 7.5/s with right-accentuated anteriorization during the first 2 seconds. Shown here is the relatively rare mirror-image equivalent to the ILA-phenomenon pictured in illustration 39.

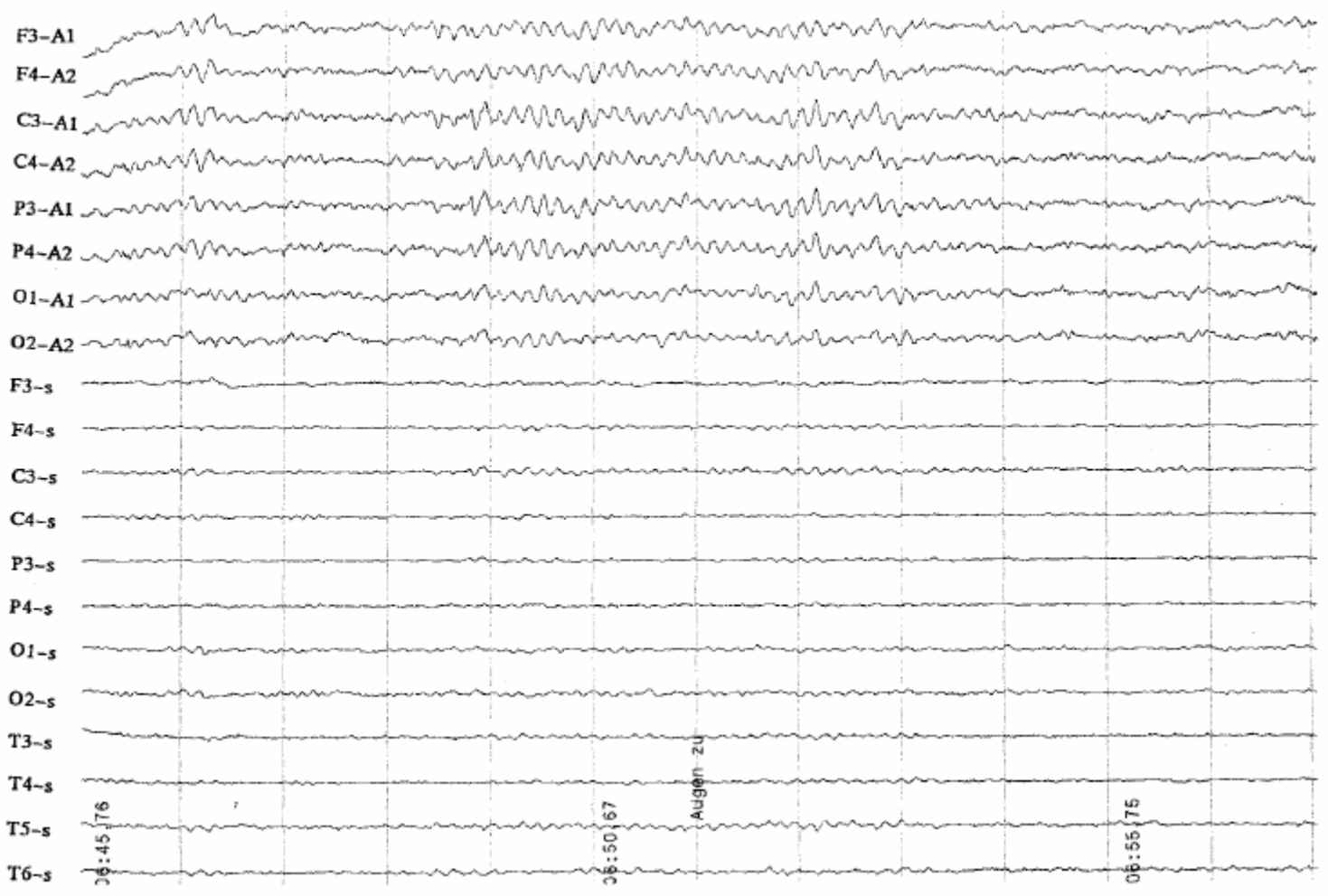


Illustration 45. Mixed form of a pathomorph gestalt change. A low-voltage desynchronized activity corresponding to a stage B1 develops into a passing phase of rhythmic anterior-accentuated bilaterally symmetrical 7/s-waves. This example contains elements of all three dissolution paths.

Finally, it must be mentioned that sometimes the definite association of an EEG with one of the three dissolution paths is difficult since elements of one of these paths can combine with the elements of another one. We are of the opinion that such overall rather infrequent cases do not question the foundations of the ordering function of our model (see illustration 26).

Apart from the possible practical-diagnostic value, our model also has implications for pharmaco-electroencephalography. In the efficacy test of a supposed nootropicum a positive effect will manifest itself in patients with baseline DR in a directional change towards DL and in patients with baseline DL in a directional change towards DR.

Since we must assume that a random sample of patients will always include some with dissolution via the A-stage (DR) and some with dissolution via the B-stage (DL) the consideration of the baseline condition is of great importance. However, one must expect false-negative group results if one, as is common practice, relies on primary quantifying, i.e. by means of spectral analysis. Since a change in the direction of DL usually is accompanied by a decrease of the spectral alpha-power as well as an increase of the beta- and sometimes also theta-power while a change in the direction of DR is evidenced by inverse shifts, one inevitably will fail to recognize an existent favorable effect in the group statistics. Since with primary quantification the retrograde correlation of the calculated power values with the morphodynamics of the raw signal is totally out of question, one will not even consider second-guessing such a false-negative result. Therefore it seems advisable to revise all thus far conducted EEG-studies regarding nootropical effects which ignore the baseline condition. In two of our studies with the calcium-antagonist Nimodipine (ULRICH 1987; ULRICH and STIEGLITZ1987), we demonstrated that the nootropical effect of this substance would not have been recognized if the baseline condition had been ignored.

In our attempt to first get the undivided interest of the reader for our model of morphologically distinct dissolution paths, and have neglected to mention an important fact thus far. The fact is that all EEG-characteristics, DR, DL, and IBA/ILA - described as dissolution correlates - can also be observed in completely healthy persons as constitutional variants in the sense of a "trait"-characteristic (s. a. 4.7.). Therefore, the observation of those characteristics can be associated with a pathological functional change only if supported by either additional clinic information or course observations. This means that there will always be cases where the electroencephalographic evaluation of a pathological functional change must remain uncertain because of constitution-related peculiarities.

3.2. From the Diffuse-Dysrhythmic EEG to Brain-Electric Inactivity

If we wanted to succumb to the strong trend that classifies organic psychoses and especially the increasingly important dementia under neurology, we could have allowed psychiatric electroencephalography to end here. There are, however, good reasons to resist this fashion (ULRICH 1992) as has been explained in previous contexts.

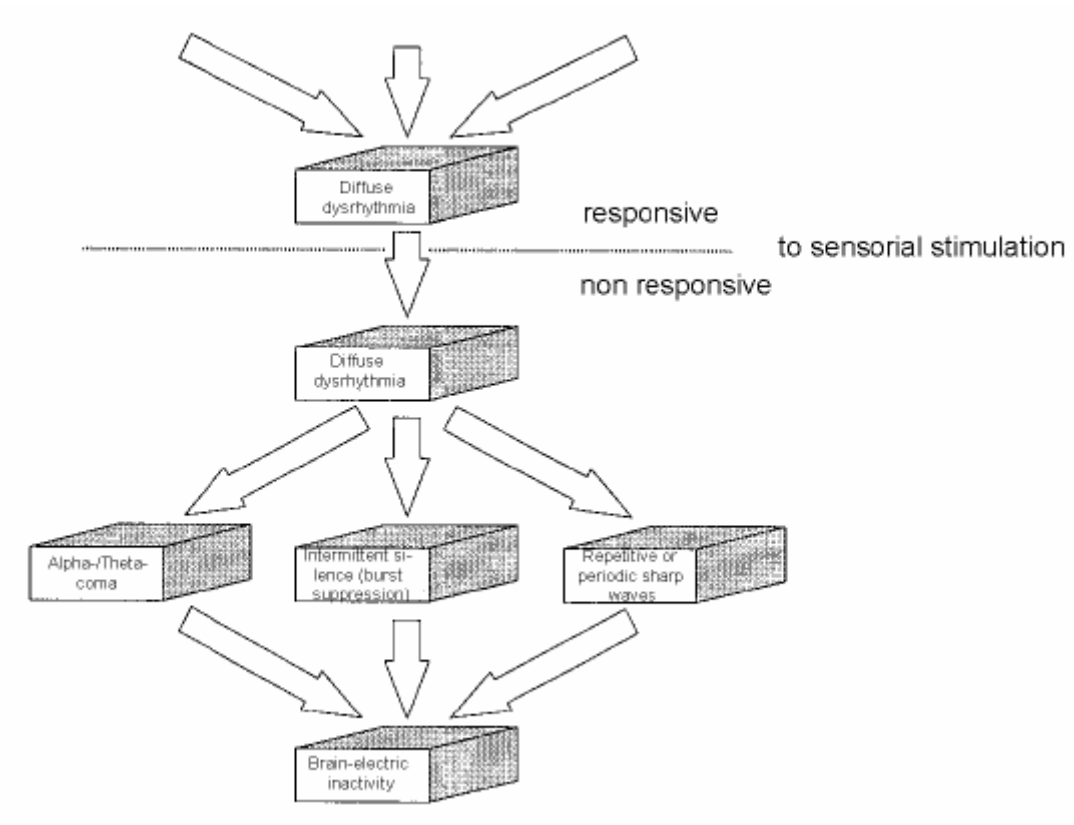


Illustration 46. The pathological gestalt change of the EEG (II).

Our dissolution model discussed in the previous chapter (illustration 26) can be extended beyond the diffuse dysrhythmia, as shown in illustration 46.

Of course, a diffuse-dysrhythmic EEG (DD) also is pathognostically ambiguous. There also does not exist any disease-specific or only pathognomonic wave forms. Contrary to older assumptions one cannot conclude hepatic encephalopathy from "triphasic" waves (illustration 47) (SMALL 1986; GLAZE 1990) nor CREUTZFELD-JACOB disease from periodic or repetitive sharp waves (illustration 48, 49) (SMITH and KOCEN 1988; SCHLENSKA and WALTER 1989). Distinctions, however, according to the disintegration level are possible. This is reflected primarily in a destruction of the physiological cycle dynamics. With progressive dissolution of functions, the delineation of subvigilant intermediary stages becomes increasingly difficult. Through a diffuse irregular theta-activity (illustration 50), the complete picture of DD (illustration 51), characterized by polymorphous delta-activity, finally develops. However, the evaluation of the functional dignity of a DD cannot be based solely on the spontaneous resting EEG. In any case, reactivity tests by means of visual, acoustical or somaesthetic stimuli are indispensable. These tests usually allow the distinction between a DD, as a result of severe encephalopathy on the one hand or as a result of psychotropic medication on the other. Medication-induced diffuse dysrhythmia that can reach considerable degrees with usually no recognizable deficit in the domain of behavior/experience can be significantly reduced by sensorial stimuli (illustration 52; s. a. 4.5.) In the case of encephalopathic DD however the sensorial reactivity is usually limited, inconsistent, or missing (illustration 53). The extent of the reduced reactivity allows conclusions about the extent of the functional dissolution.

> Here, the high variability of the responses to stimulation in repeated tests must be taken into consideration. Therefore an even moderately reliable judgment cannot be based on a single test. The most effective sensorial stimulus for unconscious patients has proved to be loud handclapping close to the ears. Startling reflexes caused by this maneuver that are evidenced in the EEG by high- amplitude, often sharp potentials should not be confused with brain-electric phenomena.
>
> With preexisting high-amplitude delta-activity, sensorial stimuli typically cause a decrease in amplitude, possibly accompanied by a frequency increase. However, in the case of a flat curve, an activation of single or grouped high-amplitude slow waves can also occur (illustration 54). But no consistent relationship exists between EEG-reactivity and behavioral reactivity.

The spectrum of possible causes of DD that are of interest to the psychiatrist is listed in table 3.

Table 3. Causes for a diffuse-dysrhythmic EEG

-	Psychotropic medication (s. a. chapter 4.5)
-	Other chemicals or drugs
-	Electro-convulsive treatment (ECT)
-	Metabolic poisoning (uremic, hepatic, acetonemic, etc.)
-	Hypoglycemia
-	Hypoxia/anoxia (state after reanimation)
-	Brain injury
-	Degenerative brain disesases
-	Acute encephalitis

In the case of a non-reactive diffuse-dysrhythmic EEG, the patient usually suffers from clouded consciousness or is completely unconscious. However, there is no consistent relationship between the depth of unconsciousness and the severity of the DD. Therefore, the extent of a DD cannot be used to draw conclusions about the degree of global brain dysfunction. In extensive observations of patients with brain trauma, LORENZONI et al. (1975) found only a "slight Allgemeinveränderung" in as much as 10% of the deeply comatose. On the other hand, they found a "severe Allgemeinveränderung" in as many as 14% of the "subcomatose" patients. The authors also refer to the possibility of discordant courses where a clinical improvement of the patient is accompanied by an increase in the degree of dysrhythmia. As a brain-electrical correlate of an apallic syndrome, the DD usually shows a periodic change from higher-amplitude faster (5-6/s) to lower-amplitude slower (2-3/s) activity. The first is regarded as a sleep activity, and the latter is considered a waking activity (SILVERMAN 1963; BUTENUTH and KUBICKI 1975). This is generally explained by the observation that waking stimuli, applied during the phases of higher-amplitude 5-6/s activities, induce a lower-amplitude irregular 3-4/s activity. If, in an apallic patient such a basic distinction between waking and sleeping activity is impossible, the prognosis is considered to be particularly bad. An even lower dissolution level than DD is represented by the three EEG pictures, shown in illustration 46, below the non-reactive diffuse dysrhythmia.

In the alpha-coma-EEG we are faced with what seems at first glance to be an inconspicuous alpha-organization (illustration 55), or, in rarer cases, a more or less rhythmic 5-7/s theta-activity (illustration 56). According to the definition, the physiomorph posterior voltage dominance is missing, just as is the sensorial reactivity. Even though this definition generally fits, there are also cases with posterior voltage dominance or sensorial reactivity (illustration 57). As a clinical correlate of the electroencephalographic alpha-coma, we find either a non-reactive coma or an apallic syndrome. Pathogenetically, this is most often a case of irreversible brain stem damage caused by pinching in the tentorium notch.

As a variation which is typically only fleetingly encountered, we would like to mention the so-called spindle-coma (JASPER and VAN BUREN 1953; OKADA and INOUE 1992). Here, an 11-14/s spindle activity of frontal accentuation which corresponds to light sleep stage C dominates the picture. This EEG pattern can be observed in comatose as well as in slightly somnolent patients.

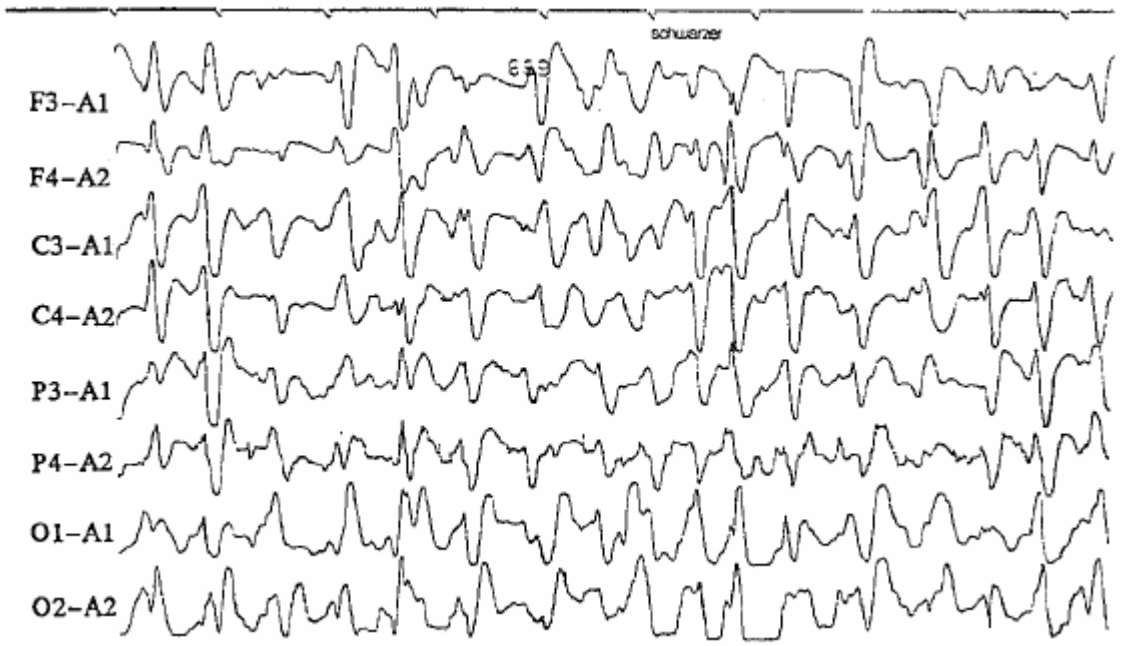


Illustration 47. Diffuse-dysrhythmic EEG with "tri-phasic" waves. State after reanimation in case of heart infarction, severe clouding of consciousness (D. A. 64 J., m., EEG-nr. 891/93). Illustration 47-64 identical derivation schema.

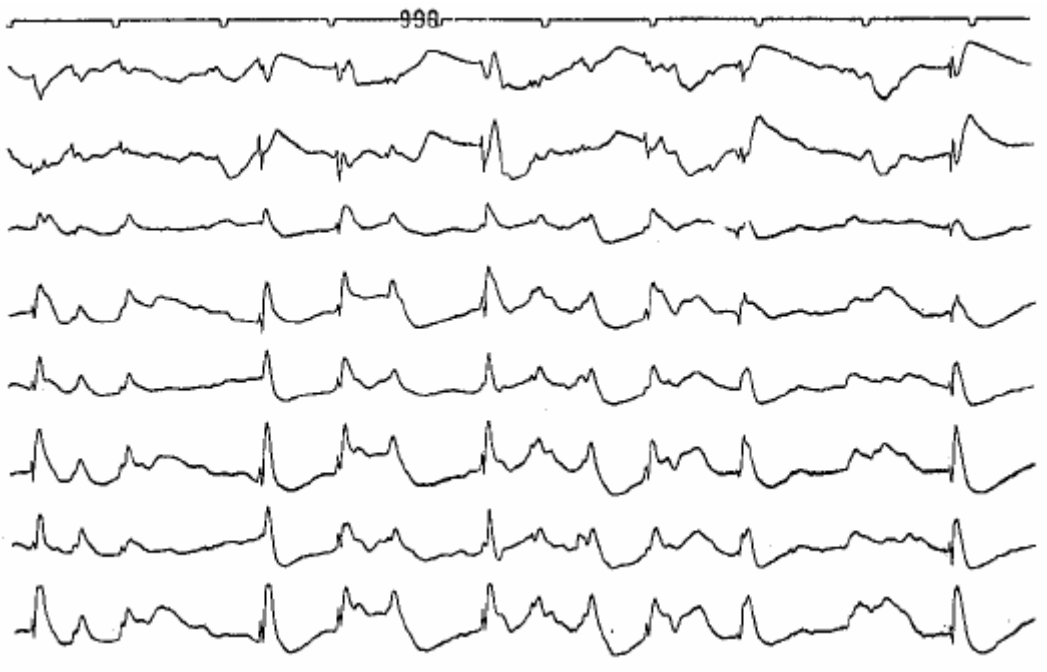


Illustration 48. Periodic complexes of steep waves combined with irregular slow waves. State after reanimation in case of heart infarction, non-reactive coma (K. P., 78 J., m., EEG-nr. 682/93).

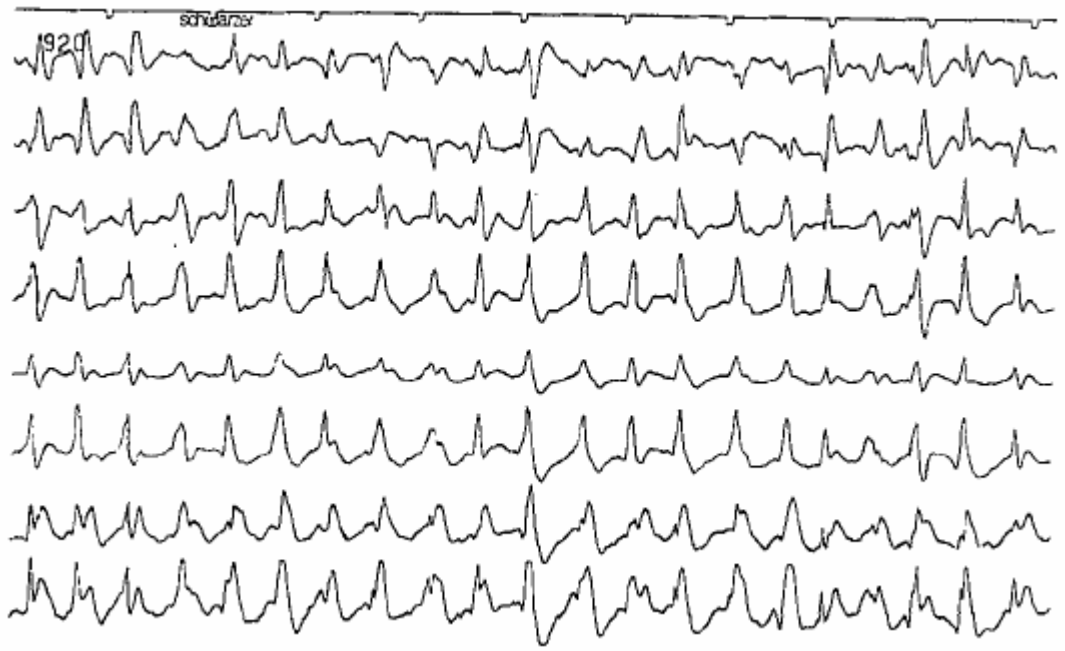


Illustration 49. Repetitive sharp waves with a discharge frequency of 1-2/s. Encephalitis of unknown origin, severe clouding of consciousness (I. P., 58 J., f., EEG-nr. 752/93; s. a. illustration 61).

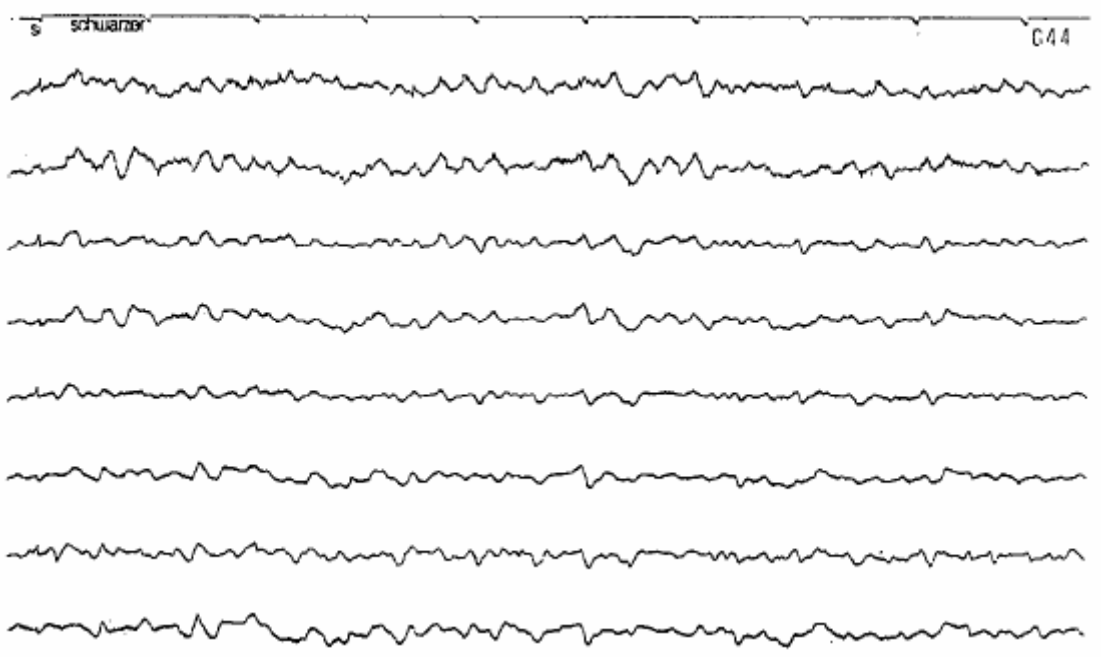


Illustration 50. Light to medium diffuse dysrhythmia, dominated by an irregular 4-5/s theta-activity of alternating topographical accentuation and sporadically superimposed alpha-waves around 9/s. Senile dementia, no clouding of consciousness (A. B., 83 J., f., EEG-nr. 506/91).

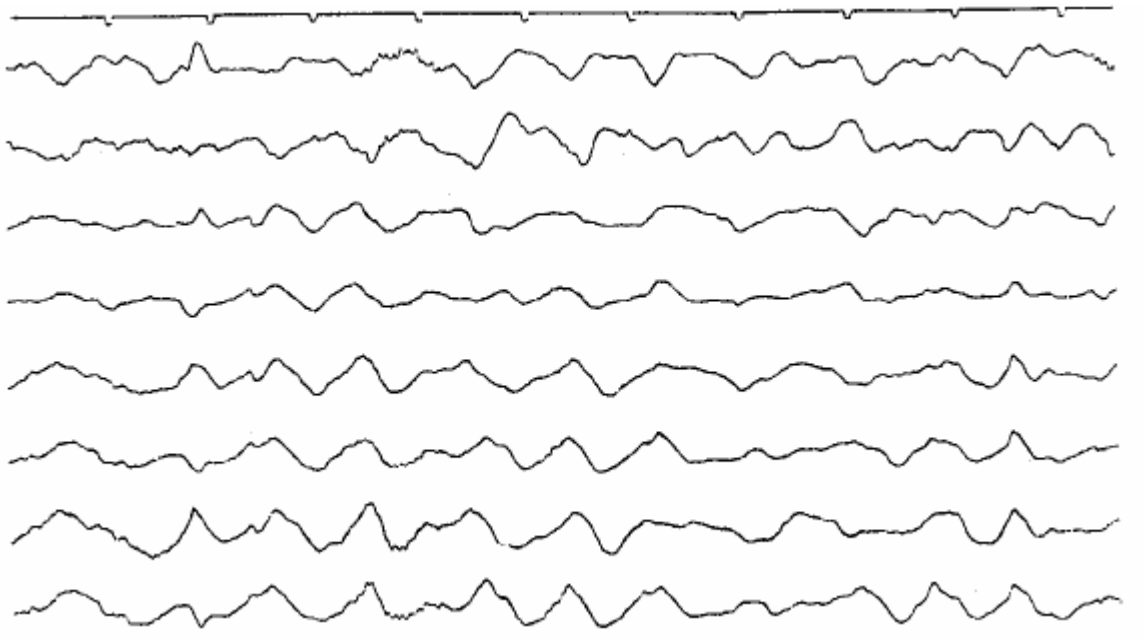
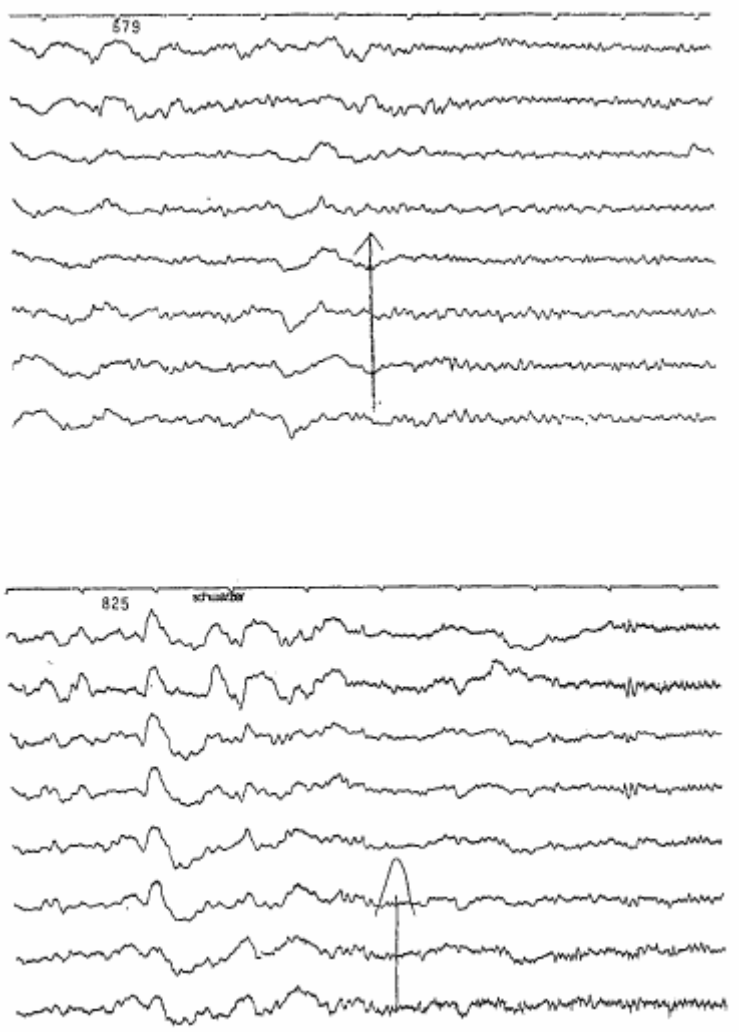


Illustration 51. Full picture of a diffuse dysrhythmia, characterized by polymorphous 1-2/s delta-waves. Senile dementia, medium clouding of consciousness (B. P., f., 82 y., EEG-nr. 102/90).



Ilustration 52. Above: Diffuse dysrhythmia with senile dementia, distinct reactivity to sensorial stimulation (hand clapping) (E. D., 85 J., f., EEG-nr. 205/91). Below: Diffuse dysrhythmia caused by carbamazepine with drug-specific reactivity to sensorial stimulation (hand clapping) (K. R., 63 y., f., EEG-nr. 1003/92).

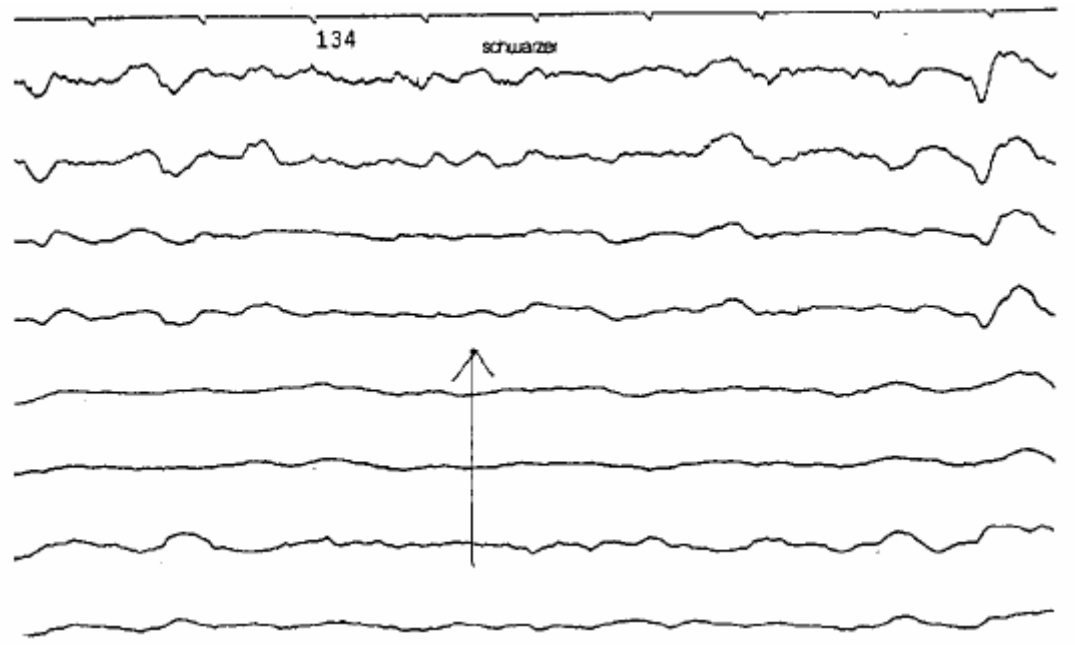


Illustration 53. Pronounced dysrhythmia in non-reactive coma without sensorial reactivity (hand clapping). State after reanimation from asystolia in status asthmaticus (E. P., 47 y., f., EEG-nr. 105/93).

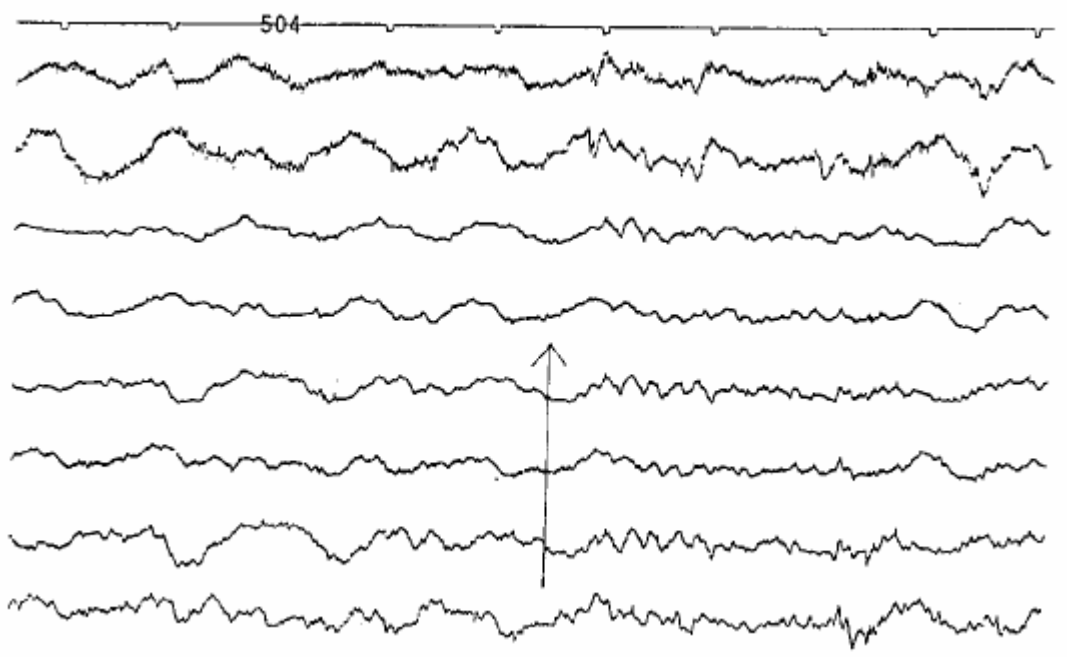


Illustration 54. Pronounced diffuse dysrhythmia in apallic syndrome after brain-trauma, with paradoxical sensorial reactivity: upon hand-clapping, a rhythmic 4-5/s theta-activity temporarily appears with preexisting close-to-baseline delta- and sub-delta waves (K. A., 33 y., m., EEG-nr. 623/92).

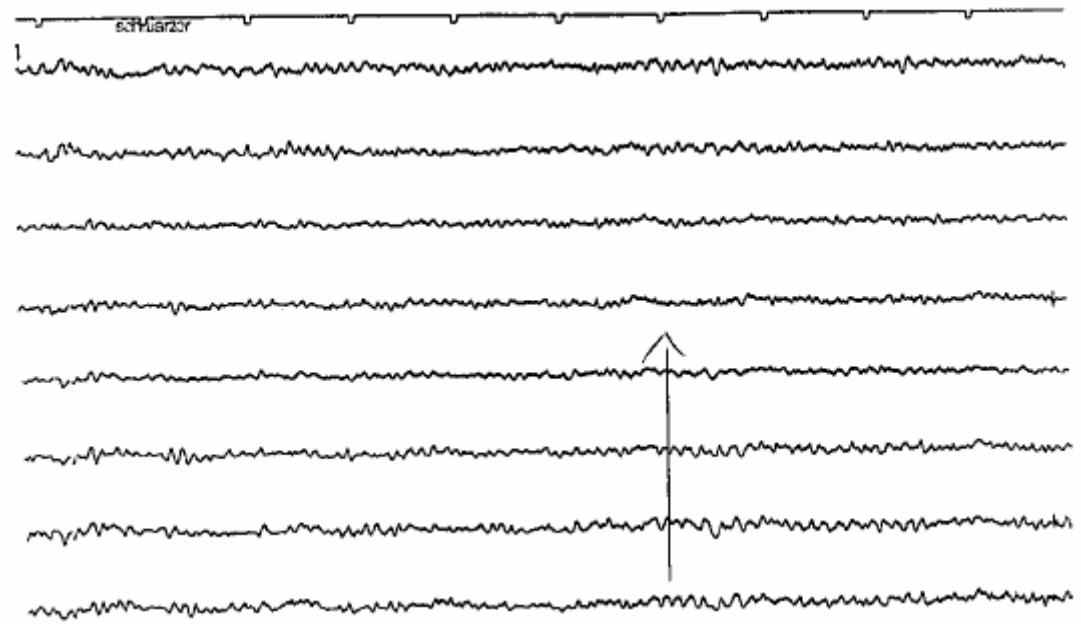


Illustration 55. Typical alpha-coma with apallic syndrome after reanimation: 9-10/s-rhythm without topical accentuation and without any reaction to sensorial stimulation (hand clapping and painful stimuli) (W. V., 44 y., m., EEG-nr. 657/93).

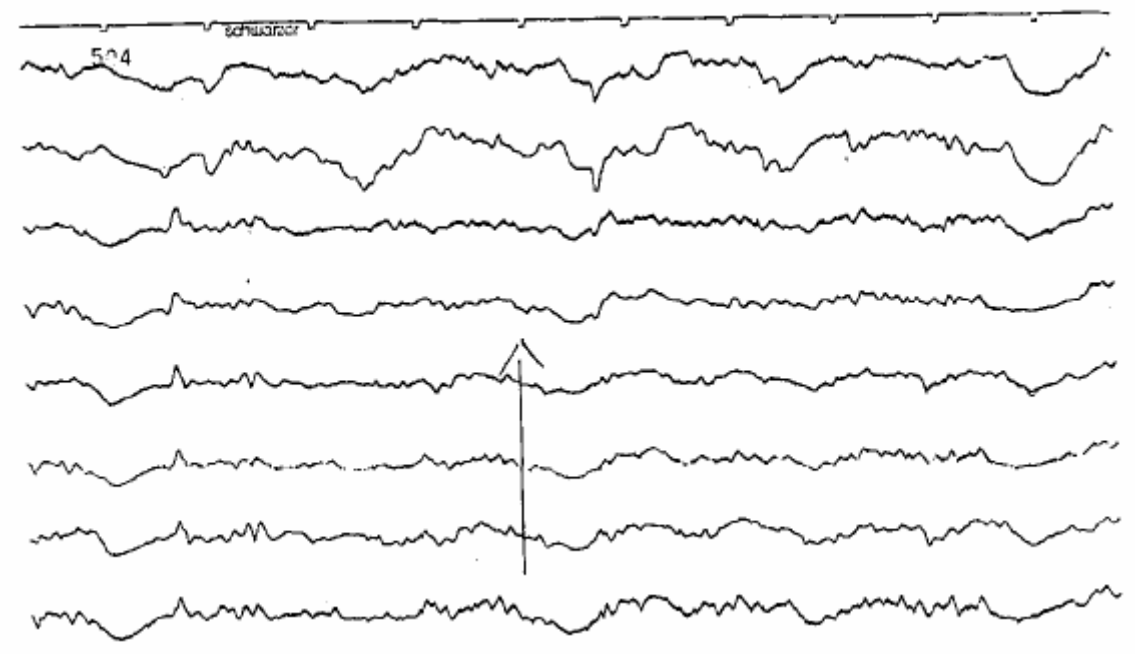


Illustration 56. Alpha/theta-coma with apallic syndrome after reanimation (same patient as illustration 55, two weeks later): a topographical-diffuse and discontinuous 9-10/s alpha-rhythm is superseded by irregular theta- and delta-waves (EEG-nr. 772/92).

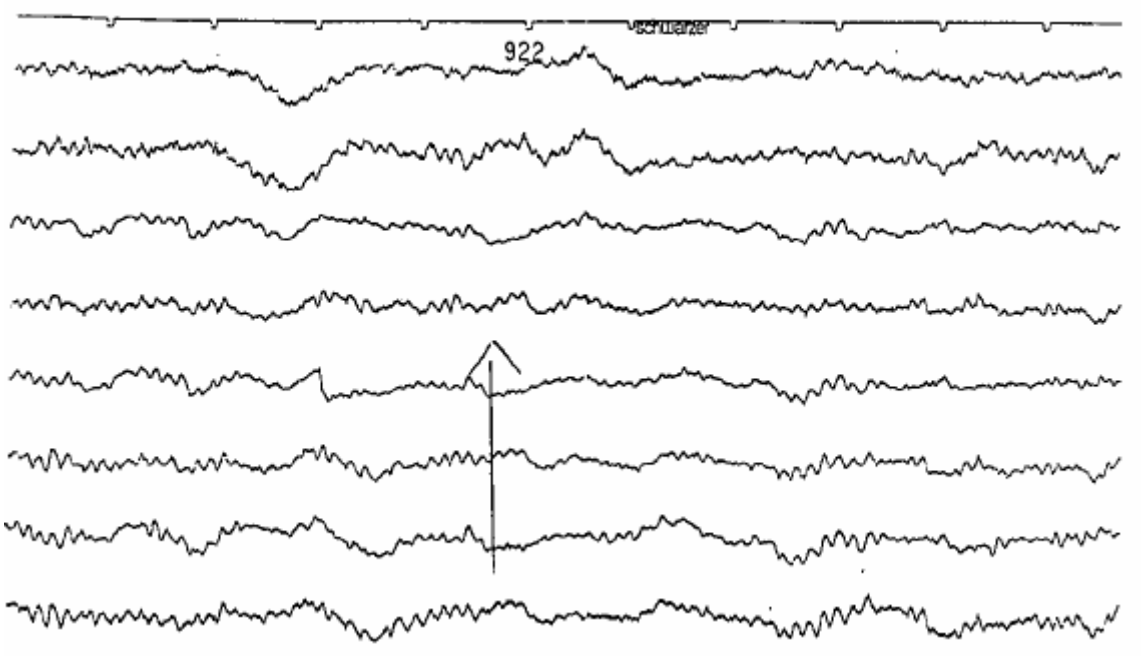


Illustration 57. Atypical alpha-coma with apallic syndrome after reanimation: slightly discontinuous 9/s alpha-activity with posterior accentuation, corresponding to a stage A1, weakened temporarily and only partially by sensorial stimulation (hand clapping) (E. D., 67 y., m., EEG-nr. 1003/92).

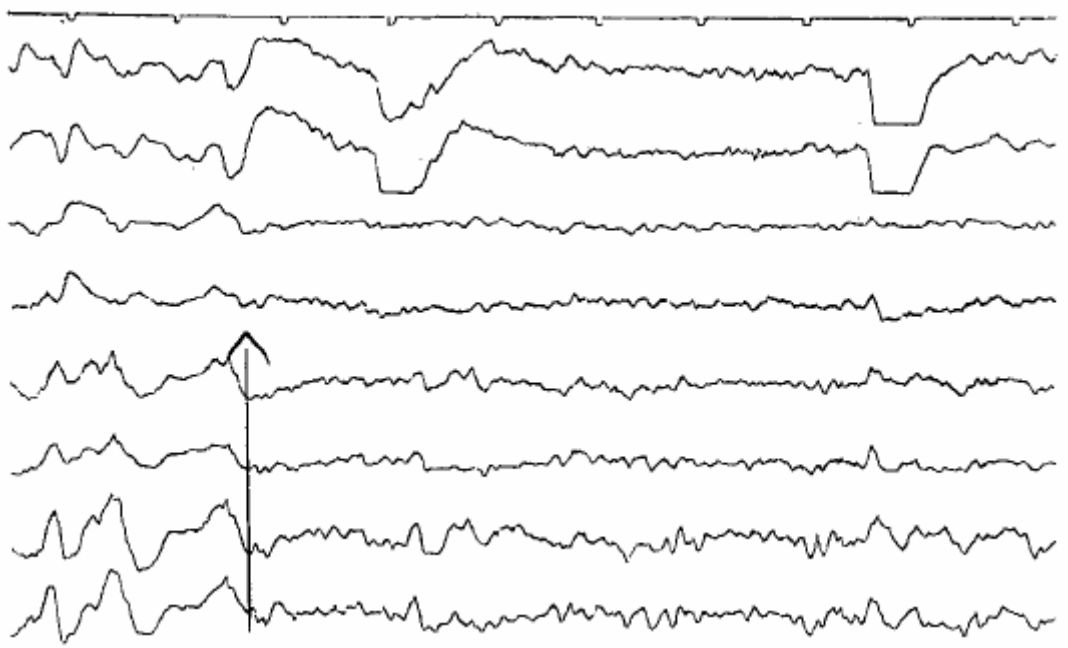


Illustration 58. Diffuse dysrhythmia with largely maintained sensorial reactivity. Medium severity clouding of consciousness, partially complex seizures, beginning approximately 36 h before recording (EEG-nr. 802/92). [Ill. 58-63: Course of an encephalitis of unknown origin (H. P. 58y, f), recordings in one-week intervals]

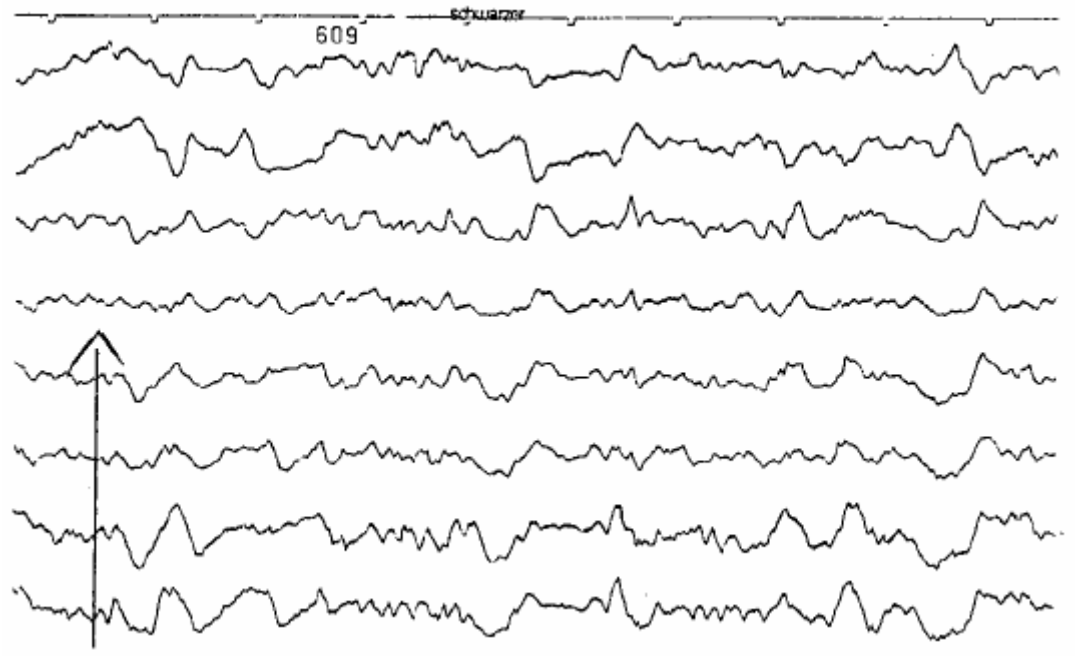


Illustration 59. Diffuse dysrhythmia without sensorial reactivity. Anticonvulsive benzodiazepine-medication, increased clouding of consciousness (EEG-nr. 837/93).

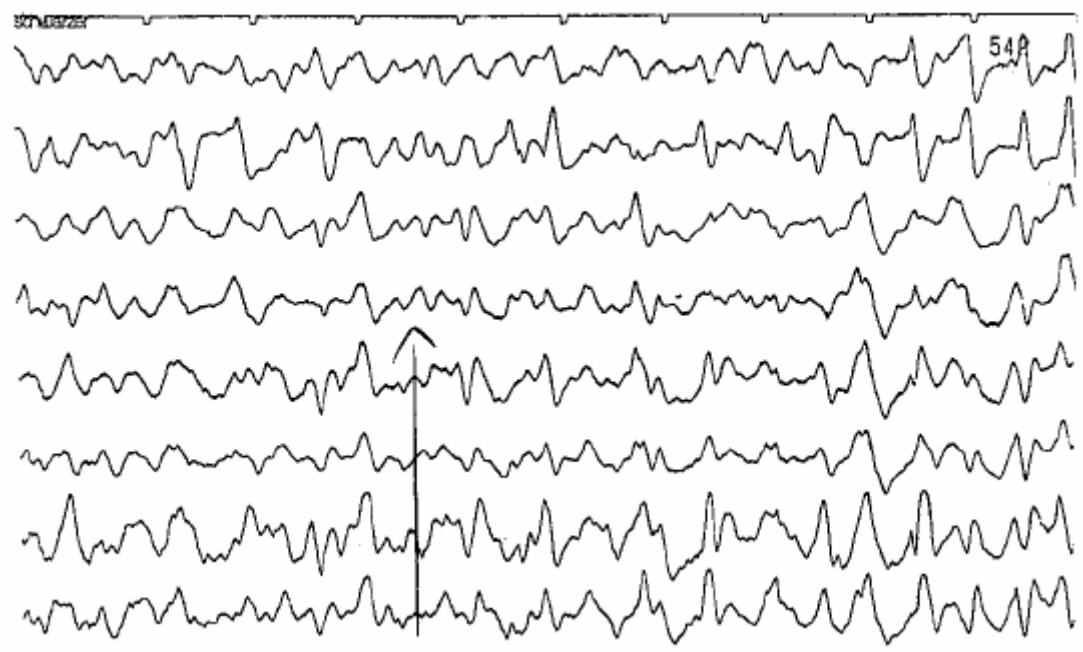


Illustration 60. Diffuse dysrhythmia with sharp and partially tri-phasic waves, still without sensorial reactivity. Clinically unchanged (EEG-nr. 870/93).

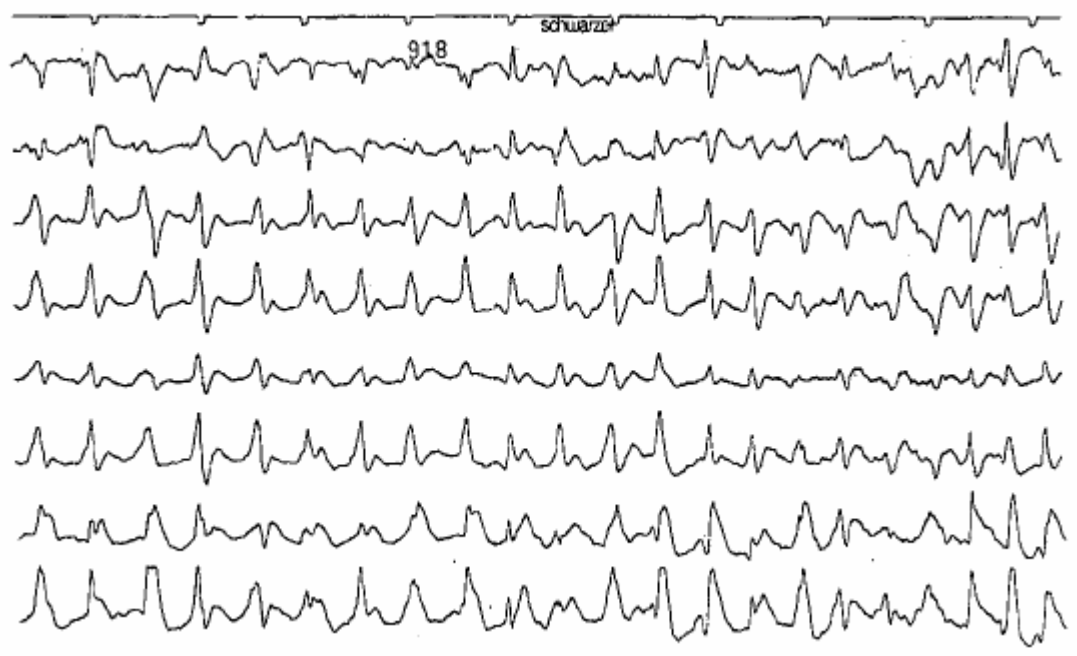


Illustration 61. Rhythmic activity in the form of repetitive sharp waves with a discharge frequency of 1-2 Hz (s. a. illustration 49). Clinical deterioration towards coma (EEG-nr. 883/93).

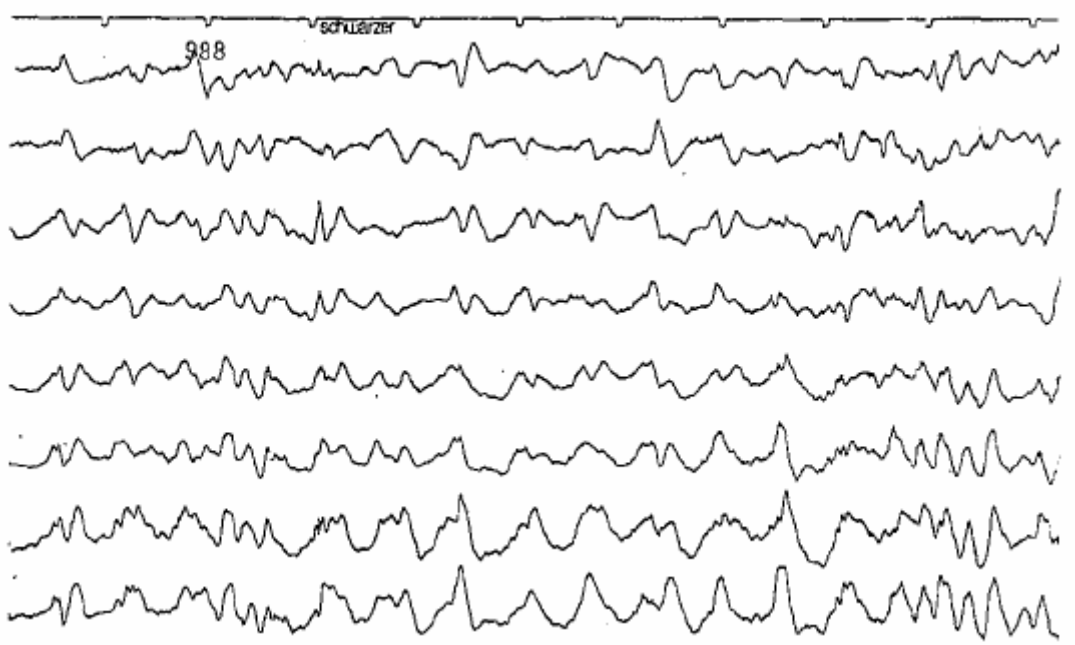


Illustration 62. Diffuse dysrhythmia with regained partial sensorial reactivity, similar to illustration 59. Distinct improvement of the state of consciousness (EEG-nr. 912/93)

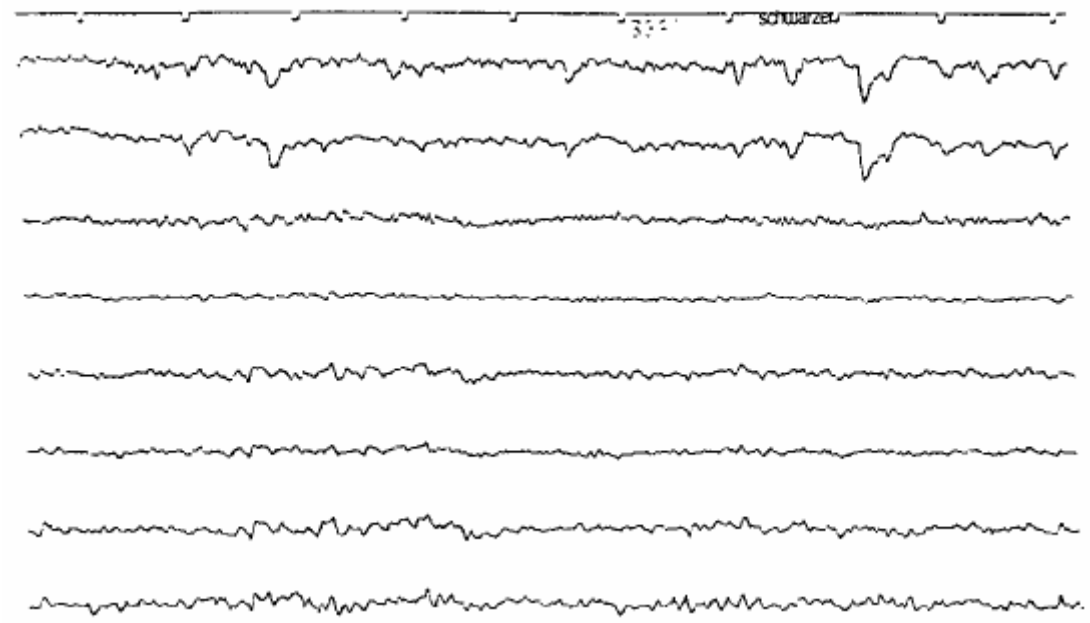


Illustration 63. Only slight remaining theta-dysrhythmia, dominating is a frequency-variable activity of 8-9/s. Due to evidence of further general recovery transfer to a general nursing unit (EEG-nr. 945/93).

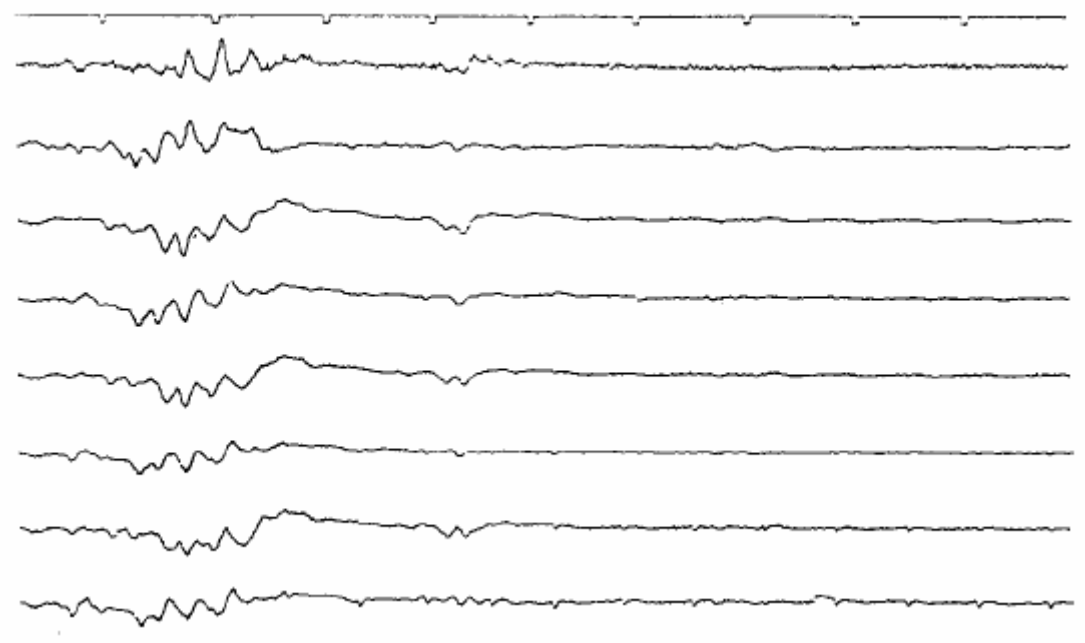


Illustration 64. Intermittent activity at brain-electric silence ("burst suppression activity"). State after poly-trauma, non-reactive coma (K. K., 32 y., m., EEG-nr. 901/93).

The uni- or bilateral repetitive or periodic sharp waves or sharp- and slow-wave-complexes are considered a "signum mali ominis" (illustrations 48, 49). As special predilection-types the "periodic lateralized epileptiform discharges" (PLED) described by CHATRIAN et al. (1964) and the cerebral bigeminy (BERTOLUCCI and SILVA 1992) can be defined. Such patterns characterize stages of the foudroyant progressiveness of a pathological process. Thus, we find, for instance, with CREUTZFELDT-JACOB disease, subacute sclerozing panencephalitis and hemorrhagic-necrotizing encephalitis, but also in the progressive loss of functions after anoxia periodic paroxysmal potentials or complexes, whose frequency and periodicity increases steadily until death (PAMPIGLIONE 1962; UPTON and GUMPERT 1970; BURGER et al. 1972; SMITH et al. 1975;

BRENNER et al. 1975; KUROIWA and CELESIA 1980; AU et al., 1980; WESTMORELAND 1982; BUTT et al. 1982; SAUNDER and WESTMORELAND 1984). Cases where such patterns regress, via a DD, towards physiomorph organization, are rare (illustration 58-63).
Intermittent brain-electric silence ("burst suppression"-activity, illustration 64) must be considered a preliminary stage of complete brain-electric inactivity if it is not a reflection of intoxication by hypnotics or narcotics. Only in cases where intoxication has not caused extensive and irreversible anoxia damages can a favorable prognosis be considered, following the proof of such patterns.
From a developmental-biological perspective, relationships of these dissolution patterns can be established to formally similar phenomena in prematurely born babies, termed "tracé alternant" (MONOD and THARP 1977) and interpreted as a manifestation of a brain-functional maturation deficit (WILDER-SMITH and KARBOWSKI 1992).

4.

EEG Findings in Psychiatric Syndromes

4.1. The EEG in Organic Psychoses

4.1.1. "Abnormal" EEG-Features in Conventional Diagnostics

The diagnostic importance of the EEG in organic and especially involutional psychosyndromes is considered rather modest today. A commonly accepted rule of thumb is that the more "peculiarities" are to be expected, the more progressive the underlying process, and that if there is no progressiveness or no chronic state, the EEG will be more or less "normal" (GREENBLATT 1945; BUSSE and WANG 1965). Thus, patients with severe mental dissolution can have "normal" EEGs and, in contrast, undisturbed-looking patients could have "abnormal" EEGs (BAGCHI et al. 1956).

Such an assessment may be correct if it is based on neurological criteria about normalcy (s. a. 2.2.1.1.). However, as we will point out in more detail, good reasons exist for the assumption that the EEG is in reality a very delicate indicator of the pathological functional change that can only be uncovered through refined analysis. Another fact to consider is that with regard to the various EEG-correlates of the brain-organic dissolution and their functional significance, there still exist many more open than unequivocally answered questions.

Literature proves that all relevant features have been observed but were described and interpreted in very different ways. These features were usually evaluated as isolated phenomena independent from their morphodynamic context. Isolating operationally defined features certainly meets optimally the legitimate need for statistical processing. On the other hand, following such a largely theory-free approach we must anticipate the possibility of ambiguous electro-clinical correlations and therefore the risk of drawing the wrong conclusions.

In this chapter, we would first like to recapitulate the findings presented thus far concerning the topic of EEG and organic psychosyndromes. Then (s. a. 4.1.2.; 4.1.3.; 4.1.4.) we will try to demonstrate that the features, regarded thus far in isolation, can be understood as aspects of a unitary dissolution process that can be sudivided into stages.

The brain-organic dissolution has forever been equated with a slowing down of the dominant frequency. It was BERGER (1933) who first described such a slowing down in patients with senile dementia. He clearly rejected the idea of a merely age-related phenomenon. Because of considerable constitution-related individual variations in the basic rhythm frequency, a slight to moderate slowing can only be assessed in comparison to a premorbid base-EEG. To this day, a relatively slow alpha-activity discovered in older people is termed as "according to age." Such an evaluation is based on the negative linear correlation between age and basic rhythm frequency found in extensive samples, a correlation which starts at about the 6th decade.

This seemed to prove the dependency of the basic rhythm frequency on the physiological process of aging (MATEJCEK 1980). However, because of a multitude of findings we must assume that this slowing is much more likely associated with the various pathological processes which become more frequent with increasing age than with the normal- physiological process of aging (FAZEKAS et al. 1953; SOKOLOFF 1966; KATZ and HOROWITZ 1982; PRINZ et al. 1982; TORRES et al. 1983; DUFFY et al. 1984; GIAQUINTO and NOLFE 1986; OKEN et al. 1989). As GIAQUINTO and NOLFE were able to prove, a decrease of frequency related to mere aging is extremely minute, if it can be documented at all: "... data do not support the hypothesis of a continuum from aging to dementia, as has been supported by anatomical considerations." A convincing argument against such an assumption of continuity is contained in the EEG-findings of very old people. There are centenarians with a seemingly absolutely "normal," even fast dominant alpha-frequency (HUBBARD et al. 1976; GREEN et al. 1986).

The situation with regard to the faster frequency components appears confusing. Thus, the increase and decrease have been described as involutional-typical. Each attempt at interpretation must consider the group-statistically founded findings that from about the 5th decade on, a steady increase of precentral-accentuated beta-activity occurs. This linear trend comes to a standstill and, at higher age, is even reversed (GREENBLATT et al. 1944; OBRIST and BUSSE 1965; OBRIST 1975; BUSSE 1983; DUFFY et al. 1984). A possible reason for the positive age correlation of the beginning involution process with beta-increase could be the increase of cerebro-vascular processes to be expected at this stage of life. A survey of the literature reveals that only the findings from DUFFY et al. (1984) support such an assumption. In more studies, the opposite was found to be true: geriatric patients with mental deterioration manifested a performance level that increased with increasing beta-proportion in the EEG (MENGOLI 1952; NoÎl 1952; SILVERMAN et al. 1955; BARNES et al. 1956; OBRIST and HENRY 1958; FREY and SJÖRGEN 1959; OBRIST et al. 1961; THOMPSON and WILSON 1966; COBEN et al. 1983, 1985; PRICHEP 1983; WILLIAMSON et al. 1990). This, however, says nothing about the situation in mentally healthy old people. The conclusion from these findings that low-voltage beta-activity is a favorable sign in seniors (OBRIST and BUSSE 1965; OBRIST 1975) seems to us appropriate only for functionally impaired patients. In mentally intact seniors, a higher beta-proportion cannot be used as an indicator of undisturbed brain function because, until the 5th decade, no beta-activity of any significance can be observed. This means we can only conclude that beta-activity in senior patients is more likely to be viewed as a positive sign, and that its disappearance indicates a progression of the involutional process. However, the question about the functional significance of the reappearance of rapid activities at beginning involution age is still waiting for an answer.

Open questions also remain with regard to the typically intermittent left anterior groups (ILA, s. a. 3.1.) of sub-alpha-, theta-, but also delta-waves (BUSSE et al. 1954) relatively frequently observed in the involution age. With regard to their age-relatedness, there exist analogies with rapid activity. Here, too, we are dealing with a feature that with beginning involution age shows a rather evident rise in frequency which comes to a standstill in the 7th decade (SILVERMAN et al. 1955;

OBRIST and BUSSE 1965; BUSSE 1973). Furthermore, the feature was found more frequently in groups of functionally intact seniors than in groups of functionally disturbed patients of the same age (SILVERMAN at al. 1955; TORRES et al. 1983). Some authors report feature-correlated performance deficits (WANG et al. 1970; HUGHES et al. 1971; VISSER et al. 1987).

Another feature considered by many authors to be involution-typical is the low-voltage desynchronization activity pervaded by more or less fast beta-waves (s. a. 3.1.). According to the descriptions (MENGOLI 1952; OBRIST 1954; MUNDY-CASTLE et al. 1954; MUNDY-CASTLE 1962; GSCHWEND and KARBOWSKI 1970; DUFFY et al. 1984) this feature possibly overlaps at least partially with the aforementioned feature of increased beta-proportion.

That the rather frequent feature of the anterior spreading of alpha-activity (s. a. 3.1.) in involutional psychosyndromes has been mentioned only by few authors (GACHES 1960; JUSTISS 1969; OKEN et al. 1989) may reflect the negligence of the topographical aspect.

As can already be suspected, we cannot expect a gain in knowledge from the conception-free EEG-mapping (s. a. 2.2.2.).

We also must not neglect to mention that some authors view dynamic parameters as especially informative (LAIRY and FISCHGOLD 1953; BANCAUD et al. 1955; DAUMEZON and LAIRY 1957; BANCAUD 1961). As an example of a dynamic parameter we want to mention the degree of alpha-stability in an EEG recorded over 20-30 minutes under the usual resting conditions.

There are, thus far, two reasons for which evaluation of the pathognostic dignity of the aforementioned features has been so difficult. First, one must largely rely on a "trial and error" strategy of statistical correlation because of the lack of a theory of electroencephalographic morphodynamics. Secondly, there exist no sufficiently sensitive, employable test-psychological indicators of the brain-organic performance change that can be used for an external validation of the EEG features. As every clinician knows, the global-intuitive judgement of the physician, especially with the diagnostically problematic organic psychosyndromes of lower intensity, is often far superior to the "scores" derived through test-psychology (HARTJE and ORGASS 1972; FISCHER and JACOBI 1978; FÄHNDRICH et al. 1981).

4.1.2. Dissolution via the A-Stage - Dynamic Rigidity (DR)

4.1.2.1. Involutional Psychosyndromes (A)

The first to describe what BENTE (1981,1982) later called the dissolution via the A-stage (DR, illustration 26; illustration 27, middle, illustration 29) was GACHES (1960). GACHES observed in a comparison of various neurological patient groups an age-correlated spreading of the alpha-activity to the frontal regions that started with the 50th year of life. This anterior spreading was most pronounced in a patient group with cerebro-vascular insufficiency. It deserves special mention that GACHES also included the wider morphological context, contrary to the common manner of viewing the EEG. For instance, he recognized the close relationship between anteriorization, continuity increase and slight slowing of the alpha-activity. This triad was for him the manifestation of a basal synchronization tendency: "Il nous parait s'agir d'un phénoméne trés général de synchronisation progressive ..."

> The excellent gift of observation of this author, who is otherwise not prominent, is also evidenced by his identification of another, entirely different involution-typical phenomenon such as the increasing rarefication of background alpha-activity in connection with an increase of the fast beta-activity.

According to OBRIST and BUSSE (1965), GACHES'S triad is an "interesting and largely neglected aspect of the senescent EEG." Their request for further research, however, did not meet with any resonance. Obviously ignorant of GACHES'S work, JUSTISS (1969) reported a negative correlation beween the performance in the Porteus-labyrinth test and the amount of semi-quantitatively measured anterior 7-13/s alpha-activity. The findings were based on a geriatric sample with a median age of 76 years.

In complete agreement with GACHES (1960), but also in obvious ignorance of his publication, OKEN et al. (1989) found an age-correlated increase of alpha-anteriorization starting in the 6th decade. Since this finding did not seem plausible, the authors thought a methodical artifact was the reason for this phenomenon. With the same lack of consideration for earlier literature, DIERKS et al. (1991) recently debated whether or not the EEG might be usable as an early indicator of dementia . Reason for this was the discovery, confirmed by BRESLAU et al. (1989), of an anteriorization of the alpha- and beta-activity that accompanied even less serious forms of dementia. That the triad described by GACHES and encountered daily by every EEG-interpreter without being noticed plays such a subordinate role in the medical literature most likely has its reason in the still predominant penchant for the isolating detail analysis.

From perceptual psychology, we know that only that is perceived for which we have the respective perceptual schemata. Perceptual schemata, however, are built only for what is considered important. The non-classifiable goes unnoticed!

To some degree, a technical aspect of the recording method might be responsible for the relative disregard of alpha-anteriorization as an important part of DR. It cannot be a coincidence that in all studies showing alpha-anteriorization, ear reference was used for the derivation. Simultaneous ear reference and source derivations as described by HJORTH (1980) provide simple proof that often, alpha-anteriorization corresponding to a stage A2 or A3 can only be found in the derivations with ear reference (s. a. 2.2.5.).

> Whether the expansion occurs in the direction of the temporal or fronto-central regions seems an individual feature without pathognostic relevance. We deem it important to emphasize this, especially considering the highly popular, equally premature and inappropriate neuro-anatomical interpretations of topographic EEG-records.

As with every classification, we cannot expect only ideally typical examples for the dissolution via the A-stage. The fully developed and complete triad of anteriorization, continuity increase and slowing of the alpha-activity (illustration 27, middle; illustration 29) is rare, compared to incompletely developed forms. Often only an isolated anteriorization or a slight slowing are noticed.

Under certain conditions, with quantitative methods, i. e. with the FOURIER analysis, findings of a dissolution-correlated frequency slowing in the alpha-range allow one to assume a DR. Since the physiomorph transition from stage A1 to stage A2 and, even more so, to A3, is already accompanied by a slight decrease of the dominant alpha-frequency, an increase in the proportion of mid and late A-stages must lead to a slowing of the alpha-frequency averaged across the entire EEG.

Finally, our model of the different dissolution paths also allows an explanation of observations of mental deterioration without the associated EEG-slowing (STOLLER 1949). In such cases the dissolution occurs not via the A-stage (DR) but via the B- stage or the pathomorph variants of the A-stage (ILA/IBA, s. a. 3.1.; illustration 26). Conducting a study with outpatients of the geronto-psychiatric department (Head: Professor Dr. S. Kanowski) we attempted to find a psychopathological correlate of the DR (ULRICH et al. ; unpublished) observed in an outpatient sample of patients. Since an earlier study involving patients with depressive syndromes had already revealed certain correlations (ULRICH and BRAND 1993; s. a. 4.2.1.) we now could test certain hypotheses.

> Included in the study were all outpatients of the department for geronto-psychiatry from 1986-1991 of whom a routinely recorded resting EEG and an AGP-documented psychiatric evaluation (CIOMPI et al. 1973) from approximately the same time period existed.

There were 151 patients who met these conditions, 119 women and 32 men, with an average age of 74.7 years ±7.23. The definitions of the AGP-items are identical to those of the ADMP-system which allows a comparison of geronto-psychiatric and psychiatric studies (see above). After assuring anonymity, the microfiche-stored EEGs were classified in one of four mutually exclusive categories, after careful re-inspection:

- physiomorph dynamics (PD)
- dynamic rigidity (DR)
- dynamic lability (DL)
- diffuse dysrhythmia (DD).

Significant for the classification were pregnancy thresholds as exemplified in illustration 33 (DR), 36 (DL) and 35 and 38 (DD).

Because of our findings in depressive patients (ULRICH and BRAND 1993), we expected for senescent patients with DR a relatively higher frequency of the items: inhibited thinking (15%), affective rigidity (8%), retarded thinking (55%), lack of drive (62%), disordered memorization (76%). The percentages listed in parentheses refer to the persons, showing the AGP-item, this being independent of the EEG classification. Because of the low frequency of patients exhibiting the first two AGP-items, a hypothesis test appeared to make sense only for the remaining three items. We replaced the melancholy-typical feature "inhibited thinking" with the involution-typical item "perplexed," found in 62% of all patients. Independent of the respective data-collecting modus, we treated the EEG and psychopathology features as alternative data in the sense of "present" or "not present."

Table 4. Bivariate frequency distributions of 151 geriatric patients among the mutually exclusive EEG-categories: physiomorphical dynamics (PD), dynamic lability (DL), dynamic rigidity (DR) and diffuse dysrhythmia (DR) on one hand and the AGP-items "lack of drive," "retarded thinking," "disordered memorization" and "perplexed" observed as present (yes) or not-present (no), on the other hand. The numbers between parenthesis indicate the percentage within the EEG-categories.

EEG		lack of drive		retarded thinking		disordered memorization		perplexed	
		no	yes	no	yes	no	yes	no	yes
PD	(n=23)	12	11 (48)	13	10 (43)	12	11 (48)	10	13 (56)
DL	(n=39)	16	23 (59)	20	19 (48)	19	20 (51)	21	18 (46)
DR	(n=51)	17	34 (67)	23	28 (55)	15	36 (71)	11	40 (78)
DD	(n=38)	12	26 (68)	10	28 (73)	3	35 (92)	16	22 (58)
		$\chi^2 = 3,25$ ns		$\chi^2 = 6,65$ $p < 0,10$		$\chi^2 = 18,94$ $p < 0,0001$		$\chi^2 = 10,51$ $p< 0,02$	

As expected, the examined items, with the exception of "perplexed," were observed most frequently in patients with DD. 92% of these patients suffered from "disordered memorization". For the patients with DR, on the other hand, the feature "perplexed," observed in 78% of the cases, appeared to be typical, while it was found in only 58% of patients with DD. Since "perplexed" corresponds to a confusion experienced by the patient, it seems plausible that with increasing degrees of disturbance expected with DD, the ability for introspection required for the registration of the perceptive quality "perplexed" no longer exists. Therefore, "perplexed" might be a thus far neglected sensitive indicator of a light- to medium-degree pathological functional change. Because of the observed correlation with the EEG, DR could be considered an objective indicator of such a medium degree of deterioration. This seems to be confirmed by the fact that the percentage of "disordered memorization" in patients with DR (71%) lies exactly between the percentage of patients with DD (92%) and those with DL (51%) or PD (48%). Although of minor importance, it deserves mention that the patient group with DL clearly seemed less disturbed than that with DR. The disturbance level of the DL group could not be distinguished from the disturbance level of the PD-group These findings support the assumption that compared to the dissolution via the A-stage (DR) the dissolution via the B-stage (DL) is characterized by a higher compensation capacity (s. a. 4.1.3.1.).

4.1.2.2. Exogenous Psychosyndromes

Although every EEG-textbook contains examples of curves that impressively document GACHES' triad of the DR in various exogenous psychoses, the phenomenon went widely unnoticed. A true treasure trove is CHRISTIAN'S (1975) textbook. Most of the curve examples meet the recording-technical requirement for the depiction of alpha-anteriorization, being ear-references. Furthermore, the curve segments are sufficiently long, ±10 seconds, to allow an evaluation of the degree of continuity, i. e. the dynamics. All of the following descriptions refer to this textbook.

> Illustration 188. Cor pulmonale: 7-8/s activity with continuous anteriorization (corresponding to a stage A2) Illustration 212. Encephalitis: course depiction; regression of an initial diffuse dysrhythmia; after two weeks, continuous anteriorization of an 8.5/s activity (corresponding to a stage A2); 7 weeks after the beginning of the disease still medium-degree anteriorization (described as "largely normal") Illustration 213. Encephalitis: course depiction; regression of an initial diffuse dysrhythmia; after 4.5 weeks pronounced anteriorization of an 9/s activity (described as "still phases of slight Allgemeinveränderung but mostly rather stable alpha-rhythm") Illustration 223. Abacterial meningitis: in the third week of disease continuous anteriorization with a pronounced frequency dissociation between the posterior 9-10/s rhythm and the anterior 7-8/s rhythm (described as "slight Allgemeinveränderung") Illustration 224. Pneumococcic meningitis: course depiction; regression of an initial diffuse dysrhythmia; 17 weeks after the beginning of the disease pronounced anteriorization of a 9/s activity (described as "leichte (slight) Allgemeinveränderung")

If we assume that the well-proven BONHOEFFER rule (BONHOEFFER 1909) about the unspecificity of "exogenous reaction types" is a principle independent of the respective domain of description, then the pathological functional change of the EEG must also be independent from the underlying noxious agent. Indeed, the EEG-changes observed in involutional cerebro- vascular, inflammatory, space-occupying, endocrinic, endotoxic and exotoxic syndromes appear to be largely independent from the respective etiopathology.

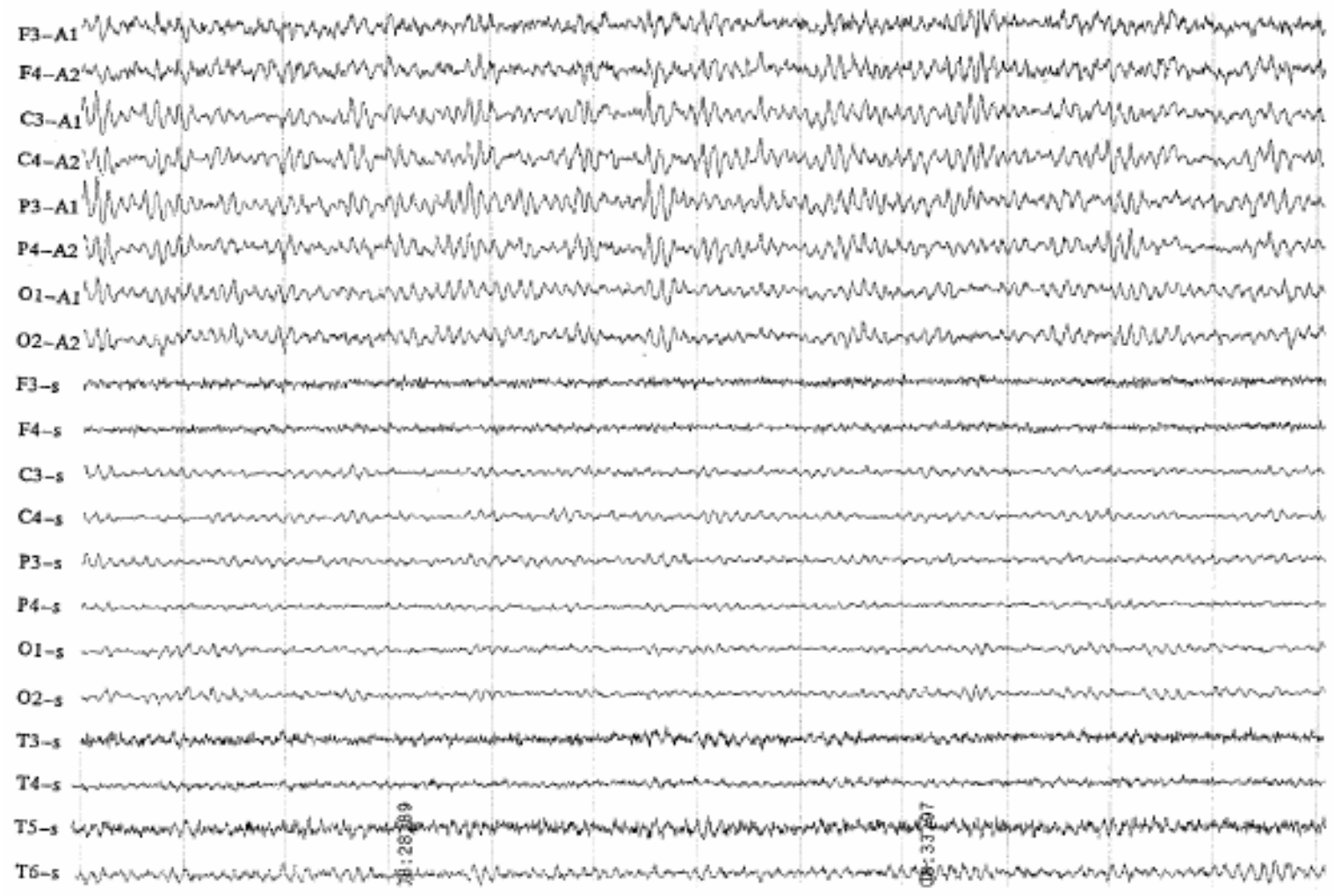


Illustration 65. Continuously anteriorized (in the reference and source derivation) 9/s activity - picture of a dynamic rigidity. Diagnosis at admittance as inpatient: reactive state of excitement in hysterical personality. (D. R. 47 y., f., EEG-nr. 952/91). (Illustrations 65-67 identical derivation schema).

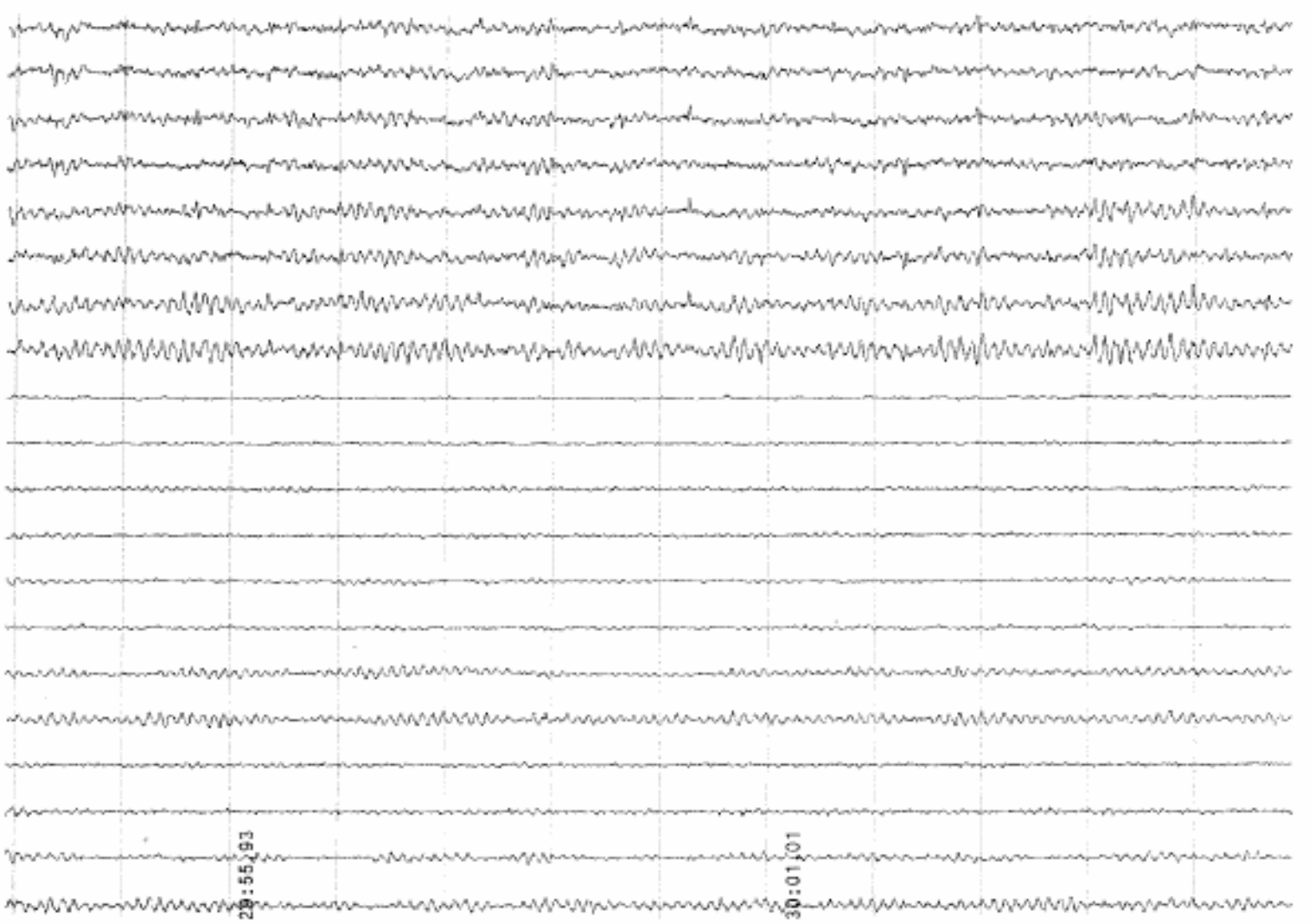


Illustration 66. Ideally-typically organized EEG with a posterior-accentuated 10/s alpha-activity. The same patient as in illustration 65 after a ten-week antibiotic treatment of Borrelia encephalitis after a tick bite that was diagnosed with liquor serology; at this time psychopathologically insignificant (EEG-nr. 1247/92).

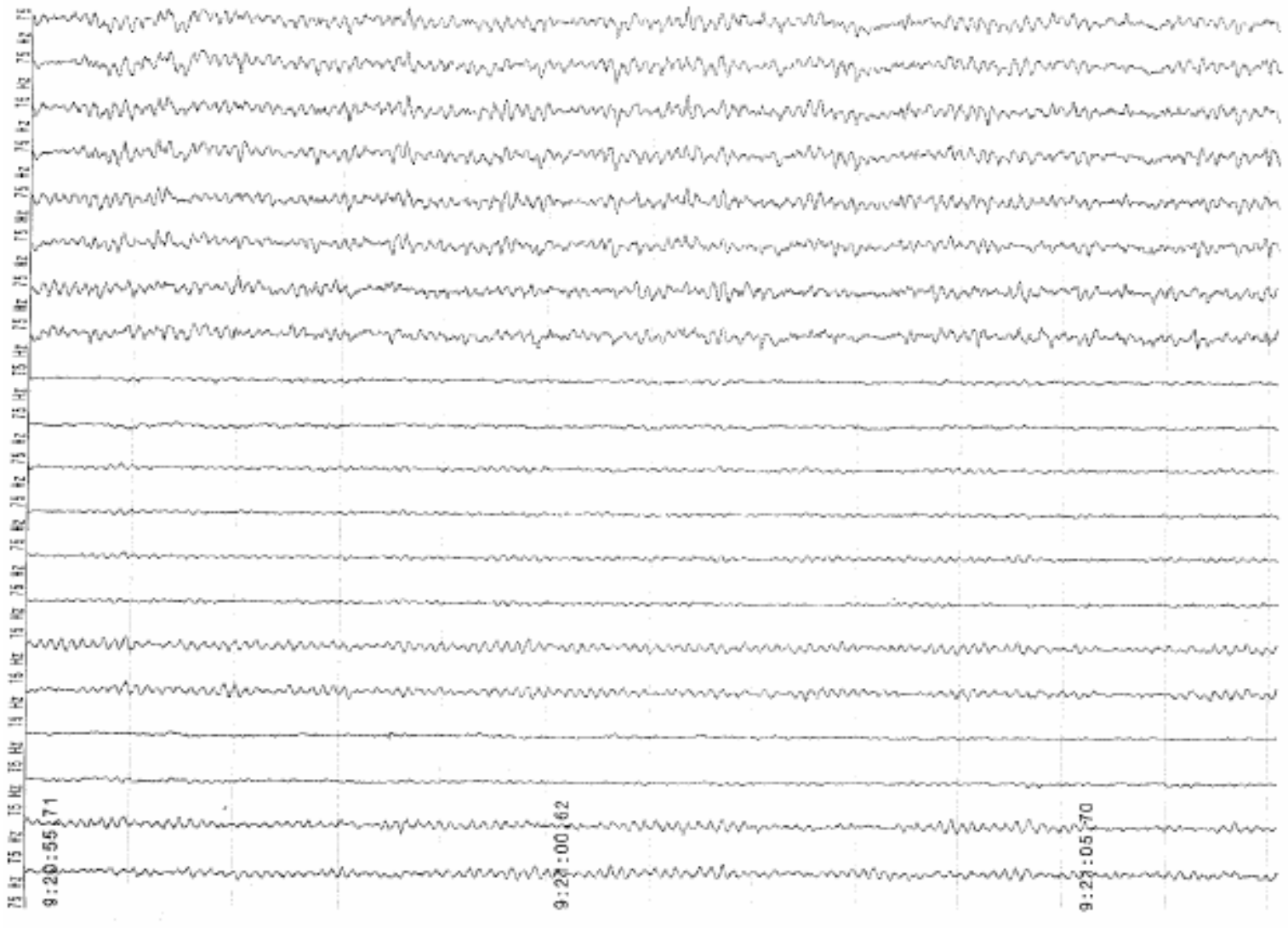


Illustration 67. Continuously anteriorized 8-9/s alpha-activity typical of dynamic rigidity (DR); pat. admitted because of suicide ideation with AIDS-related symptom complex; mild cognitive impairment (W. W., 38y, m., EEG-No. 847/92)

At the end of this chapter we will illustrate with two examples the practical consequences of the disregarding of DR as an indicator of functional dissolution.

Illustration 65 shows the EEG derived on the second day after admittance of a patient, who was initially diagnosed as suffering from a reactive state of excitement while having a hysterical personality. At the time of the recording, mood swings and diffuse neurasthenic symptomatology were prevalent. Because of a pronounced DR at a dominant frequency of 9/s (illustration 65) in the EEG, the interpreter recommended the exclusion of a neurological disorder. The ensuing liquor serology delivered proof of Borrelia encephalitis. The test-psychological examination that also occurred only because of the EEG-findings showed slightly slowed cognitive performance. After a ten-week stay at the hospital and antibiotic treatment, physiological EEG-dynamics had normalized with an alpha-background activity accelerated to 10/s, now posterior-accentuated as well as slightly spindle-form modulated (illustration 66). The patient appeared completely inconspicuous from the psychopathological perspective at the time of the second recording. In retrospect, we cannot exclude the possibility that without the EEG, the initial diagnosis would have been considered satisfactory - after all, the symptomatology did not necessarily seem "organic"! But we must emphasize explicitly that both such morphodynamically different EEGs (illustration 65 and illustration 66) would conventionally have been considered "normal," i. e. viewed as such in most EEG-labs today.

Illustration 67 belongs to an HIV seropositive patient at the stage of "AIDS-related-symptom-complex" who was admitted to the psychiatric ward because of acute suicidal tendencies. We again see the typical picture of dynamic rigidity with a seemingly slightly slowed and continuously anteriorized 8.5/s activity. Based on our experiences with HIV seropositive patients with psychiatric symptomatology - that because of the insufficient number of cases cannot yet be statistically tested - the DR seems to play an important role here.

Such examples - we could add any number of equally instructive cases - prove quite convincingly that the growing rejection of the EEG is a regrettable development that must be stopped at all costs. They show that apart from its possible usefulness as a psychiatric research tool even its practical-diagnostic usefulness as a tool for neurological screening has not yet been fully exhausted.

4.1.3. Dissolution via the B-stage - Dynamic Lability (DL)

4.1.3.1. Involutional Psychosyndromes (B)

As discussed earlier (see 3.1.) BENTE (1981) was the first to draw attention to specific morphodynamics correlated to involutional psychosyndromes, which he called "dissolution via the B-stage." Because this dissolution type is primarily a disturbance of the spontaneous dynamics typical for the resting EEG, i. e. an increased fluctuation of physiomorph patterns, we also talk about dynamic lability (DL, illustration 26; illustration 27 below; illustration 30).

Consulting literature, we learn that only static partial aspects of this DL but not the aspect most significant in our opinion, the variability of the curve pattern in the course of time, has been described. Furthermore, these partial aspects were considered, without further examination, as age-related or normal for aged persons (f. i. GSCHWEND and KARBOWSKI 1970). Thus, we read about an age-correlated increase of low-voltage activity phases or a decrease of the alpha-proportion, as well as an increased discontinuity of the alpha background rhythm - usually in connection with an increase in the beta- proportion (DAVIS 1941a; MENGOLI 1952; MUNDY-CASTLE et al. 1954; OBRIST and HENRY 1958; GACHES 1960; ZIMKINA et al. 1965; OBRIST and BUSSE 1965; GORDON 1968; DUFFY et al. 1984; WILIAMSON et al. 1990). As any interpreter familiar with the EEGs of elderly people should know, such features are all but rare in the involutional age. There are plenty of quotes that support this fact:

> "It might be conservatively estimated that 50 per cent of all elderly people show at least traces of low-voltage Beta rhythm in one or more leads" (OBRIST and BUSSE 1965). Also, „The majority of elderly people show curves of either unstable frequency, with many low-voltage beta-waves or with an over-all slowing of frequencies" (GSCHWEND and KARBOWSKI 1970, transl. from German).

We cannot share a statement such as GESCHWEND and KARBOWSKI'S (1970) which considers the aforementioned EEG- features found in clinically healthy persons to belong to the range of age norm because no proof exists of a true correlation between age and EEG-parameters (s. a. 4.1.1.). Moreover, the term of normalcy is, in all its vagueness, not only useless but counterproductive (s. a. 2.2.1.1.) for a clinical electroencephalography that considers itself a science and whose primary goal can only be to define brain-electric indicators of an incipient pathological functional or performance change.

Since the phenomenon of an increased variability of electroencephalographic pattern dynamics (DL) is hardly ever mentioned in literature we enter unknown terrain with the question about its pathognostic relevance. Certain indirect clues can be derived from the research concerned with partial aspects of DL. A partial aspect which has been well researched is

the beta-activity. As we pointed out earlier (s. 2.2.2.), the decrease in voltage and the desynchronization that correspond to the subvigil stage B1 are facultatively accompanied by an increase of fast beta-waves, i. e. the "subvigil" beta-activity. Thus, it seems possible to deduce, cum grano salis, a dynamic lability from a described or quantitatively assessed increase of rapid beta-activity and vice versa.

> We have already discounted the objection expected here: that an increase in beta is more likely associated with an "arousal" as during mental efforts or after insufficient psychological relaxation - (s. a. 2.2.1.4.).

We must not forget that there also exist clearly identifiable subvigil B1-stages without significant beta-activity. From this, we can conclude that the subvigil beta-activity cannot be considered a constitutive part of a lowered electroencephalographic vigilance level. More likely, we will have to consider BENTE'S (1964b) hypothesis claiming that the subvigil beta-activity is the manifestation of a "subliminal counter-regulatory rise of the vigilance level." Thus, a further lowering towards the late B-stages, as characterized by irregular theta- and delta-activity, is countered. Explaining the beta-increase with the dissolution via the B-stage (DL) allows an explanation of all those seemingly contradictory findings of increased or decreased beta- activity in elderly people with or without clinical symptoms (s. a. 4.1.1.) Thus the increase of low-voltage and desynchronized activity observable from approximately the 5th decade seems to be the manifestation of an incipient pathological functional change in the sense of a dissolution via the B-stage (DL). This development is often accompanied by an increase in fast beta-activity. This increase is the expression of counter-regulatory mechanisms that prevent a further lowering of the vigilance level. Such observations should explain why numerous researchers found a positive correlation between mental performance level and the amount of beta-activity in samples of slightly disturbed patients (f. i. WILIAMSON et al. 1990; s. a. 4.1.1.). In slightly disturbed patients, the beta-proportion functions as an indicator of the activated functional compensation mechanisms. It points to a neuroadaptive syndrome that is clinically inapparent at first sight (s. a. 4.1.2.1.) With the progression of the underlying pathological process, the exhaustion of the compensation capacities is evidenced by a decrease of the beta-activity and an increase of the theta- and delta-activities. The formerly positive correlation between mental performance level and the amount of beta-activity disappears.

The direction of the correlation between mental performance level or performance deficit on one hand and the amount of beta-activity on the other hand is determined quite significantly by the composition of the sample. The negative correlation between mental performance level and beta-activity found by DUFFY et al. (1984) in a sample of clinically inconspicuous, at most slightly disturbed persons, corresponds exactly to the expectations that can be derived from our premises. A negative correlation can also be postulated for a mixed sample of older and younger healthy people. Condition for this would be, however, that we succeed in objectivating, through the appropriate procedures, the performance deficit of persons with beta- activity (DL), initially clinically inapparent since it is compensated for.

4.1.3.2. Exogenous Psychosyndromes

The only systematical research done outside geronto-psychiatry on the potential importance of the dynamic-unstable EEG was conducted by BENTE (1964b) with a mixed group of neurological and psychiatric patients. BENTE defined DL as the discontinuous background rhythm with predominant subvigil activity corresponding to the stages B1-B3. From a total of 1040 patients, those with acute brain trauma, i. e. who suffered the trauma less than 6 months previously, were excluded, 164 (15.7%) showed such a DL. With 50% the DL proved pronouncedly overrepresented in patients suffering from postconcussional syndrome as well as non-traumatic brain damages. These findings confirm rather nicely older, somewhat anecdotal observations claiming that low-voltage - an essential partial aspect of our DL - is a typical residuum of brain traumata (LAIRY and BENBANASTE 1954; LECHNER 1957). Oddly enough, the phenomenon of post-traumatic low-voltage, significant for giving expert opinions on questions of financial compensation, is no longer mentioned in the literature of the past two decades. CHRISTIAN (1975) opines that the findings of VOGEL (1970) - that low-voltage EEGs have a genetic basis - play a role here. However, VOGEL'S findings do not exclude that low-voltage EEGs with other than genetic bases also exist. A low-voltage EEG allows neither the conclusion of a postconcussional syndrome (MEYER-MICKELIT 1953; JUNG 1953; JANZEN and MÜLLER 1955) nor of a genetic variant. On the other hand, the traumatic genesis of an EEG-phenomenon cannot be rejected with the argument that this phenomenon can also be observed in healthy people who never suffered brain trauma. In BENTE'S study, patients with DL could be distinguished from patients without DL by their fatigue, lack of drive, listlessness and sleeping problems, in addition to a wide array of vegatative disturbances. BENTE related these symptoms to an "exogenous reaction type" or, more exactly, to a pseudoneurasthenic syndrome sensu BONHOEFFER (1912).

> BENTE, who considered low-voltage merely a partial aspect of an underlying disturbance of morpho-dynamics, correlated the post- traumatic DL with an alteration of baso-diencephalic functional circuits.

According to our model of various dissolution paths (s. 3.1. illustration 26) we claim that DL, as a predilection type of pathological functional change that is widely independent from the causing noxa can be encountered in situations other than post-traumatic syndromes. Indeed, we find a number of studies in literature which can be used as empirical proof for the justification of this claim. EEGs that, according to the given visuo-morphological characterization, i. e. based on curve examples, fulfill the criteria of a DL have repeatedly been described as correlates of endocrinic psychosyndromes. KRANKENHAGEN et al. (1970) considered the "partial beta-type," the curves show a pronouncd DL, as typical for the CUSHING syndrome." The authors only paid attention to the (subvigil) beta-activity but not to the discontinuity of the alpha-background activity in connection with the prevalence of low-voltage desynchronized B1-stages which is decisive from our perspective. According to HESS (1954) and CHRISTIAN (1975), a low-voltage EEG with prevalent fast frequencies - this

description, too, indicates a DL - must be considered a typical correlate in a primary hyperthyreosis. Especially instructive to us is the case description of the recovery from a psychosis induced through triiodothyronine abuse. The initial acute thyreotoxic psychosis corresponded to a largely diffuse-dysthyhtmic EEG. The curve example of the 4th day shows a pronounced DL and that of the 9th day a medium DL. After complete clinical remission on the 21st day physiomorph vigilance dynamics are displayed.

A syndrome which is particularly important in neuropsychiatric practice and which is accompanied in a very high percentage of cases by various degrees of disturbances of the waking-sleeping regulation (FREAL et al. 1984; CLARK et al. 1992; WEINSCHENKER et al. 1992) is multiple sclerosis. As can already be observed during visual routine diagnosis, EEGs from such patients surprisingly often show dynamic lability, whereas we hardly ever find a DR. In a study involving 23 patients, we tried to objectify this impression quantitatively. Moreover, we were interested in finding whether the dynamics of the disease course are reflected through changes in the EEG-dynamics (BRÄU and ULRICH 1990). The data were collected at the time of admittance and after four weeks of treatment. As an indicator of the severity of the disease, we chose the clinical sum scores introduced by KURTZKE. Besides a 10-minute EEG-recording at rest, a visuo-motor tracking test was performed. As expected, the KURTZKE-scores indicated a statistically significant group improvement after 4 weeks. Equally as expected, this improvement was not reflected in the conventional average power spectra (s. a. GIBBS and BECKA 1968; RIEGER et al. 1970; COLON et al. 1981). However, the improvement was evidenced in the quantitatively assessed vigilance dynamics.

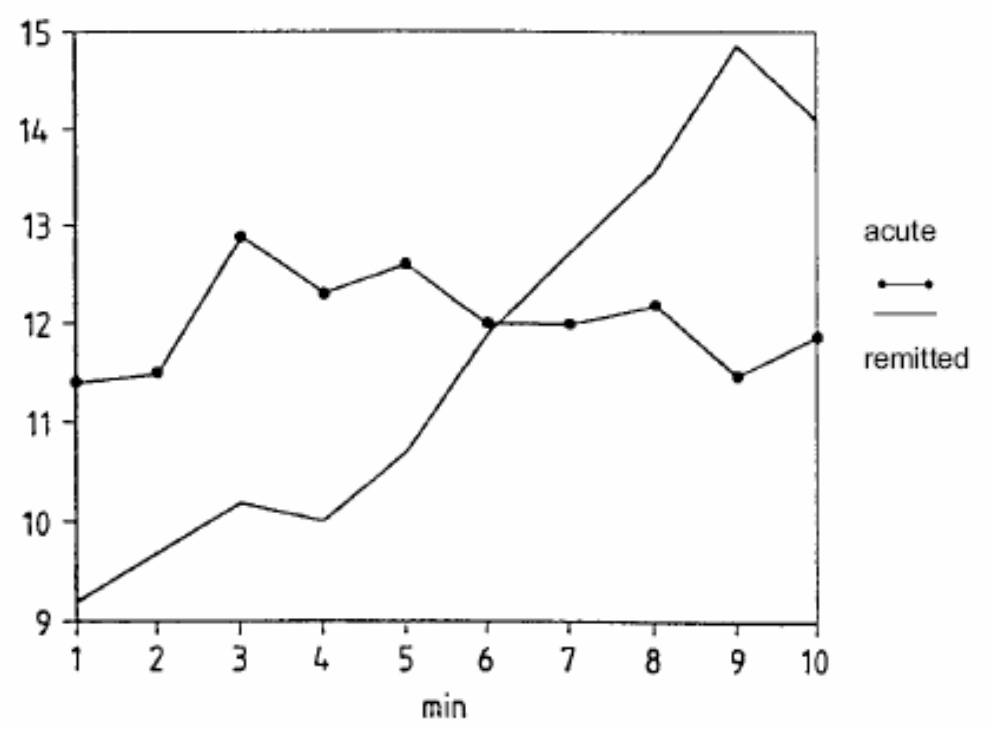


Illustration 68. Time course of the rate of the non-A-segments (group averages, n=23); 10-minute recording at rest; with a time window of 2 seconds for the analysis, a maximum of 30 non-A-epochs are possible per minute (from BRÄU and ULRICH 1990).

Illustration 68 shows the rate of subvigil non-A-epochs (time window: 2 seconds) observed for each single minute of the 10-minute recording at rest. While the rate of the non-A-epochs in the first EEG, i. e. during the acute stage of the disease, is completely independent from the duration of the recording - the group average per minute of recording is approximately 12 non-A-epochs of the 30 possible ones - 4 weeks later we find the time-dependent frequency increase characteristic for groups of young and healthy probands. This physiomorph behavior (s.a. 2.2.5.) is characterized by the relatively high stability of the non-A-rates during the first 5 recording minutes, followed by a steady increase in frequency. Comparing both

examination times merely with regard to the non-A-epoch frequencies, no differences are evident. Of the 300 possible non-A-epochs (corresponding to 600 seconds of recording time), 121 were found as a group average at the time of the first examination and 117 non-A-epochs at the time of the second. As we could also convince ourselves through an inspection of the original printouts these quantitative findings resulted from a DL, seemingly unchanged when the time structure is not considered. The time course of epoch frequencies in illustration 68 shows highly significant differences (examination time x non-A-rates per recording minute: $F_{9, 19\,8} = 3.28$, $p < 0.001$). Thus the clinical improvement is not reflected, as we originally expected, in a regression of the DL but in a normalization of the time structure determining the course of patterns. Moreover, a positive correlation between this normalization and a performance improvement during visuo-motor tracking was found.

These results can be of interest far beyond the narrow frame of the examined patient group. First, they demonstrate once again the limitations of primary quantification that has sacrificed the morphodynamics of the original time function and thus the most important source of information.

Further studies will be necessary to determine whether the prevalence of the B-dissolution (DL) typical for our sample can also be found in other samples. If this proves to be the case we have to ask what could cause this special relationship between multiple sclerosis and the kind of pathological gestalt change observed in the EEG. Since multiple sclerosis is a primary degeneration of the white matter of the brain, we could speculate that primarily subcortically attacking processes lead to B-dissolution (DL), while primarily cortically attacking processes rather lead to A-dissolution (DR). Furthermore, we will have to examine - in differently diagnosed populations - whether the time structure determining the course for the resting EEG possibly represents a particularly sensitive indicator of the pathological functional change.

> Methodically we find ourselves on the grounds of "functional electroencephalography," as propagated by LIBERSON (1944), which considers the resting state as a defined state of stress (s. a. 2.2.4.).

DL which is considered as pathognomonic for idiopathic narcolepsy holds a special position, since it does not represent a pathological functional change but rather a primary regulatory disturbance of vigilance dynamics. Statements such as those by WALSH et al. (1982) or by DALY (1984) that the EEG is irrelevant for the diagnosis of idiopathic narcolepsy are feature of the fixation on disease-specific phenomena criticized at the outset (s. a. 2.2.1.1.). According to research by HEYCK and HESS (1954), ROTH (1959) as well as our own observations, a DL characterized by abrupt stage changes and late B- and even C-stages can be found in most narcoleptics. It will hardly be necessary to emphasize that such an EEG in itself is pathognostically unspecific and that it, just as all other EEG-features, gains its clinical importance only in the clinical context.

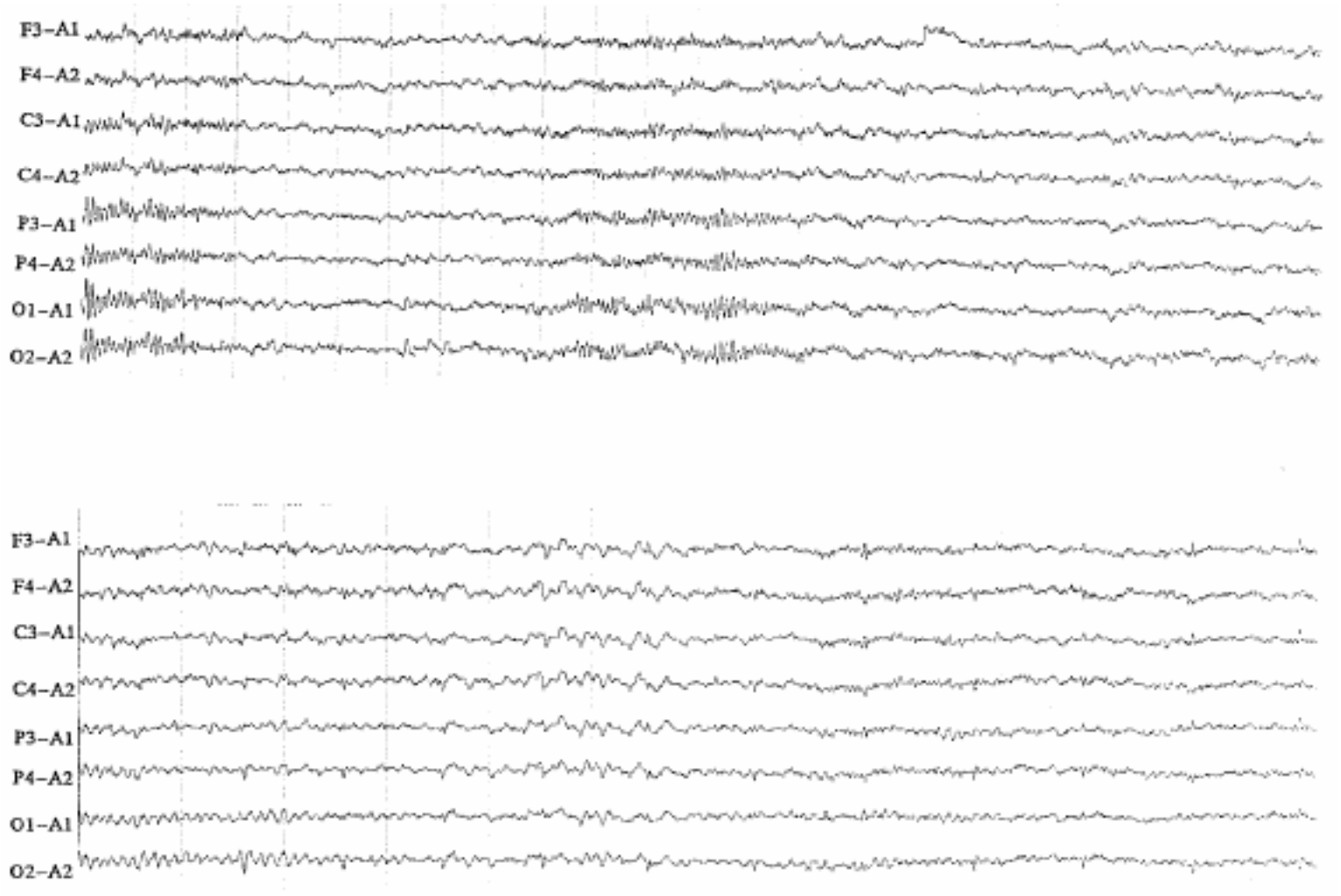


Illustration 69. Dynamic lability in idiopathic narcolepsy. above: 24-s-segment (1 cm ~ 1 s) of the first recording minute; in the 3rd second abrupt transition of a posterior 9.5/s alpha-activity (stage A1) to a low-voltage irregular activity of approximately 7 s, corresponding to the stages B1 and B2, followed by a spontaneous and again abrupt restitution of the posterior alpha-rhythm and finally another mid to late B-stage ctd.->

below: 12-s-segment from the same EEG (2 cm ~ 1 s); in the 4th second abrupt transition of a posterior alpha-activity to anterior- accentuated irregular polymorphous delta-waves corresponding to a stage B3, followed by low-voltage desynchronized activity, in phases with subvigil beta-activity corresponding to the stages B1-B2 (K. P., 45 y, m., EEG-nr. 501/92). (Illustration 69-76 identical derivation schema).

4.1.4. The Dissolution of Physiomorphological Vigilance Dynamics - Pathomorphological Variants of the A-Stage (IBA/ILA)

4.1.4.1. Involutional Psychosyndromes (C)

There are numerous literature references to an increased occurrence of intermittent left anterior and also, to a large degree, temporo-anterior as well as frontally localized groups of slow waves of varying frequencies observed in samples of elderly patients (ILA; s. a. 3.1.) (BUSSE et al. 1954; SILVERMAN et al. 1955; BARNES et al. 1956; OBRIST and HENRY 1958; HARVALD 1958; HUGHES 1960; MUNDY-CASTLE 1962; BUSSE and OBRIST 1963; HELMCHEN et al. 1967; GSCHWEND and KARBOWSKI 1970; BUSSE 1973; OBRIST 1975, 1976; KOUFEN and GAST 1981; ARENAS et al. 1986; RICE et al. 1990). In general, it was unclear why the focal changes occurred almost exclusively on the left side: "...around 70 years, the absence of any unilateral right-sided discharges and the emphasis on the left side is curious ..." (HUGHES 1960). Despite intensive research efforts, a structural correlate could not be found. The opinion still dominant nowadays is expressed in a quote by OBRIST (1976): "Little is known about the exact origin of focal temporal abnormalities in elderly people." It can be considered as proven that ILA has no relationship to left- or right-handedness nor to hemispheric dominances, that generally there exist neither aphasia nor left-hemispheric diminished blood flow, that fatigue as well as hyperventilation facilitate the manifestation of the phenomenon and that it disappears with the transition to light sleep, i. e. stage C. Several authors thought it peculiar that the positive correlation between age and frequency of occurrence is limited to the age range from about 40 to 60 years. Beyond the age of 70 years there was no longer any evidence of a frequency increase (SILVERMAN et al. 1955; OBRIST and BUSSE 1965; BUSSE 1973). An explanation for this is still missing, as well as for the seemingly paradoxical finding, confirmed in independent research, that ILA is found less frequently in samples of gerontopsychiatric patients with obvious mental impairments than in control groups of healthy or inconspicuous elderly people (SILVERMAN et al. 1955; TORRES et al. 1983). According to OBRIST, to whom we owe the majority of the findings concerning the ILA-phenomenon, there is no connection between the morphological distinctiveness of ILA and the degree of a possible mental performance deficit. In his view, such deficits exist only if ILA appears in the context of a diffusely increased irregular slow activity: "when it involves adjacent areas or becomes part of a diffuse disturbance, chronic brain syndrome is more probable." This observation conforms to the dissolution order conceived by us in which ILA proceeds, via

bilateralization (IBA), into a diffuse dysrhythmia (s. a. 3.1.). This dissolution order also explains why the positive correlation between ILA-incidence and age is no longer existent beyond the age of 70 years. If the severity of involutional syndromes - from the statistical point of view - is determined by the age we would have to expect, after a certain age, an increase of bilateralizations (IBA) as well as generalizations (diffuse dysrhythmia) of the ILA-phenomenon limited previously to the left brain. In an expansion of the term "focus" - in our opinion unwarranted - an increase in bilateral foci is also mentioned: “the incidence of bitemporal foci increases with age” (HUGHES and OLSON 1981). The unilateral and therefore in the true sense focal ILA-phenomenon becomes increasingly infrequent in very old people on account of bilateralization and generalization.

> We also must take into account that a temporal focus of a certain extension can remain undiscovered for technical reasons during recording. For bipolar array montages with relatively narrow distances between the electrodes, this can be understood easily. The same problem, however, can also occur with ear-reference recording, where the potential under the reference electrode probably is very similar to that of the temporal region. This can be deduced from the usually small amplitude of the leads T3-A1 or T4-A2 (s. a. ZSCHOKE et al. 1990).

The typical ILA-phenomenon that gains its morphological distinctiveness against the background of an otherwise more or less physiomorph EEG marks a relatively early dissolution stage in the process we sketched (illustration 26). This explains why there was (according to BRESLAU et al. 1989; OKEN et al. 1992; WANG et al. 1970; DRACHMAN and HUGHES, 1971; VISSER et al. 1987) no evidence or only minor evidence of functional deficits found in the carriers of the phenomenon. Possibly, the performance change actually to be expected remains inapparent on account of a sufficient degree of compensation, an explanation that we also considered for the involutional beta-activity in connection with a DL (s. a. 4.1.3.1.).

> The external validation through performance tests is usually viewed as proof of the pathognostic relevance of a specific EEG-feature. This implies that these performance tests are more sensitive indicators of a pathological functional/performance change than EEG- features. The opposite possibility - though equally plausible - is strangely never considered. In this case, one of course could not assume the clinical insignificance of the EEG-feature from the failure of the external, i. e. behavioral validation. We find it necessary to emphasize this, especially considering the above-mentioned contradictory opinions of the clinical significance of ILA.

If the ongoing dissolution process results in the bilateralization of ILA postulated by us and thus in the occurrence of bilaterally symmetrical, anterior-accentuated groups and sequences of high-amplitude rhythmic waves (IBA, s. a. illustrations 41; 42), we usually also observe an obvious deterioration in performance. Thus, IBA has been long considered as almost pathognomonic for the advanced stages of Alzheimer's disease (for instance LETEMENDIA and PAMPIGLIONE 1958; GORDON and SIM 1967; KRANKNEHAGEN and KÖHLER 1973). Authors who paid attention to lateral asymmetries

referred exclusively to a left-sided focus. KRANKENHAGEN and KÖHLER (1973) found seven times as many left foci than right foci in their ALZHEIMER patients and claimed that for none of the patients with such "focal" signs could a structural lesion be established.

4.1.4.2. Exogenous Psychosyndromes.

The temporary occurrence of ILA in "exogenous reaction types" has been proved numerous times. The clinical spectrum reaches from "exhaustion" of somatic or psychological genesis (BLANC and LAIRY 1961; BLANC 1962) to after-effects of electro-convulsive treatment, (SCHULZ et al. 1968; VOLAVKA et al. 1972; STRÖMGREN and JUUL-JENSEN 1975), withdrawal syndromes (VAN SWEDEN 1984), and to AIDS (RIEDEL et al. 1992; GABUZDA et al. 1988; PARISI et al. 1989; TINUPER et al. 1990). Of VAN SWEDEN'S 22 patients who developed mental deterioration as part of a withdrawal syndrome after previous hypno-sedative abuse, 6 patients temporarily showed an ILA-phenomenon: "When global EEG dysfunction receded localized slow wave activity over the left temporal regions could still be noted for several days or weeks." Based on this characteristic course the authors saw - without referring to but in agreement with similar assumptions of earlier authors - in the ILA-phenomenon the manifestation of a certain stage in the progressive improvement of a disturbed brain function.

Of 103 HIV-positive patients examined by RIEDEL et al (1992) at various stages of the disease, 18 showed a left focus and 7 a right focal accentuation of slow waves. Assuming a binomial distribution, this is a significant difference. The view that the observed left foci are to be considered as ILA and thus, according to our model, local manifestations of a global functional disturbance, is also supported by the fact that these foci were significantly more associated with memory loss than the right foci.

EEG-modifications that are effortlessly subsumed under IBA from their description are considered typical correlates of metabolic and toxic encephalopathies (FOLEY et al. 1950; JACOB et al. 1965; PENIN 1971; KÖHLER and PETZOLD 1974; KUROIWA and CELESIA 1980; SCHAUL et al. 1981 a, b; ZUREK et al. 1985), diffuse degenerative encephalopathies (GLOOR et al. 1968) and cerebral compression (DALY et al 1953). Of special interest to us is the occurrence of IBA under acute hypoxia (s. a. 3.1.), as well as hypoglycemia (SAUNDERS and WESTMORELAND 1984). Here, at least, IBA cannot be viewed as immediate evidence of the functional impairment of hypoxia- or hypoglycemia-sensitive substrates. If this were the case, cognitive stress, implying an additional need for oxygen and glucose would have to lead to even clearer evidence of IBA. In reality, however, the opposite is the case. A simple wake-up stimulus such as opening the eyes is capable of completely blocking IBA. Permanent cognitive load has a similar effect. This leads us to conclude that IBA is a reaction schema (s. a. illustration 26) representing a specific disintegration level that is not directly dependent of the triggering noxa.

This explanation conforms to the occurrence of IBA in acute as well as chronic diseases. Reaching or passing of a very specific disintegration level probably is the only determining factor for the manifestation of IBA, regardless of the kind of noxa or the intensity and speed of its impact. This places us in opposition to PENIN (1971), who considered "parenrhythmias" an indicator of process acuity.

4.2. The EEG in Affective Psychoses

4.2.1. Dynamic Rigidity (DR) and Melancholia

As we have already discussed in detail (s. a. 2.2.1.1.), today's predominant opinion about the lack of conclusive results from the EEG in psychiatric syndromes is based on the unsuccessful proof of "abnormal" or "specific" features. Even more than in involutional and exogenous psychoses, this conventional premise proves a severe impediment for research in endogenous psychoses. Nonetheless, the literature contains substantial findings that, for the aforementioned reasons, find little recognition.

This is especially true in the field of affective psychoses for the promising and in our opinion still guiding concept of BLANC and LAIRY (1960). Considering topographical as well as dynamic aspects, the authors defined two main types that are opposites of each other. The first type that was overly represented in periodically occurring melancholias was a well pronounced continuous, rather monotonous-appearing alpha-rhythm with a tendency for spreading towards the frontal regions. The second type, related to neurotic-reactive depressions, showed a more or less discontinuous alpha-activity of changing topographical accentuation. The first type can easily be associated with a DR, the second with a DL. In a number of publications BENTE confirmed and fine-tuned BLANC and LAIRY'S distinction (BENTE 1965, 1975, 1976). Regardless of that, isolated singular features continued to be the focal point of all research activity, especially the frequency variables assessed by spectral analysis.

Today, for phasic depressions, a well-pronounced and - in comparison to control persons - slightly slowed alpha-activity is considered to be feature (SHAGASS et al. 1982; SCHAFFER et al. 1983; von KNORRING et al. 1983; NYSTRÖM et al. 1986; PRICHEP, 1986; JOHN et al. 1988; POLLOCK and SCHNEIDER 1989). Furthermore, all those authors who included the topographical aspect reported an alpha-anteriorization that was more pronounced than in control persons (SHAGASS et al 1982; PRICHEP 1987; POLLOCK and SCHNEIDER 1989). As a third quantitatively assessed feature of phasic depression, a decreased variability or increased uniformity of the amplitudes can be considered (d'ELIA and PERRIS 1973; MARJERRISON et al. 1974; GOLDSTEIN 1975; SWARTZBURG and CHOWDREY 1977).

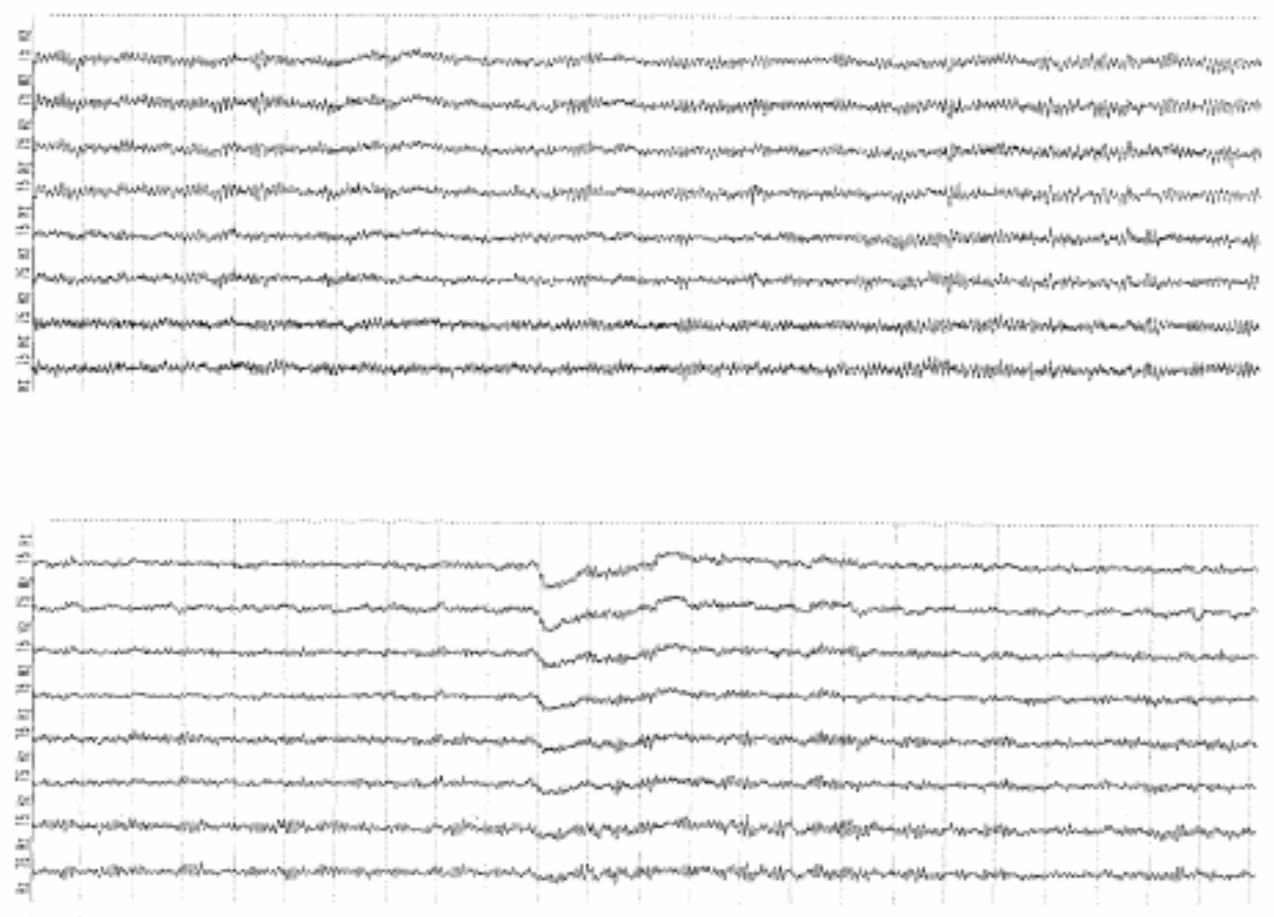


Illustration 70. above: Continuously anteriorized alpha-activity of about 9/s. Dynamic rigidity (1 cm ~ 1 s). Recording at admittance because of "neurotic depression"; 75mg/d clomipramine. Complaints about "mental block" for months, but besides that no other symptoms typical for depression (A. M. S., 43 y., f., EEG-nr. 204/92). below: At this point, largely physiomorph dynamics with posterior-accentuated, approximately by 1 Hz accelerated alpha-activity (1 cm ~ 1 s); 125 mg/d clomipramine. The recording was performed after the patient had reported the sudden disappearance of her mental block after the second night of sleep deprivation. No improvement under the preceding 12-week clomipramine-treatment (EEG-nr. 508/92).

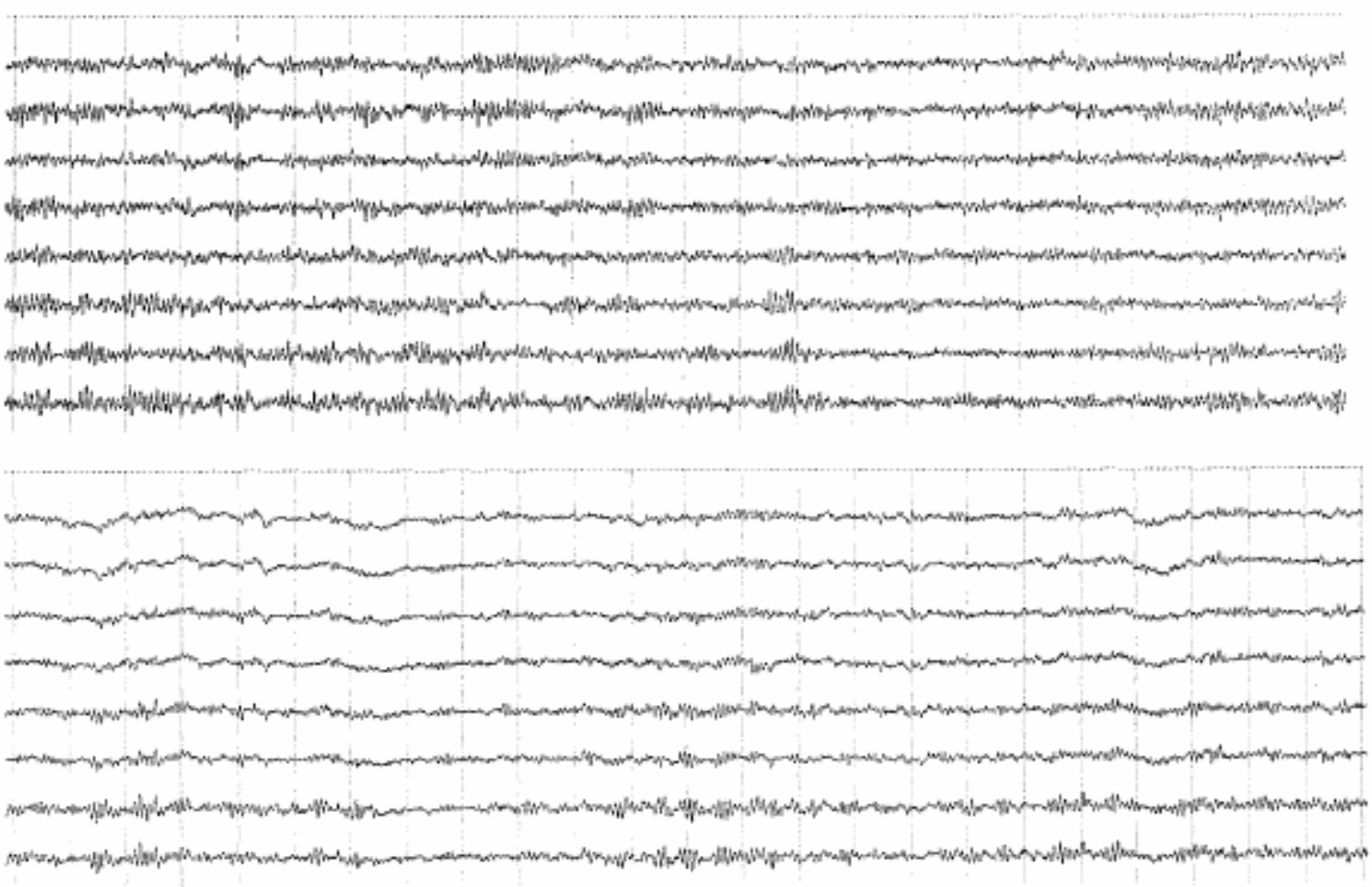


Illustration 71. Patient same as in illustration 70. above: Recurring dynamic rigidity (1 cm ~ 1 s) at readmittance 5 months later because of recidivism (compare to illustration 70, above). Complaints again about mental block (EEG-nr. 1033/92). below: Again physiomorph EEG (compare to illustration 70, below) as correlate of a recurring remission under combined sleep deprivation and clomipramine treatment (EEG-nr. 27/93).

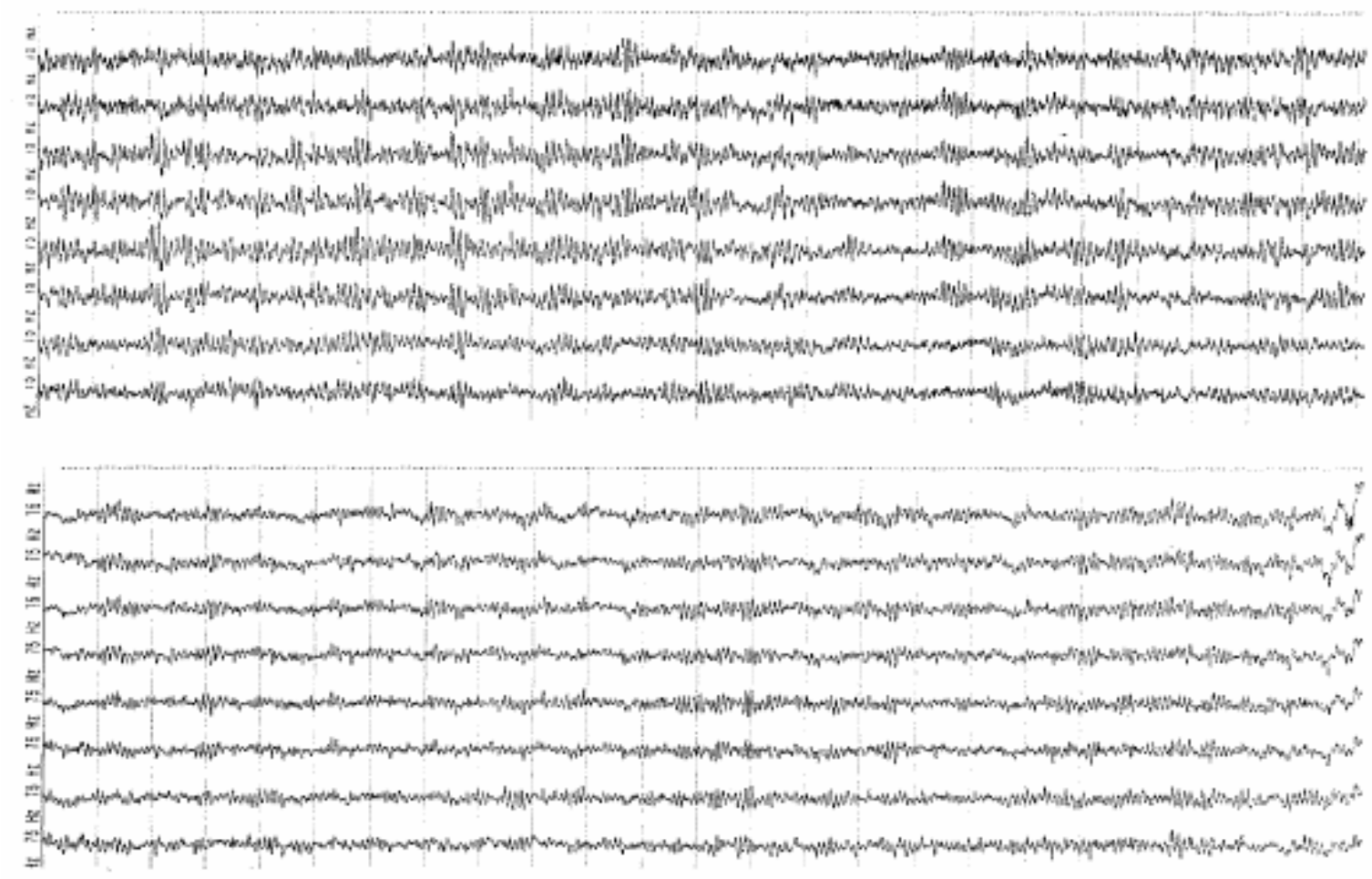


Illustration 72. above: Continuous anteriorization of a high-amplitude, slightly slowed appearing and relatively monomorph activity of approximately 8.5/s. Picture of a dynamic rigidity (1 cm ~ 1 s). Depressive syndrome with pronounced psychomotor retardation; for one week 75 mg/d imipramine, lithium-level: 0.52mmol/l (I. K., 65 y., f., EEG-nr. 614/92). below: Continuing dynamic rigidity (at best a partial regression) despite far-reaching remission after 6 weeks of combined treatment with imipramine and lithium (EEG-nr. 650/92).

No comparable research exists for the non-phasic forms of depression, also called neurotic-reactive. Our own - retrospective - study aimed at a systematization of the EEG-morphodynamics of inpatients with depressive syndromes (ULRICH and BRAND 1993). We based ourselves on the resting EEGs recorded routinely during the first week. All patients who were treated during a gathering time of 3 years were included in the study. Excluded were patients with diffuse dysrhythmia following electro-convulsive treatment and those who were treated with lithium.

AMDP			EEG DR no	yes	p
affective rigidity	≤51 y.	yes	22	19	0,05
		no	80	31	
	>51 y.	yes	26	21	0,10
		no	79	34	
ihibited thinking	≤51 y.	yes	23	19	0,6
		no	79	31	
	>51 y.	yes	25	21	0,07
		no	82	34	
retarded thinking	≤51 y.	yes	36	28	n. s.
		no	58	30	
	>51 y.	yes	42	29	0,04
		no	68	23	
off drive	≤51 y.	yes	56	37	0,03
		no	46	13	
	>51 y.	yes	60	40	0,04
		no	47	15	
disturbed memorization	≤51 y.	yes	18	17	0,07
		no	82	35	
	>51 y.	yes	22	16	n. s.
		no	87	37	

Table 5. Bivariate frequency distribution of 314 inpatients with depressive syndromes, divided according to presence (yes) or non-presence (no) of a DR in the EEG on one hand and specific AMDP-features on the other hand (the degree of intensity was not taken into account). An additional classification occurred based on the age median (x = 51 y.) calculated for the entire sample. p: Fisher-test, two-sided

In about one-third of the patients (total n = 314) the EEG showed a DR. This DR was found significantly more often in the patients classified as endogenous (in 42%) than in patients classified as non-endogenous (in 20%) (RDC-criteria, SPITZER et al. 1982). Furthermore, the DR appeared closely related to the psychomotor axis symptom of retardation. The correlation of DR and endogenity as well as of DR and psychomotor retardation appeared to be independent of age.

The definite answer to the important question whether the DR observable in acutely depressive patients is state-dependent or state-independent must be based on a sufficient number of longitudinal observations. Such observations, however, are not yet available to us. Based on unsystematic opinion forming, as well as considering certain remarks in literature (POLLOCK and SCHNEIDER 1989) we find an "as well as" worth pondering. This means the DR could be a vulnerability indicator, already observable in the euthymic state ("trait marker"), for the manifestation of psychomotor-retarded endomorph-depressive symptoms. On the other hand, we could assume a phase-related accentuation of DR ("state marker"). The finding that (only or at least) half of the psychopathologically relative homogenous subgroup with an endomorph clinical picture showed a DR illustrates once again that a sample which is homogenous from the diagnostic point of view by no means also has to be homogenous from the pathophysiological point of view. We consider this an empirical proof for the "pathobiological heterogeneity" of psychopathologically homogenous samples (s. a. 2.2.4.) postulated by WEXLER (1991). That the psychomotor retardation does indeed indicate a pathophysiological entity delimitated in several respects is also suggested by the favorable, though only temporary reaction of thus characterized syndromes to L-Dopa (GOODWIN et al. 1970; VAN PRAAG et al. 1975) or to dopamine-agonists (POST et al. 1978; WAEHRENS and GERLACH 1981; SILBERSTEIN et al. 1981). When DIEHL and GERSHON (1992) view the depression characterized by psychomotor retardation an "understudied depressive subtype" and point out their enormous theoretical significance, a renewed interest of the neurochemically oriented psychiatry in the aspect of retardation becomes evident (s. a. BRON and LEHMANN 1990). The required clinical research certainly could be advanced considerably if we succeeded in finding the pathophysiological correlate of "psychomotor retardation", using a more refined operational definition of the clinical item. We regard the EEG- phenomenon DR as such a correlate that without any problem can also be expressed quantitatively. The EEG could be particularly useful for therapy planning in all those cases where the diagnosis of melancholia seems doubtful because of the relatively slight degree of observable depressiveness - depressio sine depressione (SCHNEIDER 1959).

> About one-third of the patients with depressive syndromes in a sample tested by VAN PRAAG (1962) called themselves not-depressed.

Not in the least because of low scores on the customary depression scales such patients easily remain undiagnosed and are classified falsely as neurotic-reactive and thus receive inadequate treatment. The psychomotor retardation typically present in these cases usually manifests itself quite clearly in the non-verbal behavior. However, we must also expect to encounter cases where the retardation for the most part affects the thinking and therefore cannot be directly observed

(EBERT 1990). Especially in those cases, the discovery of a DR in the EEG can lead to the right track. Exemplary for this is our patient A. S. (illustration 70, 71) in whom the triad of grief, anxiety and guilt as regarded typical for depression was hardly present.

On the foreground there was a phase-related mental block perceived as extremely worrisome. A personality disturbance as a differential diagnosis could be rejected not in the last place thanks to the EEG, i. e. thanks to the phase- and symptom-relatedness of the DR.

> A DR as state-related electroencephalographic manifestation of a pathological functional change can also be associated with a pathological performance change. That such a pathological performance change, at least in the phasic cases, does indeed exist, should be today beyond any doubt and has been clearly objectivated in several studies (f. i. SILBERMAN et al. 1983; CORNELL et al. 1984). This allows the formulation of the easily testable working hypothesis that the intraindividually determined degree of a dynamic rigidity corresponds to the degree of the cognitive impairment or, in other words, is an objective, basically also measurable indicator for it.

In other cases, the clinical improvement is accompanied only by a partial regression of the DR (illustration 72). However, there are also patients in whom, at least in a visual evaluation, a change of the DR is not recognizable despite obvious clinical remission (illustration 73). In an attempt to explain such inconsistencies, we must remember that a clinical improvement might just as well be the manifestation of a suppression of symptoms through medication as an actual remission of the depressive phase. This distinction is important because we cannot determine yet whether a dissolution of the DR, as documented in illustrations 70 and 71, is to be associated with the suppression of symptoms through medication or with the remission of the phase. Illustrations 74 and 75 document the regression of a pronounced DR in a retarded-depressive state during successful electro-convulsive therapy via the intermediary stages of slowing of the dominating frequency and of diffuse dysrhythmia. As during pharmacological and sleep deprivation therapy, the success of the treatment manifests itself in only a number of the patients in an obvious regression of the DR. Besides them, there are numerous patients who clinically suffer from endomorph depression and also show symptoms of retardation but whose EEG does not evidence any DR (in our sample about half of the patients).

> During electro-convulsive treatment the EEG-changes usually do not occur after the first or second convulsion but only after a whole treatment series. The degree of change can vary considerably from patient to patient, even with identical treatment, ranging from only a minor slowing of the dominant alpha-frequency to massive diffuse dysrhythmias of several weeks' duration. Without the assumption of a dispositional factor which, incidentally, cannot be deduced from the preexisting baseline EEG it is impossible to explain such variations.

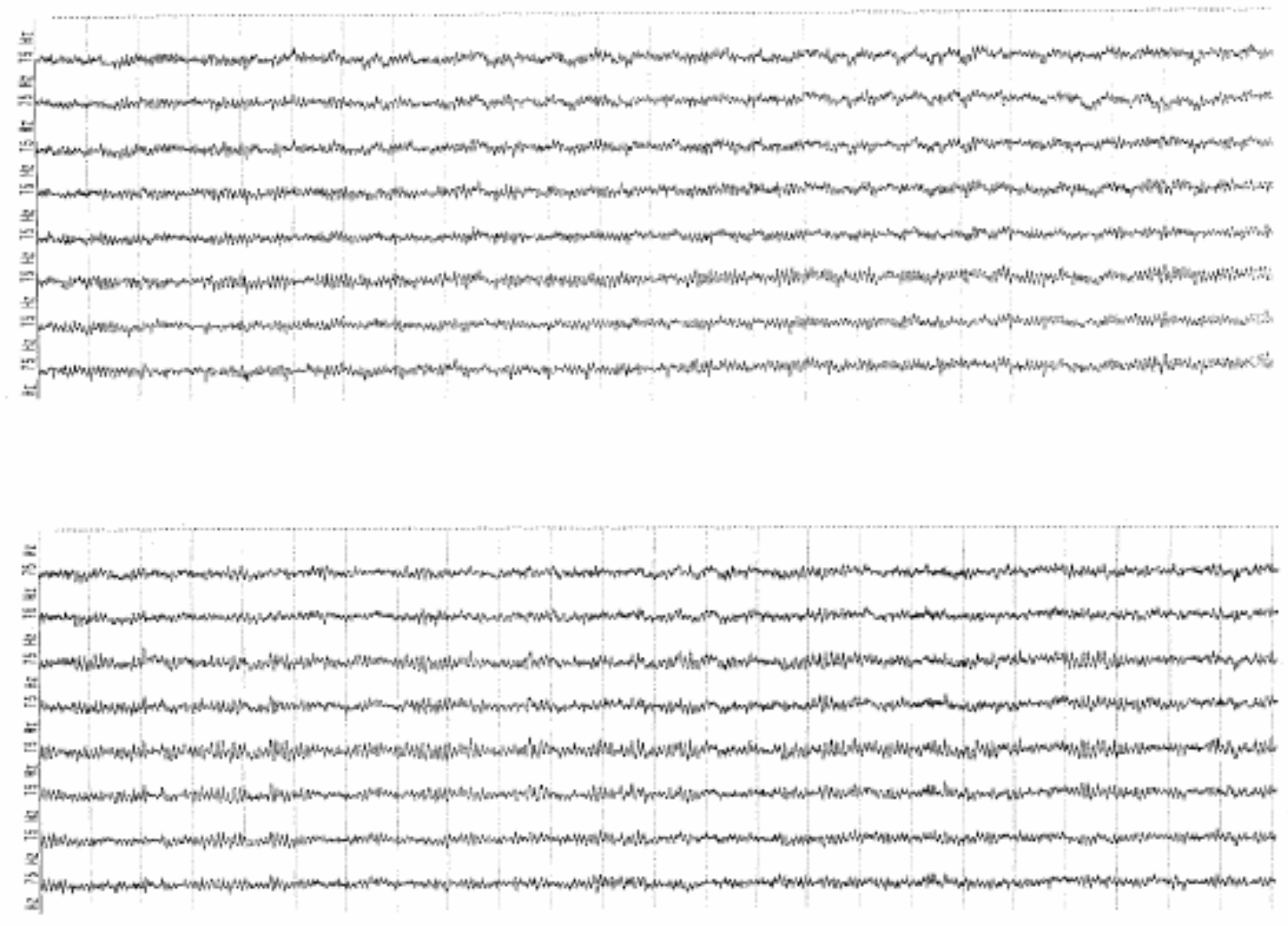


Illustration 73. above: Medium anteriorized 10.5/s activity. Dynamic rigidity (1 cm ~ 1 s). Retarded-depressive syndrome in bipolar affective psychosis - recording at admittance under 75 mg/d amitriptyline (K. W., 54 y., m., EEG-nr. 87/92).; below: No significant change in the dynamic rigidity despite remission after 8 weeks of antidepressive medication (in the end 150 mg/d clomipramine) (EEG-nr. 157/92).

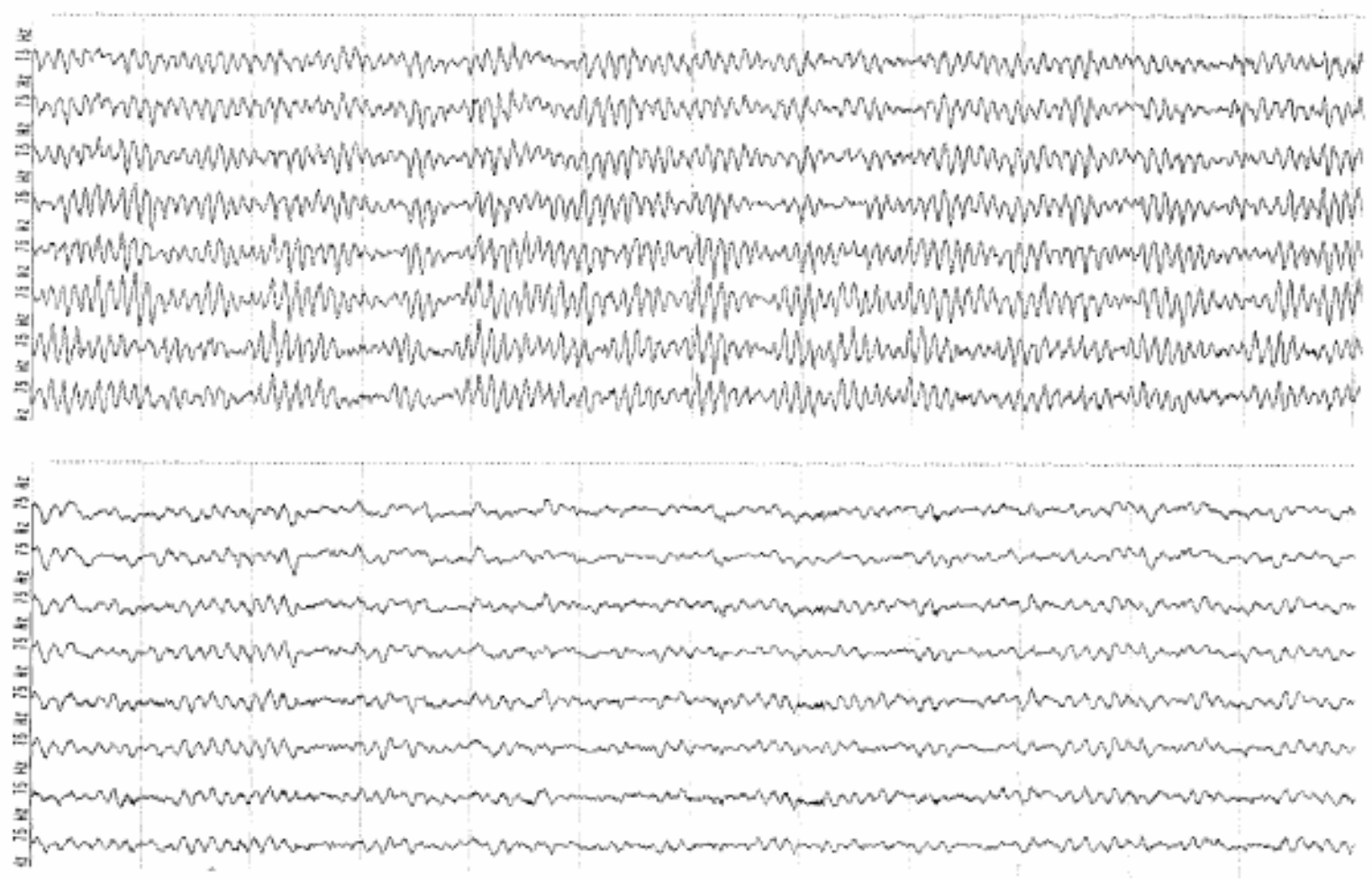


Illustration 74. above: Continuous anteriorization of a seemingly slightly slowed and monomorph 8.5/s activity. Dynamic rigidity (2 cm ~ 1 s). Depressive syndrome (thymoleptics-resistent) (T. K., 58 y., f., EEG-nr. 302/92).; below: Predominantly diffuse- dysrhythmic EEG after 5 electro-convulsive treatments. Slight recovery from the depressive syndrome with discrete indications of an "exogenous reaction type" (mnesic disturbances) (EEG-nr. 390/92).

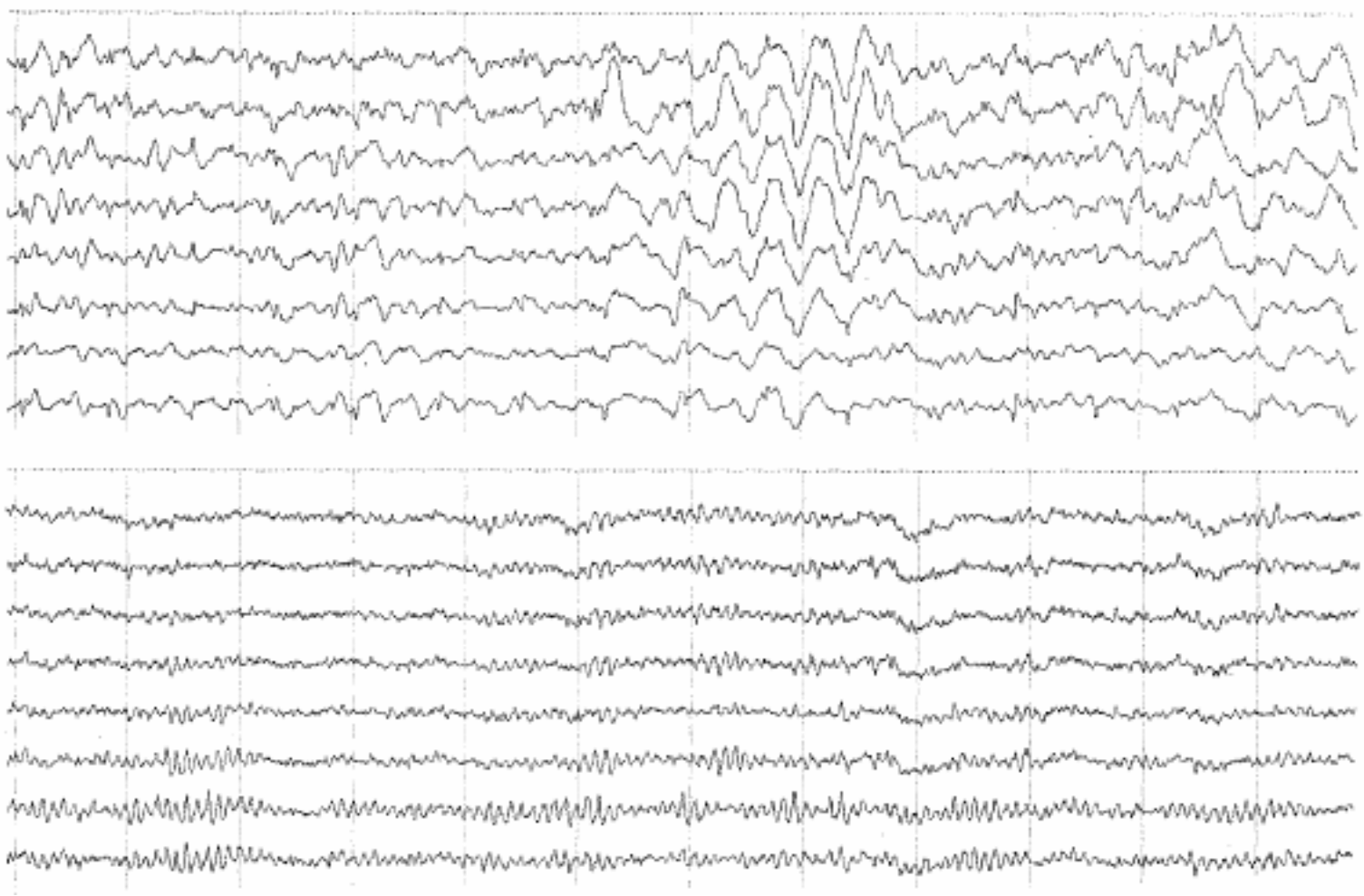


Illustration 75. Patient the same as in illustration 74. Above: of the diffuse dysrhythmia after 5 additional electro-convulsive treatments (compare illustration 74, bottom; continuing recovery of the depressive syndrome and increase of the mnesic disturbances, EEG-nr. 443/92); below: 8 weeks after the termination of the electro-convulsive treatment under 75 mg/d clomipramine predominantly physiomorph organized EEG with a posterior-accentuated alpha-activity of about 10.5/s. Clinically largely remitted, still some mnesic deficits (EEG-nr. 693/92).

It is evident that such case studies cannot replace statistically backed prospective studies that include the appropriate quantitative analyses. However, considering the situation of the psychiatric EEG today, it would help if these discussions inspired future researchers to trust their own eyes again and to start paying attention to the phenomenon of the DR in connection with depressive syndromes. The phenomenon of DR and especially its close relation to the axis syndrome of psychomotor impediment can be regarded as exemplary for the kind of EEG-phenomena that can be expected to be found in psychiatric disturbances. Far from being "disease-specific," these are patterns which can also be observed in healthy persons, but with other proportions and dynamics.

4.2.2. Dynamic Lability (DL) and Mania

The remark by PERRIS (1980) that we find "a higher incidence of unspecific abnormalities" in maniacs can be viewed as representative for today's state of knowledge. Such relatively empty statements are accompanied by a generally observed ignorance of the few but therefore even more important systematic studies about the topic. Instead, we repeatedly encounter the same individual case studies and methodically questionable reports of earlier authors (for instance HURST and MUNDY- CASTLE 1954; HES 1960; HARDING et al. 1966). The unreflected reproduction of incomplete quotes, obviously without source study, may have promoted the proliferation of certain erroneous beliefs. For instance, the statement attributed to DAVIS (1940) that manias are characterized by frequency accelerations is incorrect (KÜNKEL 1980). DAVIS actually only pointed out the occurrence of faster frequency components in some of his patients during the transition from a depressive to a manic phase.

> Judging from the description this occurrence most likely corresponds to the "subvigil" beta-activity facultatively associated with the B1-stage (s. a. 2.2.1.4.).

In contrast, no one contribution found in handbooks mentions that DAVIS (1940, 1941) also pointed out those manic syndromes whose EEG-correlate is a grouped, irregular, slow activity. Equally neglected were the findings by GREENBLATT et al. (1944) that manias can be distinguished from depressions by a higher proportion of slow and a lower proportion of faster frequencies. The first systematic study by LIBERSON (1944) also has remained widely unknown. Among all psychiatric patient groups, the maniacs had the highest proportion of EEGs with "drowsiness patterns," with 70%. "Drowsiness patterns," according to LIBERSON, are groups and sequences of irregular theta- and delta-activity. He also pointed out that in the EEG typical for manias the "drowsiness patterns" already appeared at the beginning of the recording, contrary to the EEG of a healthy person under sleep deprivation.

It took 16 years before LIBERSON'S findings were reevaluated and confirmed by BONNET and BONNET (1960). The majority of their patients in a state of acute mania evidenced frequent and abrupt transitions into phases of lower voltage of 5-10 seconds duration, with embedded irregular waves, thus, in our terminology, a dynamic lability (DL).

> During the phases of slow activity, the patients appeared quiet, but definitely not asleep. Upon the reappearance of the alpha-rhythm, as a rule, they showed signs of restlessness. After treatment with neuroleptics over several days, the clinical recovery was paralleled by an increase in the continuity of the alpha-activity.

The authors thought it paradoxical that the untreated sleepless, acutely manic patients showed signs of drowsiness in the EEG, whereas the EEG recorded under high dosages of neuroleptics indicated a relatively higher degree of alertness. The objection that this is only the manifestation of the neuroleptics effect was countered by the observation that the subvigil activity phases were most pronounced in patients who received comparatively lower doses of neuroleptics. The interpretation that the subvigil activity is a manifestation of exhaustion in manic restlessness seems to the authors equally contestable.

> Similar patterns in confusional psychoses that also are accompanied by restlessness and sleep deficit but cannot be classified otherwise as manic syndromes are hardly ever observed.

Contrary to what would be expected in exhausted persons with a tendency to fall asleep, none of the maniacs fell asleep during the recording. Thus the authors concluded that a mania or at least an important subtype is associated with a disturbance of maintaining the physiological state of alertness. With this, they referred to EY (1954) who rejected the popular opinion that the manic is lucid or even hyperlucid.

> According to EY, acute mania is a "sommeil incomplet et épuisant, etalé a longeur de journée" without the patient being able to find a deep and refreshing sleep. The mnesic deficits after complete remission indicated a disturbed consciousness during the acute manic phase.

The authors thought that the number of cases was insufficient to answer the interesting question whether manic syndromes with slow EEG-activity differ from those without.

Obviously ignorant of the work of LIBERSON (1944) and BONNET and BONNET (1960), VAN SWEDEN (1980) reported two patients with acute mania in whose medication-free resting EEG beta-spindles, corresponding to the light sleep stage C, could be observed shortly after the beginning of the recording. The author emphasized that the patients had not felt

tired, let alone fallen asleep. Despite high doses of neuroleptics, the EEG became normal after the completion of the clinical recovery.

In our experience, EEGs with phases of slow activity in maniacs are, if not the rule, at least remarkably frequent.

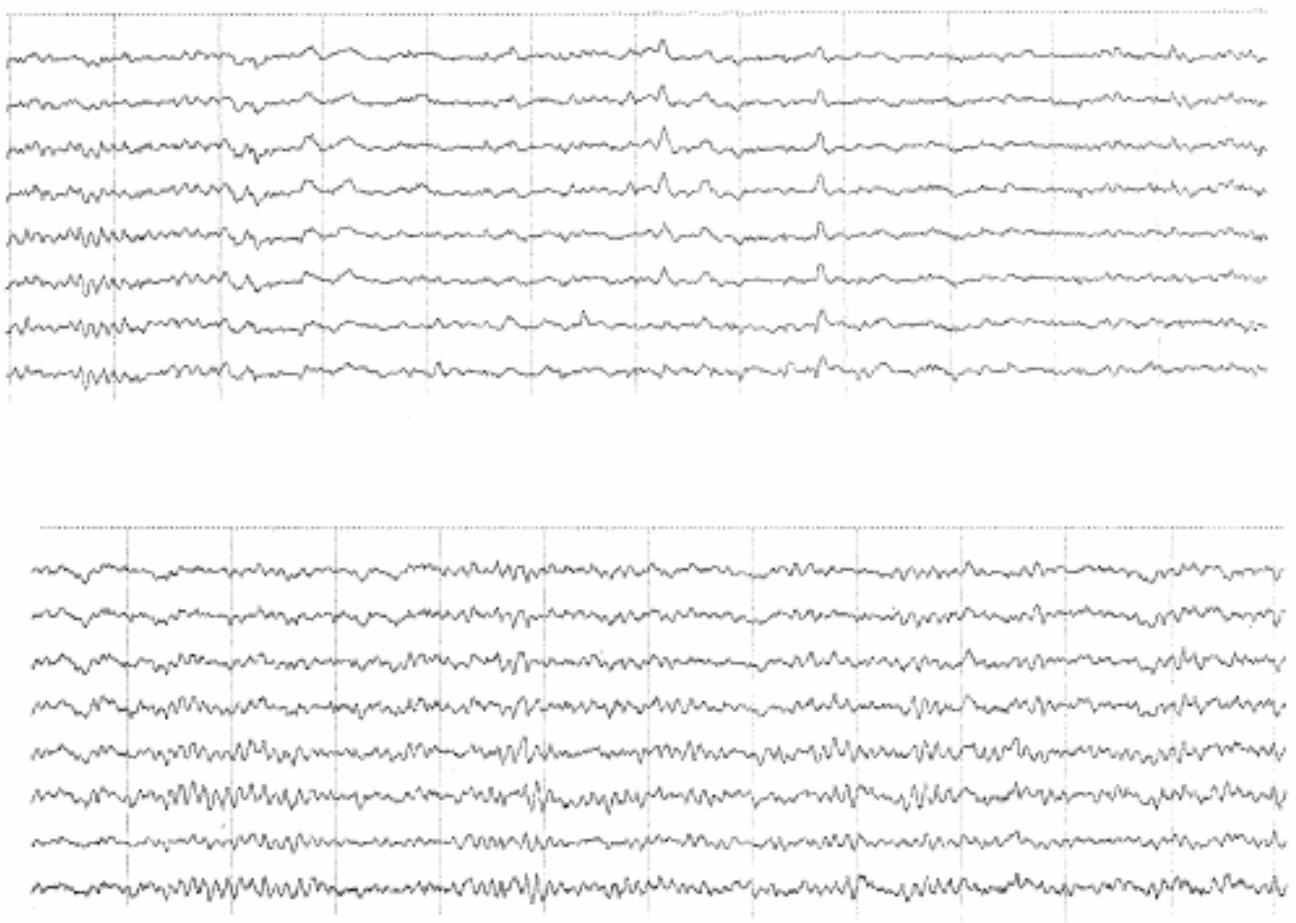


Illustration 76. above: Abrupt transitions between A- and mid- to late B-stages. Dynamic lability (2 cm ~ 1s). The recorded sample was taken from the first recording minute: an initial 9/s-activity of a posterior maximum is followed, in the 3rd second, by an irregular delta-activity of about 2 seconds, corresponding to a stage B3; an ensuing B2-stage is followed, in the 7th and 8th second, by vertex potentials in connection with a suggested 14/s-beta-activity, corresponding to a stage C. Towards the end of the registration period, a suggested restitution of a late A-stage. Manic syndrome in bipolar affective psychosis. Recording on the 3rd day after admittance under 400 mg/d perazine (G. S., 48 y., m., EEG-nr. 911/92); below: Extensive regression of the dynamic lability after 6 weeks of therapy. At time of recording 600 mg/d perazine and 600 mg/d carbamazepine, lithium-plasma level: 0.78 mmol/l (EEG-nr. 1090/92).

It is difficult to understand that a phenomenon as frequent and conspicuous has received so little attention thus far. One of the reasons is possibly that it cannot be observed in all manic syndromes and therefore cannot be called "specific." Nosologically unspecific phenomena, however, were and still are erroneously considered irrelevant and therefore ignored (s. a. 2.2.1.1.). Moreover, defining subvigil activity as mania-typical does not conform to the popular prejudice held by many psychiatrists that manic overactivity must correspond to a vigilance increase.

To expand what doubtlessly remains far too narrow an empirical basis, we decided that the topics of EEG and mania, too, would be served best by an initial retrospective study of a greater number of patients (ULRICH and SYLLA, unpublished).

> Included were all persons treated as inpatients in our hospital during a 5-year period who, at their discharge, were diagnosed with a manic syndrome and who also fulfilled the RDC-criteria of a mania (SPITZER et al. 1982). Excluded were the few patients for whom no EEG was available and patients for whom more than a week had passed between the documentation of a clinical record and the recording of the EEG. As a control group we chose sex-, age-, and medication-matched (chlorpromazine equivalent) patients with a discharge diagnosis of paranoid-hallucinatory psychosis. The EEGs stored on microfiche were rendered anonymous by assistants and then, based on a catalogue of criteria, assigned by two interpreters independently to one of 5 categories (0 = no DL, 1 = minor DL, 2 = moderate DL, 3 = obvious DL, 4 = pronounced DL with lowered average vigilance level. The interrater reliability test resulted in a kappa = 0.91 ($p < 0.01$) which means that our evaluation mode is rather practicable.

Our sample included 101 patients, 60 of whom suffered from a mania related to an affective psychosis and 41 from a mania related to a schizo-affective psychosis.

Table 6. Frequency distribution of the EEGs with non-present, minor and moderate DL (categories 0, 1, 2) as well as with obvious or pronounced DL (categories 3, 4) in a group comparison between maniacs (n = 101) and schizophrenics (n = 101) with and without indication of sex.

		Maniacs	Schizophrenics	
male + female	DL (0, 1, 2)	79	90	p<0,03
	DL (3, 4)	22	11	
male	DL (0, 1, 2)	32	42	p<0,01
	DL (3, 4)	15	5	
female	DL (0, 1, 2)	47	48	n. s.
	DL (3, 4)	7	6	

Of the 101 patients included in our sample, 54 were female (average age = 37, ± 9.2 years) and 47 male (average age 36 ± 8.7 years). To test the hypothesis that the DL, especially when accompanied by a lowered vigilance level, is a mania-typical phenomenon we arranged our frequency data in a fourfold table (Table 6). For this purpose we grouped our EEG-categories 0, 1, and 2 (no, minor and moderate DL) on one hand and 3 and 4 (obvious and pronounced DL associated with lowered average vigilance level) on the other hand.

As shown in table 6, the more pronounced forms of DL (categories 3 and 4) are, as claimed in our hypothesis, overrepresented in the maniacs compared to the schizophrenics (Fisher-test, $p < 0.03$, one-sided). To our surprise, however, we discovered after considering the distribution by sex that the manic males were solely responsible for the group differences. While the manic men considerably more often presented more pronounced forms of DL (categories 3 and 4) than the schizophrenic men ($p < 0.01$), the manic women did not even differ tendentiously from the schizophrenic women.

4.3. The EEG in Schizophrenic Psychoses

"The hope to find the physiopathological substrate of the schizophrenic process and the passion to search for it should not falter because of the multitude of failures" (CONRAD 1958, p. 140, transl. from German).

The actuality of this demand, marked by a genuine desire to learn and discover, has not faded since. However, the study of medical literature increasingly conveys the impression that the methodically ever more diversified research runs the risk of losing its original, psychopathologically determined topic. But what, if not this topic, which can be experienced with the senses and defined through differentiated psychopathological efforts could evoke the passion for research demanded by CONRAD? The method-centered actionism which is accompanied by a contempt for methodological-conceptual aspects has provided, particularly in electroencephalographic schizophrenia research, a plentitude of useless and uninterpretable data. Those who try to gain a quick overview of the present state of knowledge through some summary are confronted with lists of findings, collected in a primarily quantitative way from groups of schizophrenic patients who were diagnosed following a certain schema but are not further characterized. The target variables have been, for approximately two decades and nearly exclusively, frequency band parameters that were obtained through spectral analysis and averaged across the entire recording time and across all patients. Such findings are, for a number of reasons still to be discussed, of only limited value. The following quote exemplifies this: "Schizophrenics reveal more delta, theta, and fast beta activity, and less fast alpha and slow beta waves than normals ..." (ITIL et al. 1972). Such a statement suggests that the schizophrenia exists as an also pathophysiologically defined disease entity and that the so-called spectral feature is specific for it (s. a. 2.2.4.; illustration 1). No mention is made in most writings of the interindividual variability of psychopathological pictures at different times of recording. In most cases, we are also kept in the dark as to whether the findings are considered state- or trait-features, let alone what they actually mean. The absolute methodological low is reached, in our opinion, in recent work where the colorful topographical depiction of spectral parameters - so-called EEG-mapping- averaged across the total recording time and the total patient sample is considered a contribution to scientific knowledge.

In findings obtained by spectral analysis only a beta-power increase in comparison to healthy people seems worth discussing, since quite a number of researchers agrees on this point (f. i. ITIL et al. 1972; ITIL 1977; GIANNITRAPANI and KAYTON 1974; VACCA et al. 1980; BERNSTEIN et al. 1981; KEMALI et al. 1981). An attempt for interpretation requires, in our view, a decision about whether we are dealing with a state-related, (state-) characteristic indicating the acuity of the disease or with a state-unrelated, (trait-) characteristic that continues existing beyond the acute state, thus possibly indicating a certain disposition for the disease. As far as we can judge, this question has not yet been answered. Regardless, the beta-increase has been interpreted as a manifestation of "hyperarousal" (ITIL et al. 1977) as well as of "hypoarousal" (GIANNITRAPANI and KAYTON 1974). The objection that the data do not justify such interpretations was raised correctly (KÜNKEL 1975; KOUKKOU-LEHMANN 1987; s. a. 2.2.1.4. and 2.2.5.). If we try to reconstruct the quantitatively measured increased beta-power visuo-morphologically, we immediately think of the picture of a low-voltage desynchronized EEG with variably pronounced fast activity (DL, s. a. 2.2.5. and 3.1.). DAVIS (1939, 1942) regarded such a form of organization - which she called "choppy activity" (illustration 116) - as typical for schizophrenia more than half a century ago. She viewed "choppy activity" prognostically as a rather unfavorable sign of "overstimulation or irritation" of the cortex and as state-related, because it manifested itself often for the first time after shock treatment.

> Agreeing in the neurophysiological interpretation with DAVIS, ITIL et al. (1975) considered "choppy activity" or "low voltage desynchronized fast EEG pattern" a "trait"-feature that revealed a disposition for schizophrenia. They speculated that it should be possible to prevent the manifestation of schizophrenia in people thus predisposed by using neuroleptics to reduce the hyperarousal, corresponding to an alpha-activation.

Also widely confirmed was the finding of a decreased variability of the voltage values as integrated over the total frequency spectrum and determined for successive time intervals (GOLDSTEIN et al. 1963, 1965; GOLDSTEIN and SUGARMAN 1969; SUGARMAN et al. 1964; MARJERRISON et al. 1967; LIFSHITZ and GRADIJAN 1972; SHAGASS 1976; SHAGASS et al. 1982). As far as clinical data are available, this involved chronic schizophrenics. With the increased beta-power, the question about state and trait cannot be answered here clearly, either. Here, too, the hyperarousal interpretation defended by the majority is confronted by a hypoarousal interpretation (LIFSHITZ and GRADIJAN, 1972). According to GOLDSTEIN (1983) the hypovariability of the voltage integral constitutes a trait-feature, since repeated measuring after weeks or months showed a high stability of the values in carriers of the feature, as opposed to those without the feature. This evaluation, however, seems to contradict earlier findings by the same work team claiming that the variability of the voltage integral increases with clinical recovery (SUGARMAN et al. 1964; GOLDSTEIN et al. 1965). Moreover, a clear decrease in variability was found in healthy persons on amphetamines (MURPHEE et al. 1962) or LSD (GOLDSTEIN et al. 1963; SUGARMAN et al. 1973).

In chronic schizophrenics, on the other hand, LSD led to an increase in variability (GOLDSTEIN et al. 1963) According to GOLDSTEIN et al. (1965) the decreased variability of the voltage integral is caused by an abnormal persistence of those patterns which are already present at the beginning of the recording ("absence of periods of drowsiness").

> Thus, we must examine how this measure of variation compares to our determination of frequency and time course of the non-A-epochs (s. a. illustration 68). It is possible that the variation coefficient of the voltage integral constitutes a simple measure for the quantification of deficient vigilance dynamics (s. a. 3.1.) - whether it be a dynamic rigidity (DR) or a dynamic lability (DL).

While the failure of psychophysiological schizophrenia research mentioned by CONRAD can easily be explained by the limitations of the then available methods, the failure today results, paradoxically, from the almost unlimited availability of technologies continuously developed at dazzling speed. The failure is the logical consequence of the undisputable fact that the research conducted today is centered around methods instead of being guided by the problem or a theory. We refer to this repeatedly mentioned deplorable state of affairs again, among other reasons, to make it quite clear that the scarceness of results gathered after half a century of costly research must by no means be blamed on the EEG as a research tool of supposedly little value. Electroencephalographic schizophrenia research today requires, even more than all other areas of the psychiatric EEG, a reevaluation of the methodological preconditions for a meaningful use of the available technological potential.

Resuming our arguments from the chapter on EEG and Psychiatry (s. 2.2.4.) we would like to define the only methodological framework within which EEG-studies seem meaningful, by the following premises:

- The multiple psychopathological pictures termed schizophrenic are accompanied by a "pathologischer Funktionswandel" (pathological functional change).
- We are confronted with a uniform pathophysiological process of progressive desintegration that by definition is reversible and follows certain laws.
- In this pathophysiological process distinct, psychopathologically and electroencephalographically characterized dissolution stages can be delimitated.
- The process shows, with regard to its dynamics, a great inter- and intraindividual variability and can, at each level, come to a standstill, persist or more or less remit.

Since, due to the dynamic character of the schizophrenic process, every sample, even under strict observance of the usual operational clinical inclusion criteria, must always be pathophysiologically heterogeneous, the customary, primarily group-

statistical research designs are of only dubious value. A possible alternative could be, as HUBER (1974) already demanded, individual longitudinal analyses. Regularities will only be deducible from a sufficiently large number of single case studies. That this alternative research strategy still causes so many problems cannot be explained merely by force of habit. Another reason is possibly that the biological variability, in our view the proper topic of research, is viewed from a purely statistical point of view as some kind of variance by errors of measurement whose impact can be minimized by choosing the largest possible sample.

Demanding individual longitudinal analyses, however, makes sense only if there is a clear concept about which variables are relevant, from the aspect of psychopathology as well as from the aspect of the EEG. We are faced here with the task of not just accepting in toto the usual standardized documentations of features but to examine critically whether the listed features actually have any bearing on the specific problem. We certainly cannot be satisfied with a collective description by means of a catalogue agreed upon by convention. However, a distinction with regard to their pathophysiological significance - like as indicators for specific dissolution stages of the schizophrenic process - can only be accomplished from a higher point of view, i. e. through a theory. We would like to add to KOUKKOU-LEHMANN'S (1987) suggestion to correlate syndromes or symptoms instead of nosological terms with the EEG by stating that each kind of correlation needs to be guided by theory. Since we are dealing here with the correlation of logically incommensurable description levels, theories that only apply to one of the areas are not sufficient. Required instead is a superimposed biological theory of higher general validity that encompasses both areas and allows a logical basis for correlating psychopathology and EEG. We refer here especially to our comments under Sections 2.2.4. and 2.2.5.

> All strategic considerations aside, we believe that limiting the number of features to be correlated - the psychopathological findings record of the AMDP-documentation includes no less than 100 items - is absolutely necessary, be it from the biometrical point of view alone. The adjustment of the significance level required by multiple testing promotes the risk of false-negative results.

A discussion of the methodological conditions also clarified the boundaries of what is possible. First, we will have to accept that there hardly ever will be a premorbid EEG available for comparison. An EEG recorded during the remission stage is an insufficient substitute because there, generally, a more or less pronounced residual functional deficit must be assumed. The second unavoidable restriction results from the often mandatory treatment with psychotropic drugs. Since that which can be expected from the EEG is the result of a dynamic interaction between the effect of psychotropic drugs and the psychopathological process, we can draw only indirect conclusions about the process dynamics we are actually interested in. This also clarifies which questions can be answered and therefore can logically be asked. Since recently the opinion

that there exist no "schizophrenia-specific" EEG-phenomena seems to gather wide support, we can distinguish essentially three problem areas:

- Are there any correlations between changes of the psychopathology and changes in the EEG during the course of the disease and if so, what are they?
- Does the EEG recorded from a medication-free patient at the beginning of the treatment or the EEG derived after administering a test dose of neuroleptics give any indications about the prognosis or the response to neuroleptics?
- Can any state-unrelated features be defined that could be considered as vulnerability indicators ("trait"-features)?

The findings available for the first problem area are all older. According to HUBER and PENIN (1968), untreated schizophrenics with psychopathological signs of a process activity showed a higher number of so-called parenrhythmias (s. a. table 2), corresponding to our pathomorph variants of the A-stage, that we related to a pathological functional change (IBA, s. a. 3.1.). As signs of a process activity they considered disturbed coenaesthesia, delusional mood and hallucinations. In remitted schizophrenics, i. e. in those without process activity, on the other hand, the EEG was mostly normal. HUBER and PENIN'S findings were confirmed to a certain degree by ISERMANN (1973) who, without touching on the question of acuity, emphasized that the bilateral synchronous theta- and delta-groups - named, by him, "paroxysmal dysrhythmia" - are a "disease-specific" phenomenon and are not caused by neuroleptics. The "paroxysmal dysrhythmia" is also the core of interest in a study by HELMCHEN (1968). "Paroxysmal dysrhythmia" and "parenrhythmia" seemed to have the same meaning for HELMCHEN. Contrary to HUBER and PENIN, and to ISERMANN, who based themselves only on the EEG recorded at the beginning of the treatment, HELMCHEN conducted systematic longitudinal studies under largely standardized neuroleptics medication. To our knowledge this is the only study in literature that complies with this methodological desideratum. HELMCHEN found that the subsidence of the characteristics group delusional mood/delusional perceptions was accompanied and closely followed by more or less rhythmic slow waves of high amplitude - corresponding to our IBA-phenomenon, judging from the given descriptions and curve examples.

> With regard to CONRAD'S (1958) subtle gestalt analysis of the development of schizophrenic delusion, the comprising of delusional mood and delusional perceptions as done by HELMCHEN, seems worth pondering. "Delusional mood" (Wahnstimmung) in the sense of JASPER'S definition is only a prodrome of developing delusion, according to CONRAD. Pathognostically, however, this phase, also called trema, is very ambiguous. One can talk about a schizophrenic process only after the onset of an initially still diffuse abnormal sense about the meaning of things. Concrete delusional perceptions in the proper sense would be typical for an even later stage. Thus "delusional mood" and "delusional perceptions" possibly also mark pathophysiologically distinguished phases of the disease. This should be taken into account in replication studies.

A similar, though less close relationship, was found between the subsidence of hallucinations and the appearance of IBA. However, there was no relationship between the item "delusion" and the EEG. As HELMCHEN emphasized, no relationship with the EEG could be found without consideration of the clinical longitudinal profile.

> HELMCHEN came close in his interpretation to BAEYER (1951) who, in order to explain the therapeutic shock effect, coined the formulation "can-maintain-no-longer" (Nicht-Mehr-Haben-Können) of the psychosis because of the induced massive brain-organic functional disturbance. In a later work, however, (HELMCHEN 1975) he talked about a "pharmacogenic uncovery of a temporary functional disturbance of the unspecific reticular thalamic system."

He considered the "temporary functional disturbance" as the correlate of an acute psychosis. The contradiction, unresolved according to HELMCHEN (1975), that the subsidence of the psychosis at one time is associated with a "abnormalization" (HELMCHEN 1968) and the next time with a "normalization" (HUBER and PENIN 1968) of the EEG seems to us quite solvable. First, we want to state that the findings collected by HUBER and PENIN (1968) in medication-free patients fully agree with our theoretical premises. On one hand, these findings support the concept of psychiatry in which the various clinical pictures are associated with various mental dissolution levels (s. a. 2.2.4.; illustration 2). On the other hand, "parenrhythmias" or "paroxysmal dysrhythmias" as pathomorph variants of the A-stage (IBA) indicate a very specific disintegration level of the global brain function (s. 3.1.; illustration 26) that apparently can be reached or passed during an acute schizophrenic episode. Under the plausible assumption of cyclic process dynamics governed by their own laws, IBA marks the turning point from the disintegrative to the reintegrative phase. From SELBACH'S (1976) regulation-theoretical point of view, we could postulate that reaching a certain desintegration level, as indicated by IBA, constitutes the precondition for an initiation of the spontaneous remission. Therefore, the IBA is an indicator of a currently existing, relatively advanced schizophrenic disintegration as well as of an imminent remission.

> That IBA indeed constitutes the correlate of a far progressed disintegration is also supported by the observation that the EEG-phenomenon is very often accompanied by clinical pictures of catatonic behavior (ROWNTREE 1952; HILL 1957).

As supported by all studies, IBA is a fleeting, usually only briefly observable phenomenon. Therefore, it would be difficult, if not impossible, to offer a psychopathologically exact picture of the transition from the disintegrative to the reintegrative phase. This methodological problem supplies a plausible explanation for the seemingly contradictory findings by HELMCHEN (1968) on one hand and HUBER and PENIN (1968) on the other.

HELMCHEN'S findings found a belated confirmation in a study by KOSHINO et al. (1993). Apparently unaware of the findings obtained 25 years earlier, the authors reported a significant decrease in the distinctiveness of schizophrenic symptomatology at the occurrence of FIRDA (s. a. table 2), a phenomenon subsumed under IBA.

Therefore, in cases where because of only minor process dynamics this specific disintegration level is not reached the precondition for a spontaneous remission is also lacking. Instead, we must expect the development of a chronic state which is exactly what everyday clinical practice teaches us. The antipsychotic effect of neuroleptics therefore could be that, because of their central-disintegrative ("dampening") effect, they create the precondition for a spontaneous rebound-like reorganization (BENTE 1963). This would be true for all cases in which the critical, by IBA indicated disintegration level is not reached in the natural course, i. e. spontaneously. The assumption that a lowering of the central-nervous functional level is the precondition for a spontaneously occurring functional reorganization is, in our opinion, supported not in the last place by the temporary character of the EEG-phenomena, since generally after remission there exists no further evidence for IBA. Based on the individually existing spontaneous dynamics of the pathophysiological process, we can postulate a continuum that starts with the rather rare patients who after the highest possible clinical acuity (catatonia!) experience a relatively speedy and complete remission even without neuroleptics, continues with those most numerous cases who recover with the help of neuroleptics within a few weeks and leads to patients who even after longterm and high-dose medication seem to be therapy non-responders. We must assume that the patients in the middle category were responsible for the results in HELMCHEN'S study. This interpretation also conforms to the often-confirmed impression that a neuroleptics-induced “abnormalization” of the EEG represents a clinically favorable sign (f. i. BENTE 1963; DASBERG and ROBINSON 1971; KOUKKOU-LEHMANN et al. 1979, 1983).

That in HELMCHEN'S study disturbed thinking and delusion appeared to be independent from an “abnormalization” of the EEG is not surprising since these features are signs of chronicity rather than acuity.

The assumed differences in the spontaneous dynamics of the pathophysiological process lead to our second problem area. It has long been known that the medication-free recorded EEG provides, with a certain probability, some prognostic clues. A well-pronounced, continuous, monomorph alpha-background activity, possibly even spreading to the frontal regions, - according to the descriptions corresponding to the picture of our dynamic rigidity (DR) (s. a. 3.1.) - generally is considered a negative sign. A mostly low-voltage EEG with only discontinuously occurring short alpha-groups and possibly a higher beta- proportion according to the descriptions corresponding to the picture of our dynamic lability (DL) (s. a. 3.1.) on the other hand is considered a positive sign (IGERT and LAIRY 1962; BENTE 1963; HELMCHEN and KÜNKEL 1964; SMALL and STERN 1965; ITIL et al 1966, 1975). We succeeded in quantitatively confirming this evaluation which is based primarily on qualitative impressions (ULRICH et al. 1988). Inpatients who reacted positively to a 4-week treatment with

neuroleptics (responder) showed in the medication-free recorded EEG at the beginning of the treatment, as expected, more non-A- epochs, corresponding to a predominance of low-voltage desynchronized activity phases than patients with rather unfavorable treatment results (non-responder). The group of responders but not the group of non-responders showed the physiologically to be expected increase of non-A-epoch rates with increasing recording time. A lesser therapeutic response to neuroleptics therefore indicates a deficiency of the spontaneous vigilance dynamics of the type of a dynamic rigidity (DR).

That non-response is related to deficient vigilance dynamics could also be deduced from the reaction of the anterior-posterior alpha-quotient as assessed by means of spectral analysis to a single dose of neuroleptics. While in responders a prompt and extensive increase of the quotient, corresponding to an anteriorization of the alpha-activity, occurred followed by a counter-reactive restitution of the same kind, the non-responders showed no significant changes at all.

> Our findings express a biological regularity that was phrased by SELBACH (1976) in cybernetic terminology. SELBACH contrasted systems with low system tension as hyperstable systems with those with high system tension as unstable systems. The former could possibly be associated with our non-responders and the latter with our responders. The prognosis is supposed to be even better than the less rigid the regulation, i. e. the less an disturbance factor (here: the test dosage of a neuroleptic) affects the flexibility of the regulation (here: reactivity of the alpha-anteriorization quotient).

We pointed out earlier (s. 3.1.) that the EEG-phenomena of dynamic rigidity (DR), dynamic lability (DL) and the pathomorph variants of the A-stage (IBA/ILA) associated by us with a pathological functional change can also be observed in healthy persons. The same is true for patients in remission. In that case, we talk about constitution-related variants that remind us of a functional brain maturation deficit (s. a. 4.7.). We must remember here that such variants of course also vary according to the spontaneous cycle dynamics, i. e. that they manifest themselves only during a spontaneous or pharmacologic lowering of the vigilance level. When we say state-unrelated, we mean a relative unrelatedness from the psychopathological state. But strictly spoken, this definition, too, is rather weak, since in most cases, the comparison with the premorbid state is impossible. Moreover, once a psychosis has been diagnosed, the assessment of a psychosis-free interval is shaky. A stable remission phase of only minor process activity can be used as reference just as little as the residual state characterized by a "reduction of the energetic potential" (CONRAD 1958). Since each outburst encounters a changed structure, there is also no remission or residual state that is identical to a previous one. Therefore, difficulties with the interpretation do not only arise for the above-mentioned peculiarities but even for a seemingly ideally typical patient-EEG with, for instance, a continuous posterior- dominated 9/s background activity. Such an EEG can very well be the manifestation of a low-level functional change, like in the case of a premorbid frequency of the background activity of 11/s.

It is evident that the significant interindividual differences observed in samples of schizophrenics, that are about 3 times as high as in healthy people (GARMEZY 1970; s. a. illustration 1), are partially also determined by such constitution-related features. Thus, it does not seem unthinkable for us that the "choppy activity" (or beta-increase) considered typical for schizophrenics is the result of a higher number of patients in the sample with constitution-related dynamic lability (DL). It certainly is a serious flaw that we know next to nothing about the different composition that can be assumed for samples of schizophrenics on one hand and of healthy persons on the other hand with regard to constitution-related EEG-variants (s. a. 4.7.). Such knowledge, however, would be one of several indispensable conditions to justify the effort and expense usually associated with group-statistical comparisons between schizophrenics and healthy persons. As long as this has not been clarified it is not only impossible to reject the idea that the discovered differences between groups of psychiatric patients or specific psychiatric groupings and healthy persons (s. a. 2.2.1.1. and 2.2.4.) are not the result of a disease-specific pathophysiology but that we are faced with group differences with regard to the proportion of constitution-related EEG-variants (s. 4.7.1.). On the contrary, this must be considered quite probable.

4.4. The EEG in Epileptic Psychoses

The psychological disturbances accompanying epilepsy presented from the beginning a specific challenge for the neurology and the psychiatry. The symptomatology of these syndromes playing in different colors and thereby obscuring the artificially erected boundaries between the organic and the endogenous has always been an inspiration for psychiatric theory formulation. An enormous leap in knowledge is owed to the use of the EEG. On the other hand, the institutional separation of neurology and psychiatry was an impediment. The psychosyndromes under discussion raise differential-diagnostic difficulties that can only be conquered by subtle psychopathological analysis. Epileptology has established itself unequivocally as a neurological discipline.

For some of today's psychiatric clinicians however, epileptic psychoses that they see only rarely are a book with seven seals. This is evidenced not least by the helplessness in defining concrete problem areas to be addressed during the EEG-examination (s. a. 2.2.1.3.). An always vividly discussed question of particular interest for the psychiatrist is whether an epileptic psychosis can be diagnosed even if there has never been any evidence of epileptic seizures. Generally, we must answer in the affirmative (KRAEPELIN 1919; GRUHLE 1936; FIRNHABER and ARDJOMANDI 1968; BASH 1969; WAGNER 1969; WOLF 1976). But due to the risk of an uncritical expansion of the diagnosis "epileptic equivalents" we must here apply the strictest criteria. Of particular importance is that the decision under no circumstances be left to an EEG-clinician who ideally may be an experienced physician but has never seen the patients.

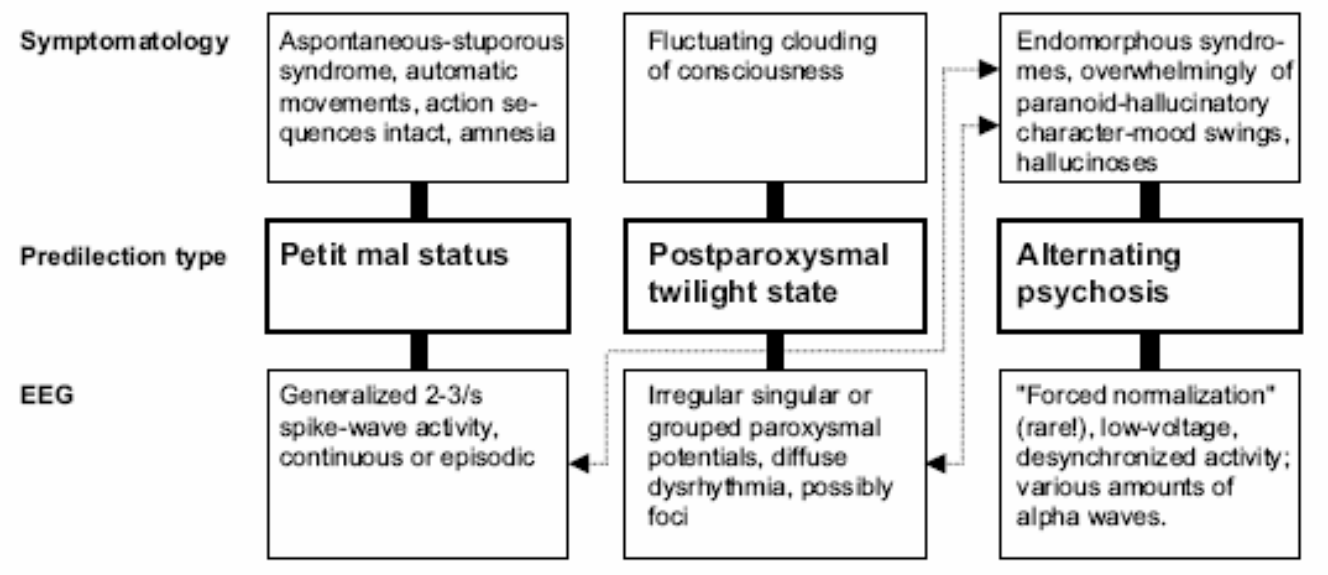


Illustration 77. Clinical and electroencephalographic criteria for the definition of the main types of epileptic psychoses.

Since a one-on-one association of syndrome-typical - and of EEG - characteristics does not exist (s. a. 2.2.6.), a diagnosis based solely on the EEG is impossible.

> To immediately counter any objections expected here, we hasten to point to the rule-confirming exception, the petit mal status. In the case of continuous generalized regular 2-3/s spike- and slow-wave activity a clinical diagnosis can indeed be formulated based on the EEG with a high degree of certainty. However, one and the same EEG-picture can be associated with rather different levels of severity of the syndrome (DONGIER 1967).

As with each classification of psychiatric syndromes, here, too, we cannot arrive at a sharp delineation of clearly defined units. Such classifications can only be justified by virtue of their categorizing, order-creating function.

The form of acute epileptic psychoses in all likelihood still most frequent is the postparoxysmal twilight state, typically after a grand mal status.

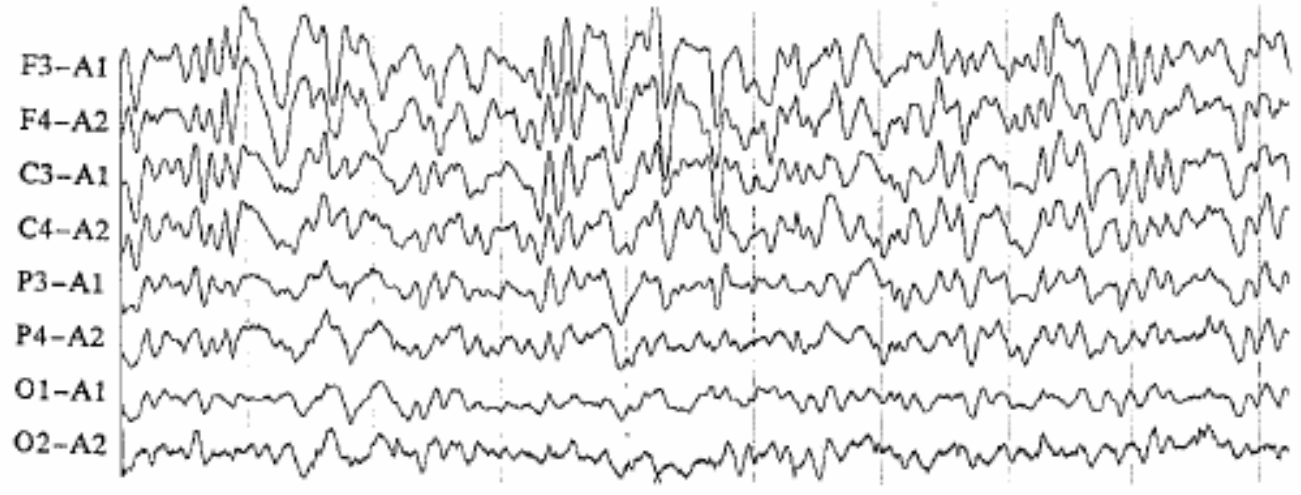


Illustration 78. Diffuse-dysrhythmic EEG with anterior-accentuated sharp waves in connection with slower ones during the postparoxysmal twilight state (1.6 cm ~ 1 s). Recording approximately 6 hours after a nocturnal grand mal (K. K., 67 y., m., EEG-nr. 227/89).

WOLF (1976) associated a generally observed frequency decrease with the availability of increasingly more powerful anti-epileptic medication. As a rule of thumb, we can assume that the severity of the postparoxysmal twilight states corresponds to the severity and frequency of the previously suffered seizures. Clinically, a pronounced brain-organic symptomatology is often prominent. Frequently, it is accompanied by motor phenomena such as abortive actions and stereotypical movements. The spontaneous remission occurs over a period of 2-3 weeks. The EEG typically shows a diffuse, mostly anterior- dominated dysrhythmia in connection with "postparoxysmal after-discharges" (illustration 78). Although the patients normally evidence the axis symptom of disturbed orientation there also exist forms with predominant paranoid-hallucinatory symptomatology. Sometimes, lucid phases alternate with twilight states (KRAEPELIN 1919; JANZARIK 1955; LORENTZ DE HAAS and MAGNUS 1958; DONGIER 1959; LANDOLT 1960; EY 1963; HELMCHEN 1975). However, there is no evidence

that the alternating per se or the actual severity level of the psychosis are reflected in the EEG. On the other hand, there exist EEGs with massive changes of the described kind without a clinically definable twilight state of whatever kind. If there have been no seizures in the recent past and yet the EEG shows very distinct changes, we must consider a possible intoxication with anti-epileptic medication. Most recently, the opinion that an acute postictal psychosis exists which is clearly distinguishable in its appearance from the postparoxysmal twilight state has entered literature (LOGSDAIL and TOONE 1988; SO et al. 1990). In clear sensorium patients, a schizophreniform syndrome with symptoms of delusion and hallucinations manifests itself after a symptom-free interval following the seizures. This picture in most cases lasts only a few days but in rare instances it can be observed over several weeks. A typical EEG-correlate is temporal spikes. From the differential-diagnostic point of view we must consider especially a state of complex-partial seizures (status psychomotoricus). The most distinctive difference is the lack of a clouded consciousness. Whether the, occasionally in a forensic-psychiatric context discussed "autochthonous twilight states" - i. e. those which are unrelated to a seizure time-wise and are not caused by intoxication - do actually exist seems rather doubtful. If we are faced with a clinically evident twilight state but the EEG does not indicate any changes, we must consider an "alternative psychosis" (see below).

The differential-diagnostic significance of the EEG is, as formerly remarked, greatest for the petit mal status or the LENNOX-syndrome.

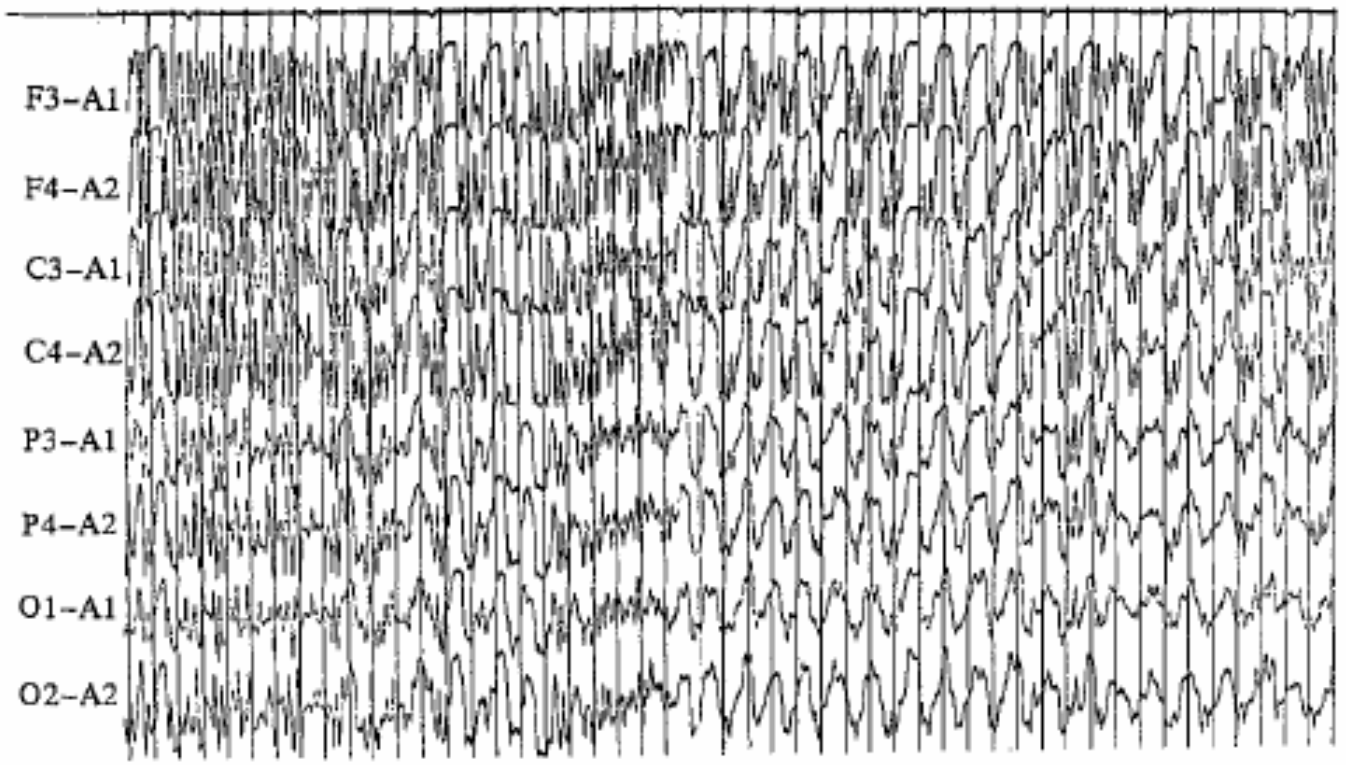


Illustration 79. Continuous and generalized spike-wave activity of variable frequency in a petit mal status since 3 h (1.5 cm ~ 1 s); finally terminated by clonazepam injection (H. J., 41 y., m., EEG-nr. 115/88)

Clinically, this is an aspontaneous-stuporous picture with mostly massive impairment of cognitive-adaptive or communicative performances. This is contrasted by a largely maintained ability to perform automatic actions. An activity started before seizure onset, even reading and writing, is continued in a more or less meaningful way. At the same time, the patients are unable to give reasonable answers to questions. It has been pointed out on several occasions that there also are states without recognizable psychic changes which can clearly be diagnosed electroencephalographically (LANDOLT 1955; DONGIER 1967). Extremely rare are possible petit mal status with a prevailing paranoid-hallucinatory picture (ANDERMANN and ROBB 1972; PRÜLL 1976). Nevertheless, we mention them because these cases confirm once

more the impossibility of a complete reduction of the psychopathology to the EEG and vice versa. A petit mal status can continue for hours, days, even weeks. Besides the previously discussed prototypical continuous generalized rhythmic spike and slow- wave activity we also find discontinuous sequences of such activities in the EEG. A psychiatrist should be familiar with the clinical and electroencephalographic indicators of a petit mal status not in the least because this often is the only form of manifestation of an epilepsy, and he therefore might be the first one to be confronted with such patients.

The third main group that of the "schizophreniform psychoses," "alternative psychoses," or also chronic interictal psychoses is clinically characterized by a paranoid-hallucinatory symptomatology without major intellectual deficits. These, too, may last for days or weeks. A hebephrenic or catatonic symptomatology is considered absolutely atypical (SLATER et al. 1963; TELLENBACH 1966; JANZ 1969; KÖHLER 1975). A feature difference with endogenous schizophrenia is that patients can at all times report in a distanced way his or her delusional experiences. This ability of "double-sided accounting" (JANZARIK 1955), which implies that the patients can literally be talked out of their delusions and that a systematization of the madness usually does not occur can be considered as almost pathognomonic. With regard to CONRAD'S (1958) gestalt analysis of the development of schizophrenic delusion we can state that contrary to endogenous schizophrenias, the delusion here remains related to the environment. Since the inner world or the EGO are not touched, an "anastrophé" does not occur. This is a parallel to the early stage or the minor forms of the developing endogenous-schizophrenic delusion, during which the possibility of the reflective crossing from not-EGO to EGO and thus of a distancing from the delusion also is maintained. Since the patient does not go through the subsequent apophenic ("apophäne") stage he also does not reach the "apocalyptic" stage ensuing as a rule and characterized by catatonic symptomatology. Common in both the endogenous and epileptic syndromes is the initiation of the actual psychosis by a phenomenologically similar preliminary syndrome. In both cases, we find a delusional mood in the sense that "something threatening is in the air" (JANZARIK 1955).

LANDOLT (1955) was the first one to point out that pre-existing paroxysmal potentials occurring during seizure-intervals as well as dysrhythmias disappear during psychoses of this kind. He coined the term "forced normalization" of the EEG for this phenomenon. Today, after extensive research, we can assume that although "forced normalization" does exist, it is the exception rather than the rule (f. i. RODIN 1970; KÖHLER 1975).

According to RODIN (1970) "schizophreniform" psychoses can be associated far more frequently with a low-voltage desynchronized EEG than with an alpha-typical one, as postulated by LANDOLT. The numerous observations that "schizophreniform" psychoses are possible also if a "pathological" EEG exists (f. i. FIRNHABER and ARDJOMANDI 1968; GRÜNEBERG and HELMCHEN 1969; KÖHLER 1975) further relativize LANDOLT'S concept. Confirmed without any reservation, however, was the existence of a reciprocal relationship between the EEG and psychopathology, i. e. between seizures and psychosis. TELLENBACH (1965) called these, instead of a seizure occurring syndromes, "alternative

psychoses." From the first manifestation of epilepsy - usually of the primarily generalized type - it takes on average 14 years before an "alternative psychosis" occurs. That the principle of reciprocity between "pathological" changes of the EEG on one hand and behavior/experience on the other hand has a general importance that reaches beyond the topic of "alternative psychoses" becomes evident from the manifold observations that mood swings in epileptics frequently have an EEG- correlate.

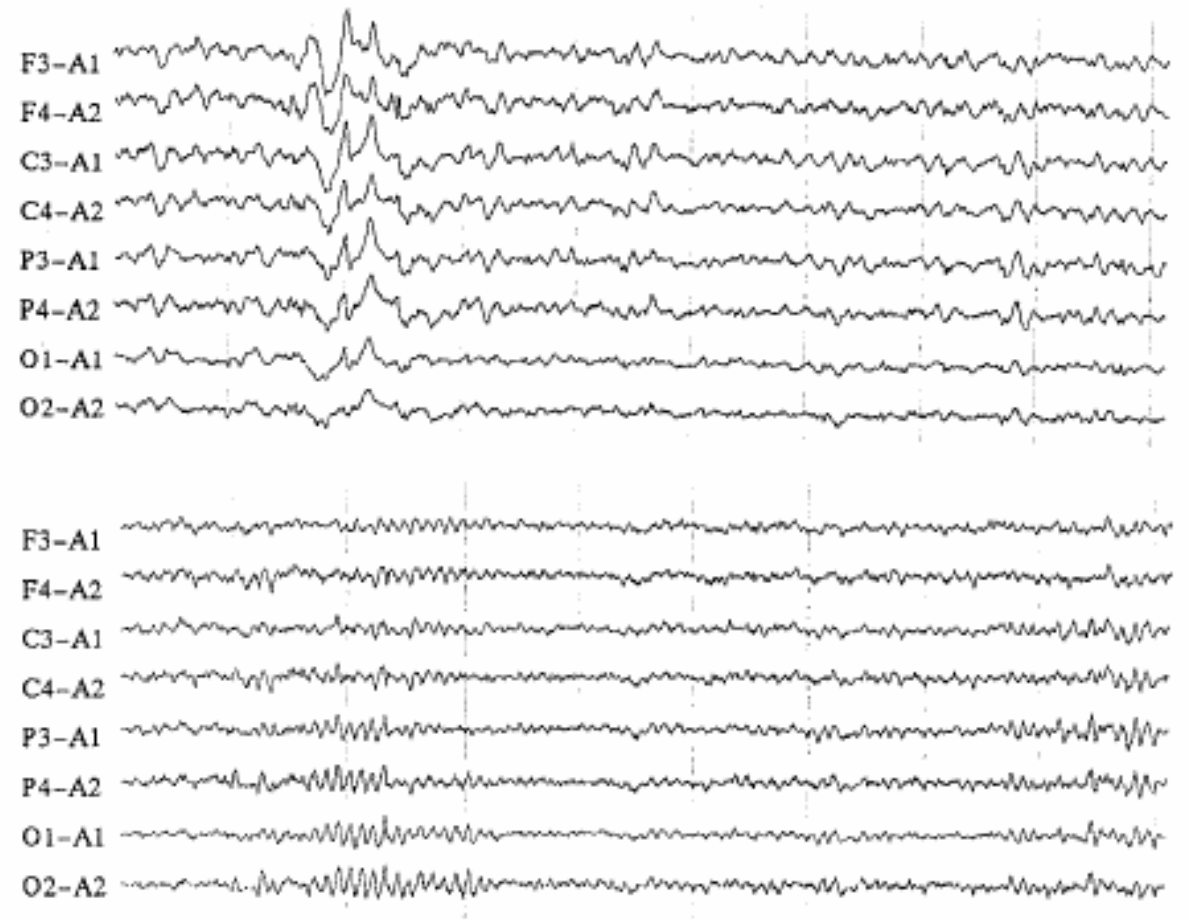


Illustration 80. Above: Predominantly diffuse-dysrhythmic EEG (1.6 cm ~ 1 s) with irregular 5-7/s-activity and interspersed sharper to steep elements in a psychopathologically inconspicuous patient under treatment with phenytoin and carbamazepine because of genuine epilepsy (K. B., 51 y., m., EEG-nr. 942/88) Below: Extensive regularization ("forced normalization") of the EEG with manifestation of an acute paranoid-hallucinatory syndrome after ending the phenytoin treatment because of adverse reactions (EEG-nr. 1008/88)

The rule of thumb is that a subjective sense of well-being more likely corresponds to a "pathological" EEG while dysthymia, irritability and affective lability are reflected by a "normalized" one. This has been observed in episodic parathymic conditions (KÖHLER 1975) as well as in preparoxysmal states (SCHORSCH and HEDENSTRÖM 1975). The preictal flattening as typical aura-correlate was related to a "forced normalization" by LANDOLT (1963). The knowledge of such psycho- physiological relationships causes the physician to request systematic repetitive recordings. The EEG-interpreter, however, can rightfully expect that he will not just receive general instructions - such as recording an EEG every day - but that the question will be rephrased at each request, based on the actual clinical situation. While we know today that "alternative psychoses" occur in the first place in primarily generalized epilepsies, it was assumed earlier that there existed a special relationship with "temporal lobe epilepsy" (GASTAUT et al. 1956; LORENTZ DE HAAS and MAGNUS 1958; BINGLEY 1958; GLASER et al. 1963; HERRINGTOIN 1960; FLOR-HENRY1973). The neuroanatomic speculations surrounding the temporal lobe, the limbic cortex and and the midbrain can in retrospect be called each and all erroneous. The creation of a temporal lobe mythology was promoted by an inappropriate EEG-interpretation. Phenomena that were confined to specific regions were without further ado considered to be manifestations of topographically, i. e. neuroanatomically corresponding damages. Consequently, bilateral symmetrical changes were also interpreted in the same sense, i. e. as a manifestation of bilateral focal damage (s. a. 4.1.4.1.). Based on our own observations and on a critical evaluation of the case studies found in literature, we think that the unitemporal and bitemporal foci described as typical for "temporal lobe epilepsies" are generally phenomena like the ones subsumed by us under ILA/IBA (s. a. table 2 and chapter 3.1.). However, since these patterns can typically be observed in interictal EEGs with a totally inconspicuous behavior/experience, this probably is much less a manifestation of pathological functional changes than of constitution-related phenomena (s. a. 4.7.2.) indicating a maturational deficit. This interpretation must, however, take into account the typically observed disappearance of the phenomenon at the onset of the psychosis. A number of authors postulated an active mechanism for this alternation (HESS 1955; GLASER 1964; BENTE 1969a; HESS et al. 1971; WOLF 1973; KÖHLER 1975).

> WOLF (1973) discussed a "change of the propagation mode" or an expansion of the paroxysmal activity into other functional areas. He also raised the question whether such a shift of excitation is associated with the regular anti-epileptic mechanism of action or whether a special predisposition of the simultaneously excited systems is necessary.

The fact that "alternative psychoses" occur only with a certain latency, counting from the first manifestation of the epilepsy, that only a relatively small number of epileptics develops "alternative psychoses" and finally that the supposed trait-quality of the temporo-anterior projecting EEG-patterns (ILA/IBA) seem to be clear indications for the significance of predisposing factors. Although for the practice not as important as originally thought, the "forced normalization" has inspired far-reaching speculations (LANDOLT 1957; PENIN and HUBER 1968; PENIN 1971). LANDOLT adopted the view held by HESS (1955) that a "hyperactivity" of the formatio reticularis is the underlying reason for the "forced normalization."

This "hyperactivity" manifests itself in the agitation component associated with twilight states. Such an interpretation is however defied by those "orderly" twilight states without any agitation symptoms which are known to us also as "alternative psychoses." Pharmacoelectroencephalography seems to be opening the way to a more promising interpretation. We know from experiments with LSD (BENTE 1958) that this substance causes a characteristic dissociation of experience/behavior and EEG. After pretreatment with LSD, sleep occurred during intravenous barbiturate administration just as well as without pretreatment, although the associated sleep patterns in the EEG did not present themselves. Similar observations were made during intravenous administration of chlorpromazine. As BENTE (1958) proved with impressive curve examples, a "forced normalization" of diffuse-dysrhythmic EEGs of patients with genuine grand mal epilepsy occurs under the influence of LSD. This drug-induced "forced normalization" reached its maximum, manifested in an almost ideal-typical alpha-EEG, about one hour after the intravenous administration of LSD. The patient felt sleepy at this point of time. KOREIN and MUSACCHIO (1968) observed in neurological patients with unilateral focal injuries and the corresponding EEG-findings besides a bilateral frequency acceleration a more or less complete disappearance of the foci under the influence of LSD. According to them, the EEG appeared to be "less abnormal" along with an intensified hemisymptomatology. However, the authors failed to make the almost obvious connection between this LSD-effect and the then already well-known "forced normalization" in epileptics. On the other hand, LANDOLT (1963) discussed, evidently without knowledge of the EEG-effect of LSD and based solely on the psychotogenic features of this substance, the possibility of a mechanism related to "forced normalization." As far as we can see, this problem area, by no means scientifically exhausted, today no longer receives specific attention.

Also worth mentioning is the only rarely diagnosed but in actuality obviously not so rare status psychomotoricus (ENGEL et al. 1978; MEDALIA et al. 1988; BAUER et al. 1992; RITACCIO and MARCH 1993). Since the clinical picture is multifarious and the EEG is not as typical as for the petit mal status, the diagnosis is easily missed.

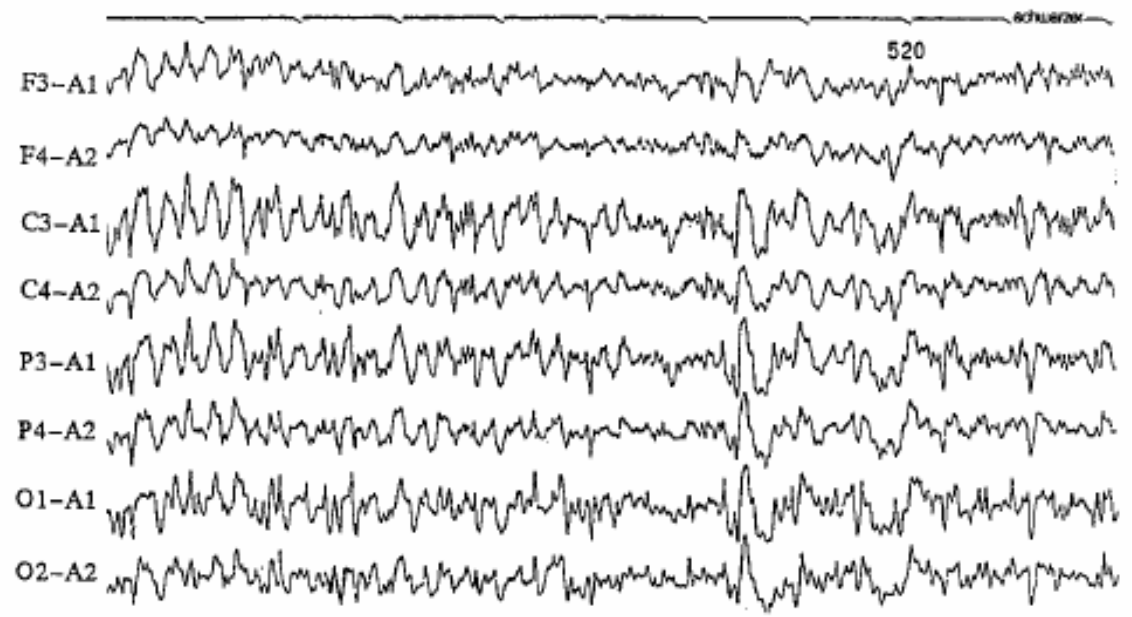


Illustration 81. Paroxysmal-dysrhythmic EEG (1.5 cm ~ 1 s) with intermittent left temporo-anterior accentuation of a slow high- amplitude and sharper rhythmic activity during a status of complex-partial seizures with right-side perioral myoclonus, verbigeration and clouding of consciousness. Fading of the status after approximately 48 hours under treatment with clonazepam and phenytoin (R. S., 29 y., m., EEG-nr. 707/87).

In contrast to "alternative psychoses" here a persistent temporal region-projected paroxysmal activity represents the immediate pathophysiological correlate of the psychosis (GASTAUT et al. 1956; v. HEDENSTRÖM and SCHORSCH 1959; DREYER 1965). For a firm diagnosis, a comparison of ictal and interictal EEG is one of the decisive aspects.

The most common form of an episodic epileptic parathymic condition can more or less be regularly observed, prior to the actual seizure, as so-called aura. In our opinion, the term "preparoxysmal twilight state" is an unfortunate choice, since it suggests a non-existent proximity of the syndrome to the postparoxysmal twilight state. Mostly, we are dealing with bland dysthymias Auras also present themselves as paranoid-hallucinatory syndromes, as states of elation or even ecstasy, as states of compulsive restlessness and infrequently, as dipsomania or poriomania. The EEG-correlates of these states vary. Beside a decrease in voltage related to desynchronization which is considered typical by several authors and which LANDOLT (1963) viewed as a form of "forced normalization," the occurrence of paroxysmal-dysrhythmic activity - of interictally inconspicuous EEGs are observed. A rather infrequent phenomenon is the aura-status or the aura continua. Clinically, these are mainly rising and ebbing and sometimes also persistent, intense sensations of diverse provenance. Here, too, the EEG often is only minimally or not at all changed (WOLF1980).

Only for the sake of completeness, we also want to mention adversive seizures which are typically accompanied by visual hallucinations (HELMCHEN et al. 1969; PALEM et al. 1970; LUGARESI et al. 1971). Sometimes, only an isolated hallucinosis exists. As in the equally infrequent isolated hallucinoses associated with alcoholism, one also does not find any paroxysmal EEG-activity during these epileptic equivalents but instead usually an alpha-typical or low-voltage EEG.

The polymorphism of epileptic psychoses, confusing with regard to the clinical appearance and the associated EEG-phenomena as well, makes us long for a conceptual framework that could create some order. Thus, LANDOLT (1961) considered the petit mal status and the psychoses related to "forced normalization" as "extreme states of a dynamics continuum." PENIN (1973) added the aspect of process activity and then contrasted the absence as a kind of "time-accelerated" psychosis with "peractive" EEG and schizophreniform psychoses with "subactive" EEG. WOLF (1973) endorsed this model, saying that in both cases we are dealing with a psychosis that originates from a pre-syndrome and is terminated by a grand mal. He explained further that in both cases an epileptic process documented by the EEG corresponds to the psychosis. While a polar antagonism of petit mal status and psychoses related to "forced normalization" has clinically and electroencephalographically been established beyond doubt, no empirical proof exists to justify the assumption of a continuum of intermediary forms.

EEG-changes associated with the petit mal status (illustration 79) cannot be classified under our model of the pathological functional change (illustration 26). The petit mal pattern represents a special modus of brain-functional disorganization that

belongs in the field of epileptic pathophysiology. The same is true for the forced-normalized EEG that does not reveal its underlying pathological events. Contrary to all other modi of functional dissolution, the disorganization manifests itself here in a regularization of a normally pathological EEG (of a “normalerweise pathologischen EEG” , LANDOLT,1975). The disappearance of dysrhythmia, paroxysmal potentials and focal changes should not fool us about the pathological character of the "forced normalization." We are reminded of it not least by the obviously totally analogous gestalt change under LSD-influence (see above). To be consistent, one should have mentioned here an exogenously induced "forced normalization." The fact that the "forced normalization" corresponds to a pathological event fosters the expectation that, contrary to the first impression, feature differences to the proper physiomorph EEG can be found, using the appropriate analytical methods. We are primarily thinking here of a disturbance of the morphodynamics, i. e. of the "Zeitgestalt" (time course pattern) (s. a. 3.1. and 4.1.3.2.) or also of the chaos-theoretical correlation dimension D2 (s.a. 2.2.3.). Such primary quantifying analyses which render our methodological premises of the electroencephalography as a primarily morphological discipline relative but do not disqualify them seem, in our opinion, to be worth investigating, regarding possible relationships to the endogenous schizophrenias.

> A working hypothesis could be formulated that the mechanism of "forced normalization" also plays an important role in the endogenous schizophrenic syndromes. Such a working hypothesis implies that schizophrenics present a "pathological" EEG before the outbreak of the disease, like an increased proportion of interspersed irregular slow waves and/or paroxysmal activity, and that these peculiarities disappear or alternate with the occurrence of the psychosis. Thus, LANDOLT (1957) indeed reported that non-catatonic schizophrenics, before the outbreak of the disease or between acute psychotic episodes, had shown "temporal seizure potentials" or "generalized or focal dysrhythmias." During the acute psychotic episode a more or less complete normalization of the EEG occurred. However, this information, has a more anecdotal than systematic character.

Finally, we want to emphasize once more that also with epileptic psychoses, the association of pathological pictures with certain EEG-changes is the exception rather than the rule. WOLF (1976), who discussed this matter of association in depth, pointed to the possibility of a complete decoupling of psychosis and epilepsy based on case studies. We agree with WOLF when he firmly rejects the idea that a psychosis is nothing but an epiphenomenon of a pathophysiological process (s. a. 2.2.6.). We also have to consider here that once a psychosis has started it follows its own rules.

4.5. The EEG under Psychoactive Drugs and Other Psychotropic Substances

4.5.1. Basics

This field of the psychiatric EEG is claimed today by the "pharmacoelectroencephalography." Narrowly connected to and significantly influencing the beginnings of a natural science oriented psychiatry, it has over time grown farther apart from the clinical psychiatry.

Methodically, the "pharmacoelectroencephalography" rests on three pillars. As we will attempt to prove, serious doubts about the soundness of these pillars are permitted. They are actually much fewer pillars than theoretically and empirically largely unfounded presumptions:

1. A similarity in the EEG-effects of various substances indicates a similarity in the clinical-therapeutically effects.
2. The so-called power spectra obtained by means of spectral analysis and averaged across the entire recording time represent pharmacoelectroencephalographically relevant information.
3. Healthy young male probands on one hand and psychiatric patients on the other hand generally show similar pharmacoelectroencephalographic effects.

The first-mentioned presumption certainly was necessary as a working hypothesis to initiate research in the first place. But instead of modifying the initially necessarily undifferentiated working hypothesis by means of the obtained findings, one concentrated on the compatible findings and ignored the incompatible ones. The formula claiming that similar EEG-effects allow us to expect similar therapeutic effects therefore soon became dogma (ITIL 1974; FINK 1975).

> The difficulty resides not only in the fact that substances which must be distinguished based on their clinical action profile can present similar EEG-effects, and that different EEG-effects can be associated with one and the same clinical action. We also must take into account that practically every psychotropic substance does not have only one clinically defined effect but a whole spectrum of effects. Which effect takes predominance depends at least as much on the person as on the kind of substance.

It is evident that a pharmaco-electroencephalography which claims the ability to predict the clinical action of a substance from the EEG-effects must be of the highest interest for everybody involved in the development of new psychiatric pharmaceuticals. In retrospect, however, we notice that the original optimism quickly evaporated. Numerous findings which did not comply with the postulated regularities can no longer be relativized as "exceptions" (s. a. illustration 84-95)

Also proclaimed as dogma was the second presumption declaring that the usual average power spectra are actually the relevant target variables. This happened even though BENTE (1963) as one of the pioneers of pharmacoelectroencephalography already declared three decades ago that the "form change of cortical macrorhythms" ("Formwandel der kortikalen Makrorhythmen") under psychoactive substances cannot be sufficiently recognized if one limits oneself to the technically easily measurable frequency and voltage variables. Instead of primarily changes of complex structural characteristics, i. e. of the spontaneous morphodynamics, are to be considered. Although these statements remained unchallenged, the resonance was deplorably minute. Rare was the author who dared to contradict the trend of primary quantification supported by the spirit of the age. A sheer magical significance, immune against any questioning, gained the phrase of the "computer-assisted EEG." The only exception was KÜNKEL (1980) - noticeably not in an original work but in an internal discussion of researchers engaged in pharmacoelectroencephalography (s. a. 2.2.2.).

To answer the question of how far the EEG-effects of a substance A and a substance B vary, one must start with the raw EEG unaltered by transformation. Only then is it guaranteed that not exactly the information decisive for the distinction is eliminated. As already explained elsewhere (s. 2.2.2.), two morphodynamically different EEGs can result in rather similar average power spectra.

Fink (1975) phrased the third presumption with commendably clarity: "The methods of cerebral electrometry or quantitative EEG depend on observations that normal male volunteers respond to psychoactive drugs indistinguishably from patients ..."

With this, Fink ignores the in our opinion indisputable fact that EEG-effects depend as a matter of principle on the baseline condition. Numerous findings substantiate that this dependency is not only evidenced in the degree of distinctiveness of the EEG-effect but that in certain cases, even diametrally opposite effects must be expected. Since the psychopathological disintegration of a psychiatric patient always corresponds to a brain-functional disintegration (s. a. 2.2.4.) it is logically compelling to postulate differences in the EEG-effects to psychoactive drugs - in comparison to healthy persons. Thus far, we have confirmed such differences in all studies comparing healthy persons with patients. In this context, we would like to refer to the basic pharmacological knowledge long since accepted as fact that, depending on the psychic baseline condition, psychotropic substances can result in "paradoxical" clinical effects (f. i. DIMASCIO et al. 1968; HEIMANN 1974). A particularly instructive example is the lithium-effect that manifests itself differently in groups of healthy young men than in patients suffering from affective psychoses (ULRICH et al. 1987; ULRICH et al. 1993). That pharmaco-electroencephalography cannot do justice to the tremendous range of possible EEG-effects has its reason not least in the premises we have called into question. It is evident that the natural variety was ignored in favor of the desire to arrive at purely pharmaco-related systematics of EEG-effects. The elimination of the interfering variance occurs statistically, a time-tested and always successful method. Incidentally, the problems here are similar to those encountered in the

electroencephalography of endogenous psychoses, especially schizophrenia (s. a. 4.3.). We must emphasize, however, that a phenomenological variety can never be annoying for the researcher. On the contrary, it is the actual source of all knowledge in biological research. Group-statistical designs together with case number estimates may be useful for the comparison of effectiveness of two pharmaceuticals but for the investigation of psycho- or pathophysiological mechanisms they are dreadfully out of place. As we explained in detail with the example of the EEG-effects of lithium (ULRICH et al. 1993), respecting a certain sequence of steps is mandatory for an appropriate research strategy. It must always begin with the visual analysis of the morphodynamics.

In summary, we conclude that the three pillars supporting today's pharmacoelectroencephalography prove to be rather unsound on closer inspection. This is also the ultimate explanation for the dwindling interest in this discipline, for which people once had such great hopes. Its initial goal was to gain insights into the pathophysiology of endogenous psychoses through the examination of the action mechanisms of psychoactive drugs. In these early stages, biochemistry and electroencephalography mutually inspired each other. The pioneering work was in the hands of clinically experienced psychiatrists. In retrospect, however, we cannot claim that the entire psychiatric discipline was under the spell of the new research impetus. Because of their background in the humanities, many kept a reserved distance. Although we owe a multitude of insights and extremely stimulating speculations to the Sixties, the whole suffered from a lack of purposeful execution. Many promising approaches were, for whatever reason, abandoned along the way. The speculative element, forever in search of new insights, clearly dominated the confirmatory element striving to conserve existing knowledge. Thus, many of the hopes initially entertained remained unfulfilled.

This was especially true for the high expectations and demands for results immediately applicable to daily practice. The disappointed hopes led to a loss of prestige for the EEG in psychiatry. Since the early Seventies the most current technology is applied to compensate for this loss of prestige. When, in the mid-Seventies, a growing disproportion between technological costs and benefits began to manifest itself, psychiatry quickly discovered other, supposedly more promising methods such as the event-correlated potentials. The finishing touch was added by the true fetish of "funded projects" as a decisive criterion for evaluating the quality of research. Due to this development, it goes almost without saying that psychiatric research today is guided by methods rather than by theory (s. a. 2.2.7.). More and more ignored by the psychiatry, "pharmacoelectroencephalography" developed a life of its own essentially supported by the pharmaceutical industry. The original intent of exploring the pathophysiology of endogenous psychoses via the pharmaco-EEG has completely disappeared from view.

The study of drug effects still has a central position in our efforts for the revival of the EEG as a psychiatric research tool. Of little help, however, if not downright counterproductive, are clinical trials comparing the effects of substance A to

those of substance B or correlating clinical parameters with EEG-variables of dubious significance. The attempt to revive lost traditions and to once again conduct psychiatric research via the pharmaco-EEG can succeed only if the methodological premises criticized as inappropriate are realized and recognized as erroneous.

Our criticism of today's practices contains a number of conclusions. The most elementary is that an unequivocal taxonomy of the EEG-effects of the various psychotropic substances is not possible. The "classifications" of psychotropic substances based on the homogenized samples of healthy young men (HERRMANN 1982; ITIL 1982) can always apply only to those very samples. They tell nothing concrete about the effect in a specific individual. We must constantly be aware that the effect of a substance is always the result of its interaction with an organism and that organisms, despite all attempts of homogenization, will always differ. Consequently, the EEG-effects of psychotropic substances can be described only relationally to a defined state of the system. Therefore, it does not make any sense to associate a specific EEG-effect with a specific psychotropic substance without mentioning the baseline situation. However, it would be also meaningless to use a group-statistically calculated average baseline as its basis. Occasionally, the inclusive criterion "alpha-carrier" is mentioned. However, without further specification of topography, dynamics and frequency, this is far too vague. Moreover, we must consider that the baseline sometimes can be inapparent. This follows from the observation of rather different EEG-effects despite a seemingly identical baseline EEG. In these cases, a specific initial disposition inapparent in a drug-free state manifests itself only through the action of the drug (4.7.2.). Since only a relatively limited number of different baseline conditions can be defined - in the most simple case two - the possibility of arriving at a certain order by defining "reaction types" presents itself (ULRICH et al. 1993). However, such a reaction typology is basically already a schematic simplification. Strictly spoken, only in the case of the not very naturalistic acute test one deals with a medication-free baseline. The regular administration of a drug, typical for the therapeutical situation, over an extended period of time implies that each new administration encounters a change relative to the previous state of the system. We can assume that after a certain time, the system state no longer changes essentially. The EEG-effect associated with this state is also termed the chronic effect. Degree and speed of the adaptive processes most probably are again determined largely by the drug and the organism. The analysis of the pharmacogenic gestalt- or functional change therefore also must be done from a dynamic perspective. It is obvious that the drug effect determined by the baseline condition and dynamics of the adaptive mechanisms has a wide range of variations. This insight is incompatible with the premise criticized at the outset of the chapter that similar EEG-effects can be associated with similar clinical-therapeutic effects. Incidentally, apart from all theoretical considerations, the untenability of this premise manifests itself in daily clinical practice. A positive effect of one and the same drug on the production of schizophrenic delusions can, for instance, be accompanied by an alpha- activation as well as desynchronization or by a diffuse dysrhtyhmia with or without paroxysmal activity. Thus far relatively unnoticed yet important is the opposite situation, that psychotropic substances with different action mechanisms have rather similar EEG-effects. A beta-increase, for instance, can be caused by such different substances as diazepam, lithium,

clomethiazol or amitriptyline. But we must immediately ask whether these are not merely delusive similarities, caused by insufficient methodical power of discrimination. Whatever the explanation, the findings support our request for a reaction-typological characterization of psychotropic substances.

As discussed in detail with the example of the EEG-effects of lithium (ULRICH et al. 1993) a suitable strategy requires a specific sequence of steps. The visual analysis of the morphdynamics must always be the first step. However, the generally practiced easy routine analysis, ossified in certain perception and interpretation conventions, will not create the empirical induction basis necessary for the definition of reaction types. Instead, a permanent openness of mind for new impressions and insights that seem to us just as inexhaustible as the diversity of human faces is indispensable. The second step serves to reconstruct the discovered differences quantitatively. As already demanded by BENTE (1961) this quantification must be guided by the visual gestalt perception (s. a. 2.2.2.).

> This requirement still applies to the current quantification methods, i. e. mostly to spectral analysis. However, we must be open to new methods which might allow us to access relevant information invisible to the naked eye (s. a. 2.2.3.). Like the electroencephalography of the endogenous psychosis the future pharmacoelectroencephalography must start from the meticulous study of individual cases. Here, too, statements about regularities can only be formulated when a sufficient number of individual case studies are available.

The sole purpose of this quantitative reconstruction is to establish intersubjectively obligatory rules, in keeping with the method ideal of nomothetic sciences. It would be wrong, however, to consider the quantitative parameters as some kind of superior, condensed information. Instead, we have to take the unavoidable loss of information caused by the quantifying data reduction into account during their evaluation. We measure the usefulness of quantitative parameters by the degree to which they can be "re-translated." It is obvious that such a re-translation into the original function from an averaged power spectrum - maybe even from a single track - cannot be accomplished (compare to illustration 99 and 100). Therefore we have to reject the usual frequency band variables as description elements for a relational, differential and dynamic pharmaco- electroencephalography. According to our concept of the EEG as a morphological discipline, the description elements required here can only be the "formative tendencies" (s. a. 2.2.2.).

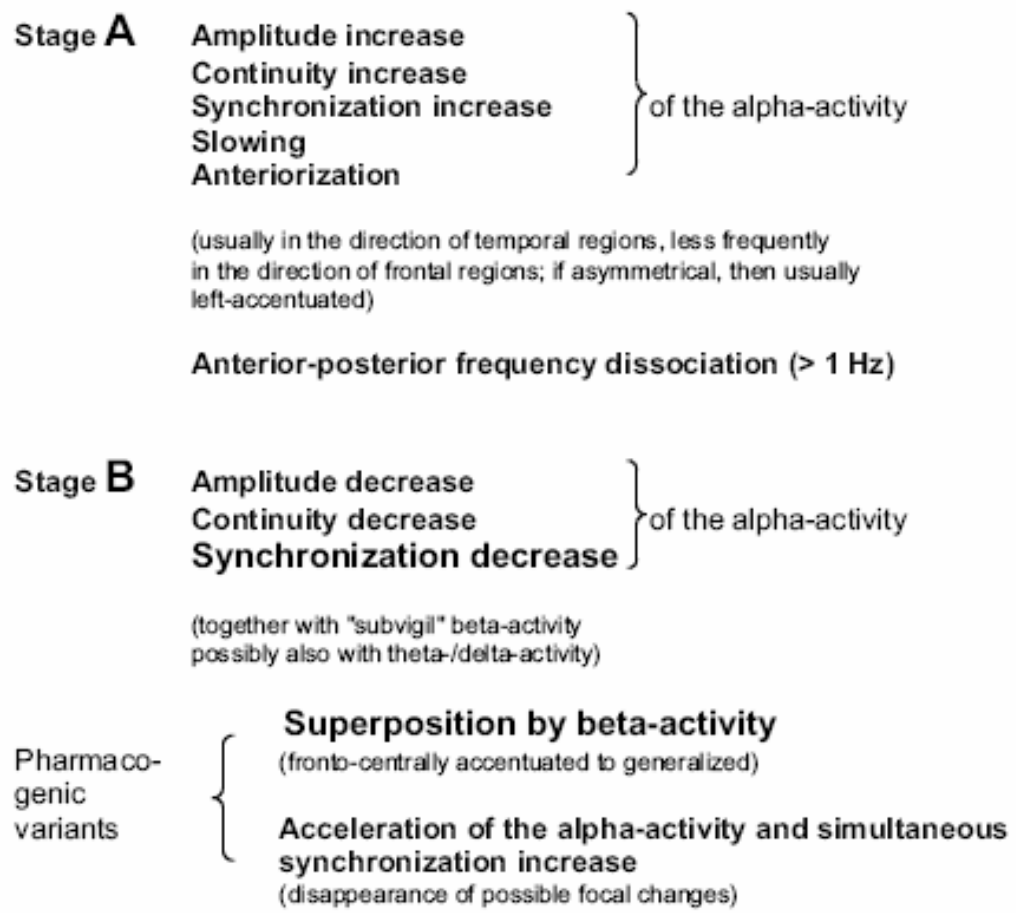


Illustration 82. The formative tendencies as components of the pharmacogenic gestalt-/functional change ("Gestalt-/Funktionswandel") of the EEG.

With this, we follow BENTE'S (1961) concept claiming that psychoactive drugs cause a changed proportionization of the pattern correlated to the physiological process of falling asleep. It will hardly be necessary to emphasize that this concept is incompatible with the continuously raised request for vigilance stabilizing measures such as "alerting tasks" during the recording (FINK et al. 1977; SANNITA et al. 1980; MATOUSEK and PETERSEN, 1983; COPPOLA and HERRMANN 1987; SALINSKY et al. 1991) since it is those measures that eliminate the actually relevant information.

As we will concretize later, the pharmacogenic gestalt change follows a natural course relatively independent of the respective psychotropic substance. In the case of an alpha-typical base-EEG, as a rule the formative tendencies of the A-stage and later those of the B-stage initially dominate in the acute test. Finally, from a certain serum concentration on, the formative tendencies of the mid and late B-stages prevail for all psychotropic substances, resulting, in connection with a disturbance of the spontaneous cycle dynamics, in the picture of a diffuse dysrythmia. This two- or three-phase regularity of course provides the frame for a differential, reaction-type oriented pharmacoelectroencephalography. Within the boundaries established by the diverse baseline conditions, the various substances can be more or less distinctly delineated from each other because of the different disproportionalizations of the formative tendencies. In our opinion, the dynamics of this pharmacogenic disproportionalization constitute an important differentiation feature. For instance, with certain substances the initial formative tendencies of the A-stage remain inapparent because of their fleetingness, while with others they are prominent even in high doses. Finally, there also exist modifications unfamiliar to us from the physiological process of falling asleep. We view them as accentuations of partial aspects of the subvigil intermediary stages or "pharmacogenic variants" (s. a. illustration 81).

It is obvious that the dynamics of an EEG as decisive differentia specifica can be determined only by meticulous analyses of individual case studies and never primarily by group statistics.

4.5.2. Neuroleptics

An "accentuation of the processes feature for stage A, i. e. a slight slowing, increase in amplitude, synchronization and anterior spreading of the alpha-activity" (BENTE 1961 a, b) is considered typical for the chronic effect of the classical neuroleptics of the phenothiazine-type.

Such a constellation resulting in a dynamically rigid appearance can be observed in the majority of the treated patients but by no means invariably. Besides, for this group of substances, a two-phase acute effect was described as typical at the beginning of the era of psychopharmacology (BENTE and ITIL 1954, 1959, 1960). An initial phase characterized by

formative tendencies of the A-stage was followed more or less regularly, under slow intravenous administration, by a desynchronization with the facultative occurrence of fast beta- and slow irregular waves, corresponding to a stage B.

In a psychiatric therapy that concentrates on "target symptoms" (FREYHAN 1957) neuroleptics are chosen because of their supposedly differing characteristic relationship between sedative and antipsychotic potential. These two potentials are assumed to have a reciprocal relationship.

In illustration 83, the most important available neuroleptics - except for clozapine - are arranged on a continuum between the extremes of strongly sedating/slightly antipsychotic and slightly sedating/strongly antipsychotic.

Considered to be more sedating and less antipsychotic are the phenothiazines with aliphatic lateral chain (chlorpromazine, levomepromazine, trifluopromazine), while the phenothiazines with piperazine ring in the lateral chain (perphenazine, fluphenazine, butyrylperazine) as well as the butyrophenones (haloperidol, benperidol, pimozide, fluspiriline) are considered to be less sedating and more antipsychotic. The phenothiazines with piperidine ring in the secondary chain (thioridazine, pericazine) and the thioxanthene-phenothiazines (chlorprothixen, flupenthixol) take an intermediary position.

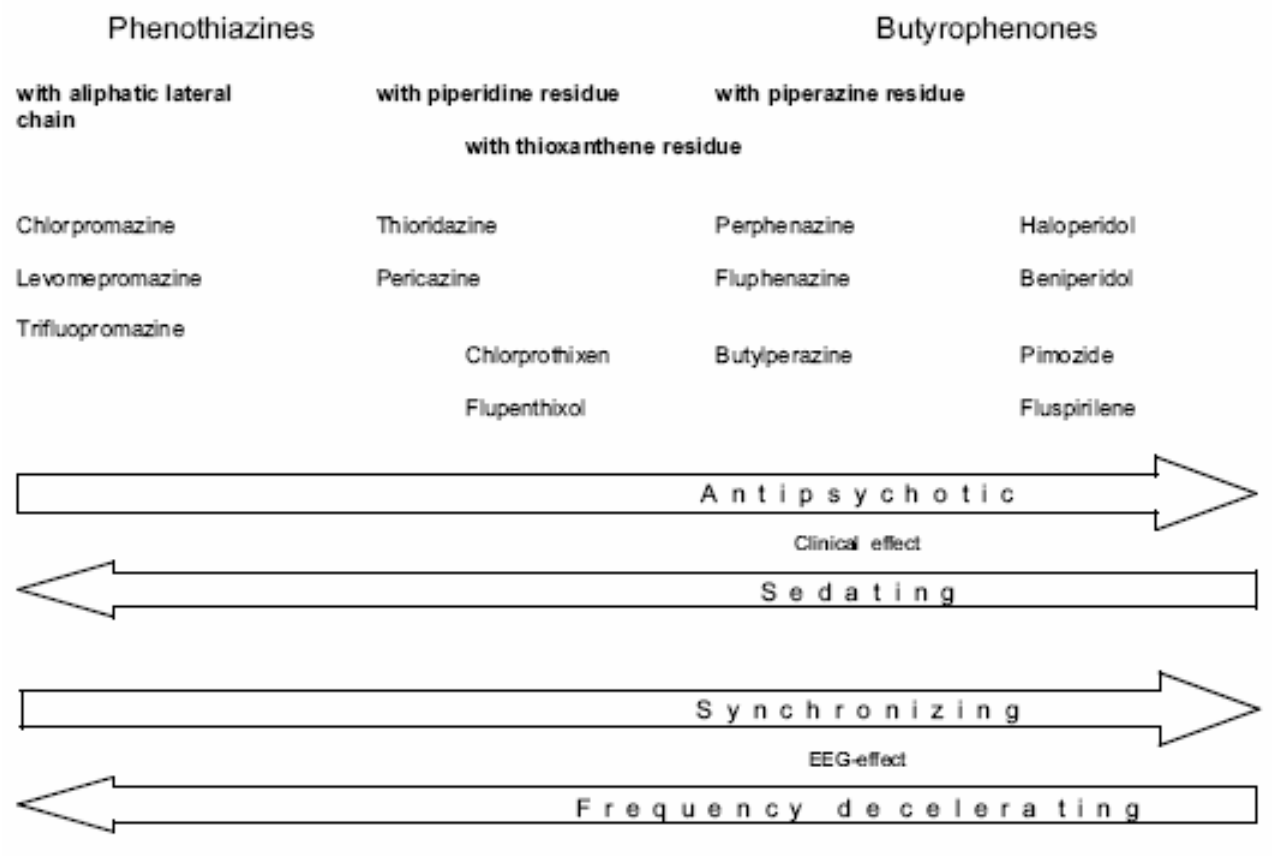


Illustration 83. Clinical-electroencephalographic characterization of the conventional neuroleptics.

It has been mentioned repeatedly that the relationship between sedating and antipsychotic potentials is also expressed in the EEG. Besides a positive correlation between synchronization and antipsychotic effect a positive correlation between frequency deceleration and sedation has been postulated, too (s. a. illustration 83). Of course, such regularities can only be expected in the case of an alpha-typically organized baseline EEG. To the degree that the premorbid baseline EEGs of healthy young men on one hand and schizophrenics on the other hand differ (s. a. 4.3.), the drug effects will differ depending on the sample.

In many aspects, a special position is also occupied by the chemically clearly different tricyclic dibenzdiazepine derivative clozapine. This is the neuroleptic with the - at least initially - strongest sedating effect. A frequency slowing reaching into the delta-region is considered a pharmacon-typical effect (f. i. ISERMANN and HAUPT 1976; BENTE et al. 1978; KUGLER et al. 1979). Although the clozapine-modified EEG hardly shows any synchronizing effect, the substance also has outstanding antipsychotic effects. The synchronization tendency associated with the antipsychotic effect is possibly manifested in the supposedly equally clozapine-typical sharp gradients, with the EEG showing a generally rather desynchronous character because of the prevalence of irregular slow waves (s. a. KUGLER et al. 1979; KOUKKOU-LEHMANN et al. 1979).

> Different to a diffuse dysrhythmia in encephalopathies (s. a. 3.2.), a clozapine-induced diffuse dysrhythmia can be eliminated to a large degree by sensorial stimulation, sometimes even resulting in an alpha-typical EEG.

Besides, all those findings claiming that a "abnormalization" of the EEG promises a successful treatment (f. i. BENTE 1963; HELMCHEN 1968; DASBERG and ROBINSON 1971), support the view of a positive correlation between the drug-induced synchronization tendency and the antipsychotic effect.

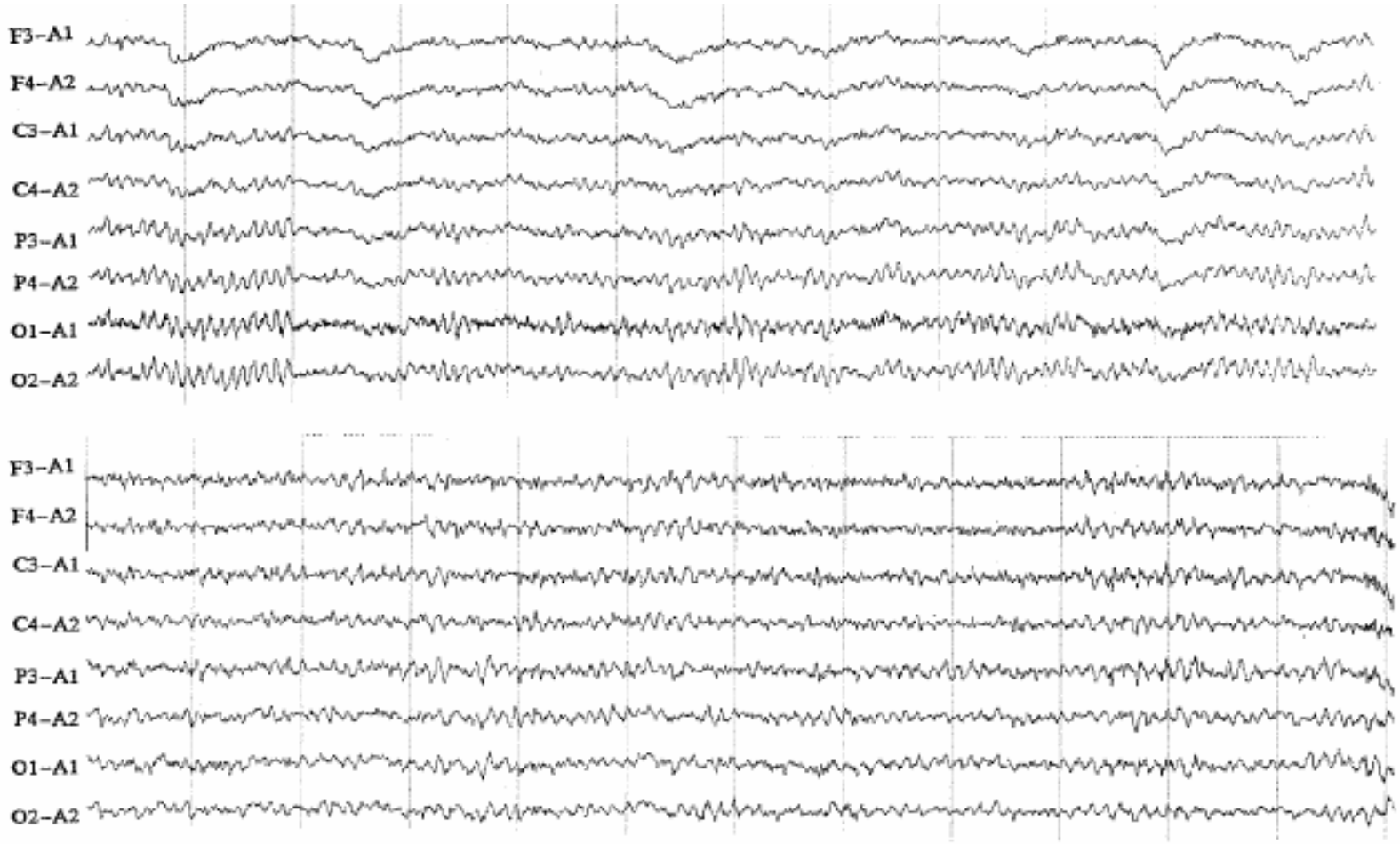


Illustration 84. above: Essentially physiomorph, medication-free recorded EEG (2 cm ~ 1 s) with slight frequency-variable posterior- accentuated activity of approximately 9/s with acute paranoid-hallucinatory syndrome (K. H., 31 y., f., EEG-nr. 299/92). below: After 6 weeks of treatment with neuroleptics (at time of recording 15 mg/d haldol and 150 mg/d perazine) slowing and rarefication as well as anteriorization of the background activity. The change points in the direction of a diffuse dysrhythmia (EEG-nr. 401/92) (illustration 84 - 96 identical derivation schema).

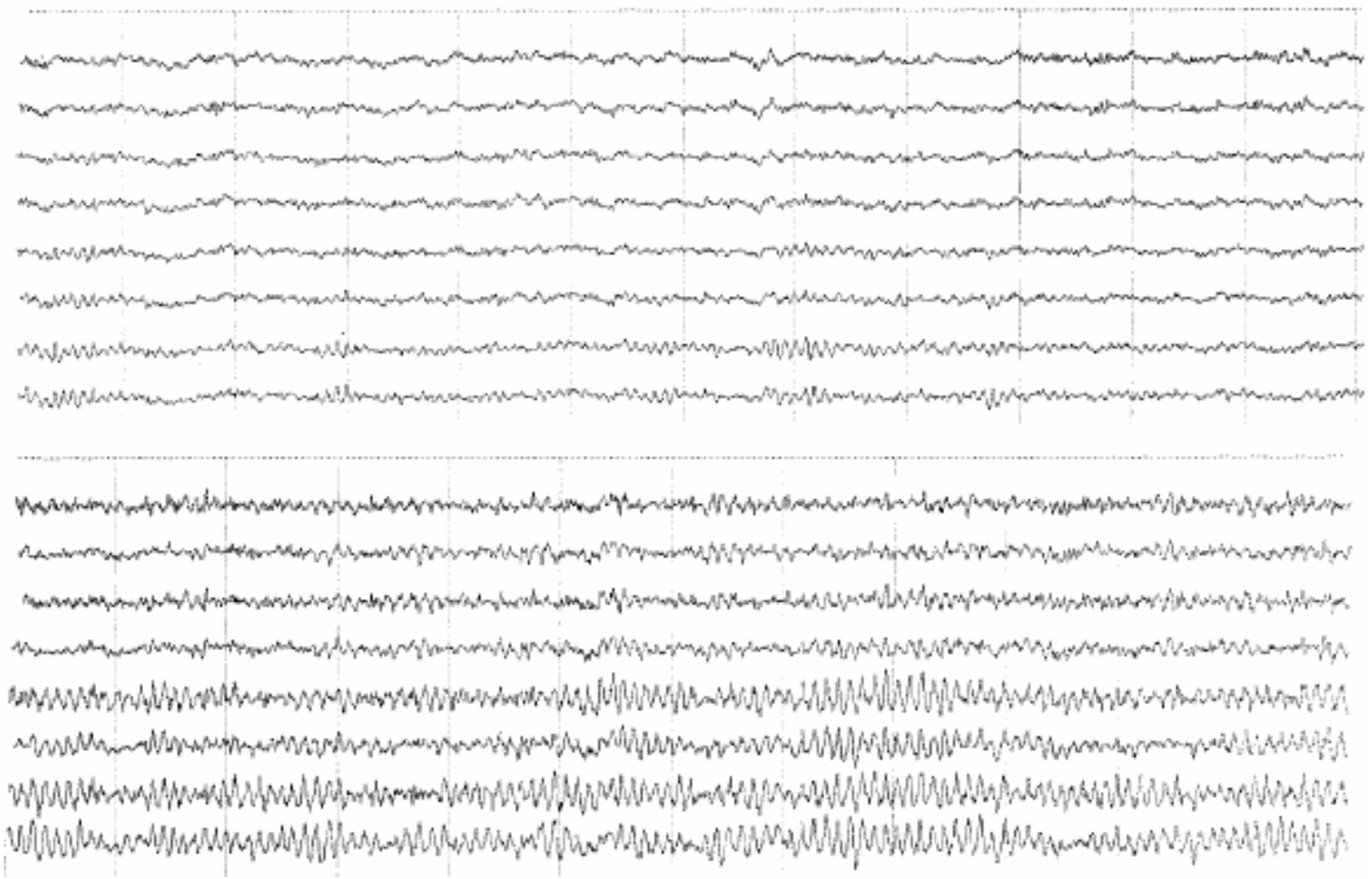


Illustration 85. above: Slightly discontinuous 10/s-activity with posterior dominance. Minor dynamic lability under 50 mg/d promethazine with acute paranoid-hallucinatory syndrome (K. F., 41 y., m., EEG-nr. 203/92) below: After 4 weeks of treatment with neuroleptics (at time of recording100 mg/d perazine and 10 mg/d haldol) increase in continuity and amplitude and frequency decrease of 1 Hz of the alpha-activity (EEG-nr. 304/92).

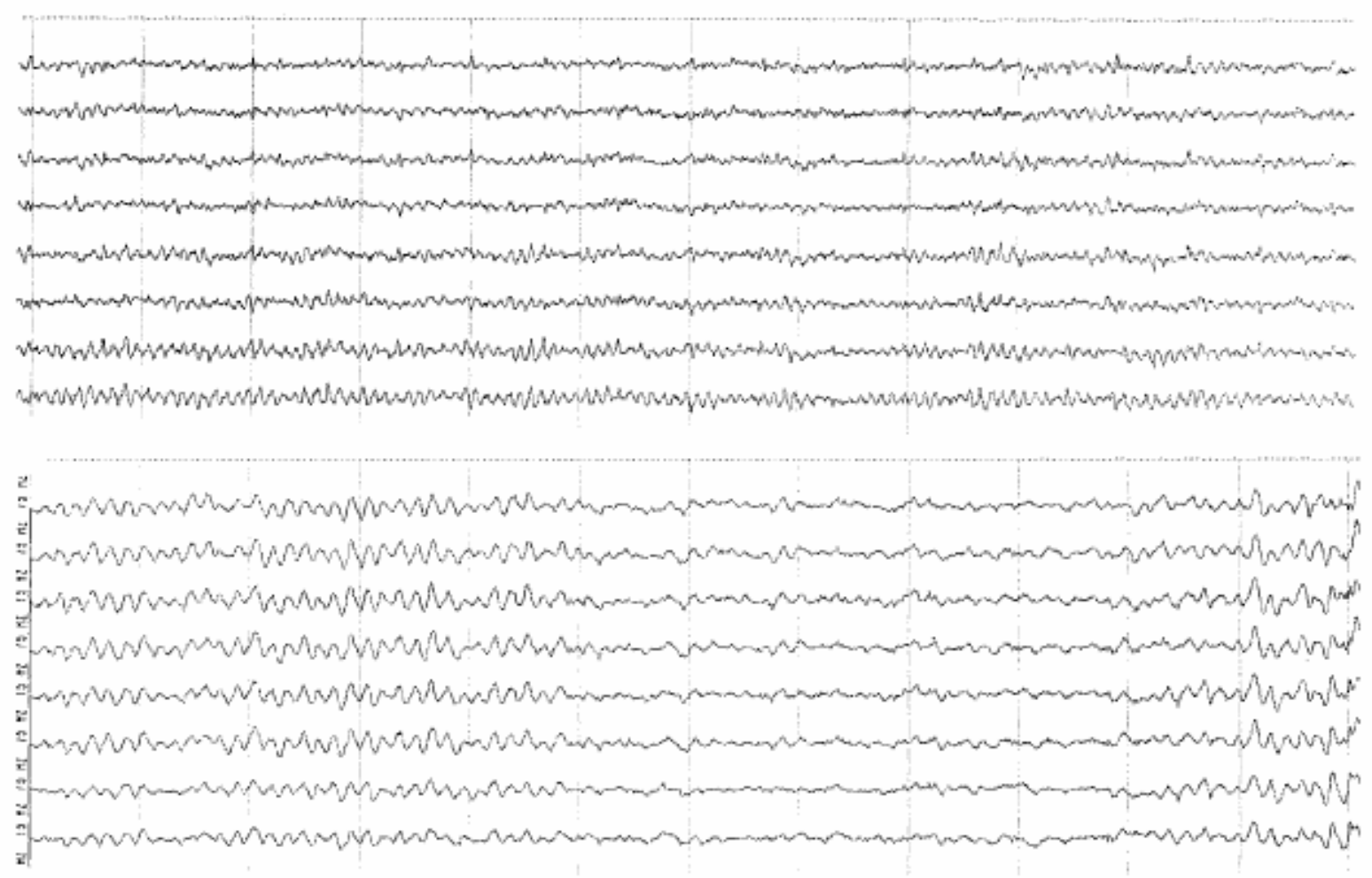


Illustration 86. above: Ideal-typically organized EEG with a continuous posterior-accentuated activity of approximately 9.5/s under 75 mg/d amitriptyline with chronic delusional psychosis (A. L., 46 y., m., EEG-nr. 702/92), below:: After 8 weeks of treatment with neuroleptics (at time of recording 15 mg/d haldol) slowing of the dominating frequency to 6.5/s with spreading to the frontal regions and frequent transitions into low-voltage phases corresponding to the stages B1 - B2 (EEG-nr. 926/92).

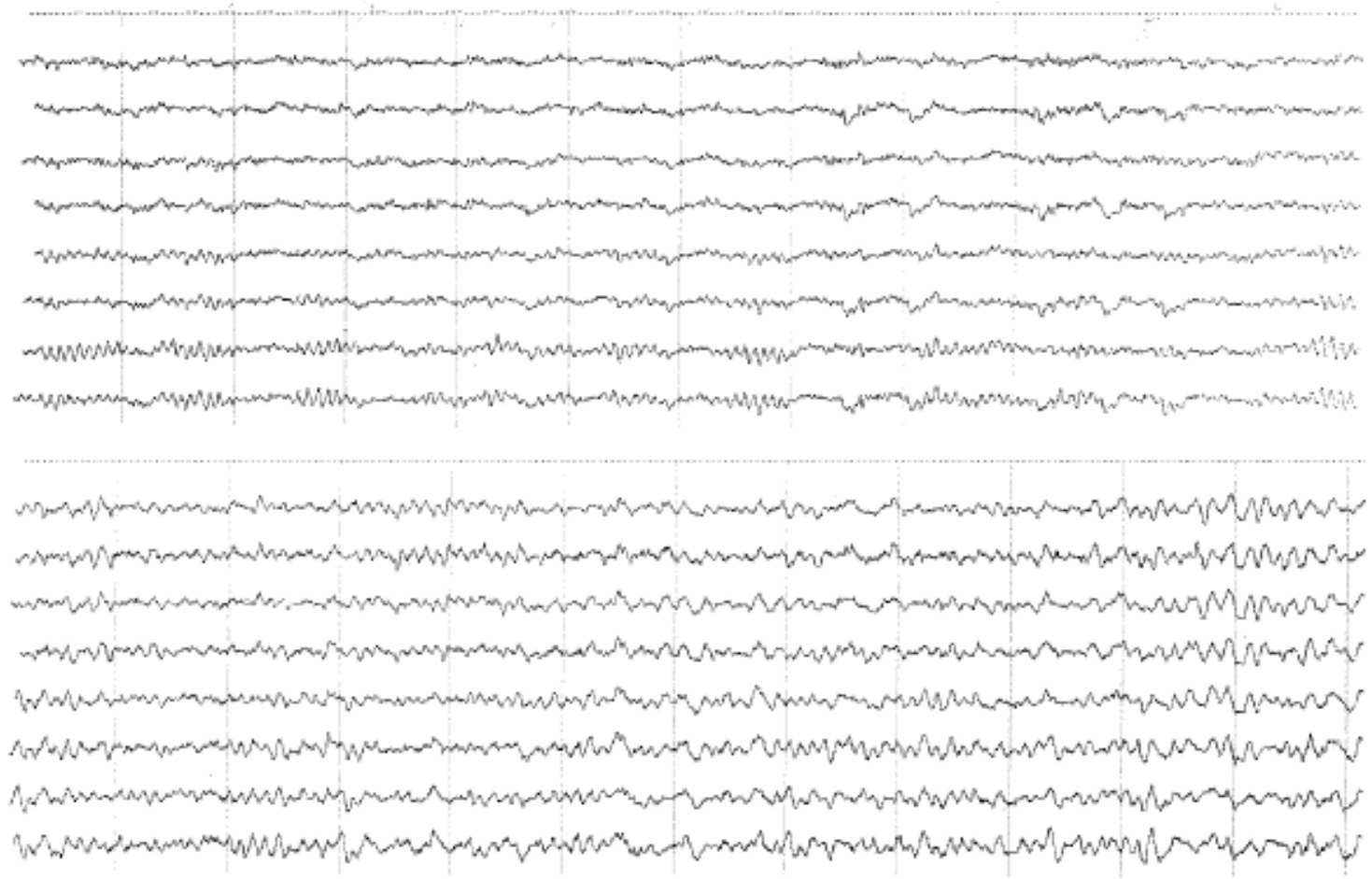


Illustration 87. above: Slightly discontinuous activity of approximately 10-11/s with posterior dominance under 10 mg/d diazepam with acute paranoid-hallucinatory syndrome (A. B., 23 y., m., EEG-nr. 601/92); below: After 3 weeks of treatment with neuroleptics (at time of recording 300 mg perazine) diffuse-dysrhythmic EEG dominated by an irregular theta-activity and only sporadically short alpha-groups of changing topographical accentuation (EEG-nr. 1015/92).

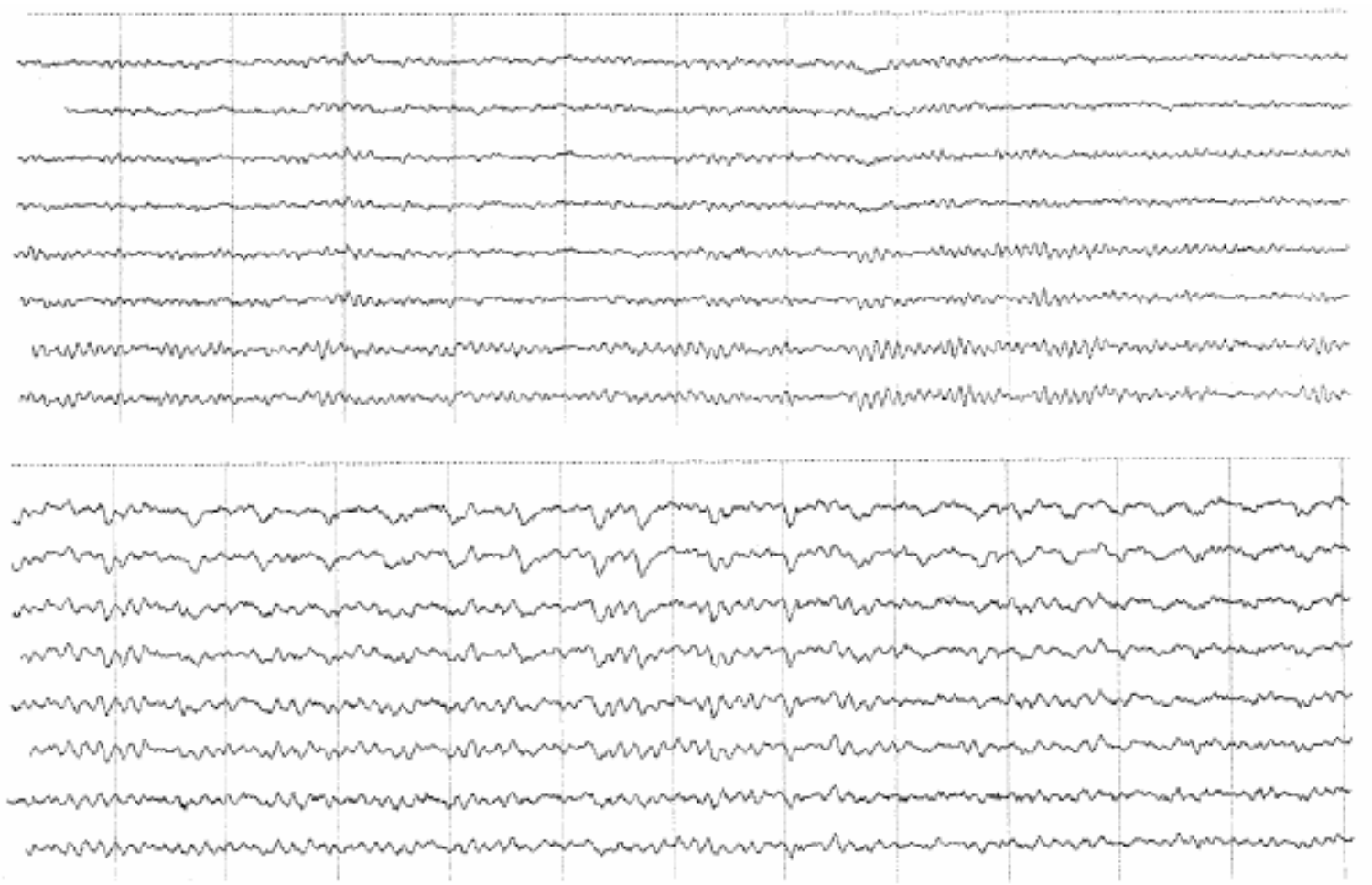


Illustration 88. above: Slightly discontinuous alpha-activity of approximately 10/s with minor intermittent anteriorization under 50 mg/d perazine with acute paranoid-hallucinatory syndrome (K. K., 27 y., m., EEG-nr. 104/92); below: After 6 weeks of treatment with neuroleptics (at time of recording 350 mg/d clozapine) slowing of the dominant frequency to approximately 8/s with spreading to the frontal regions, increased dysrhythmia caused by diffuse-pervasive irregular slow activity (EEG-nr. 286/92).

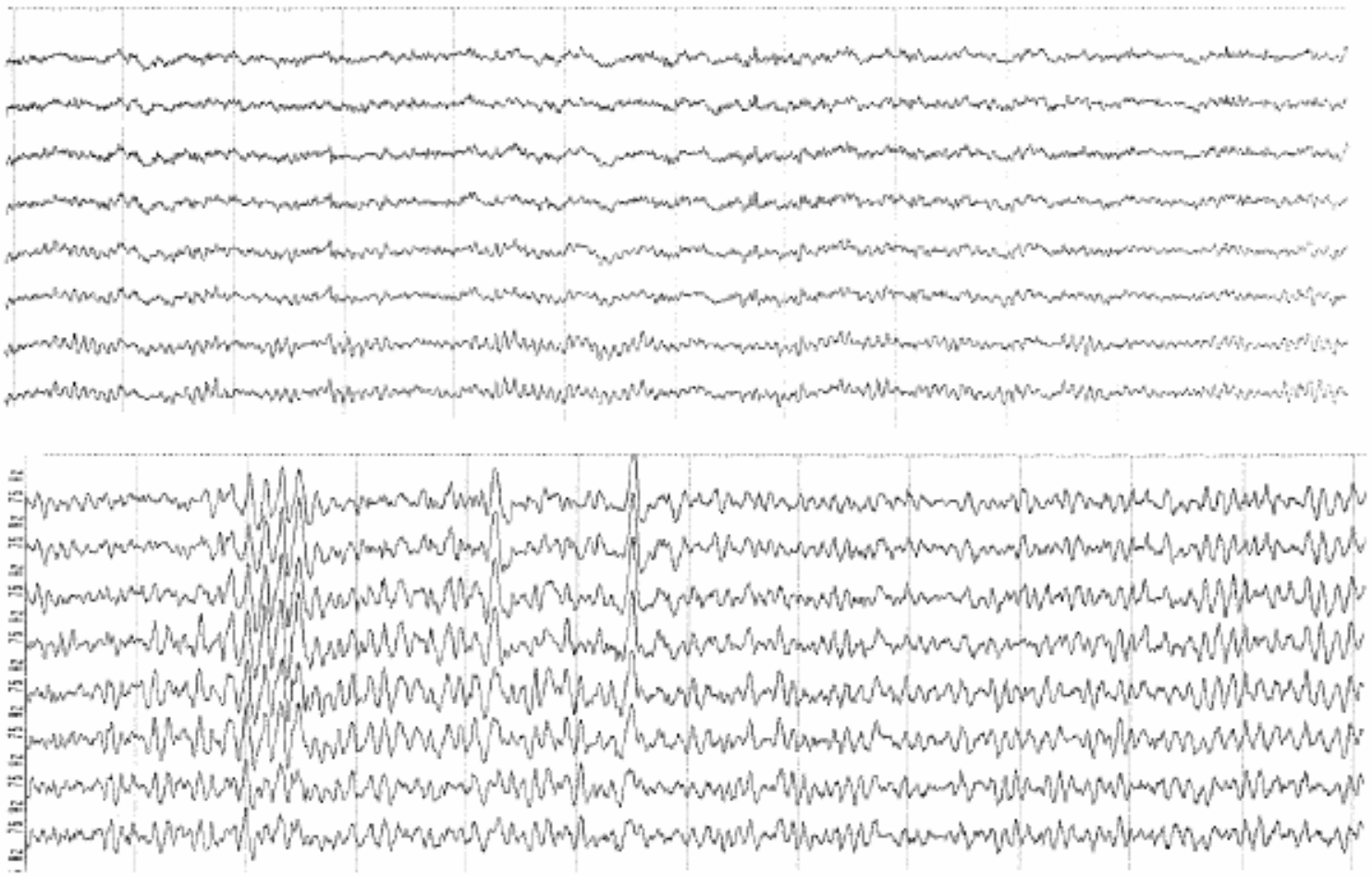


Illustration 89. above: Posterior-accentuated 11-12/s-activity under 50 mg/d promethazine, 500 mg/d chloraldurate and 10 mg/d diazepam with acute hallucinatory syndrome (R. S., 41 y., f., EEG-nr 800/92); below: After 3 weeks of treatment with neuroleptics (in the end 150 mg/d clozapine) slowing of the dominant frequency to 7-8/s with anterior spreading and frequent occurrence of singular as well as grouped sharper to sharp waves (EEG-nr. 870/92).

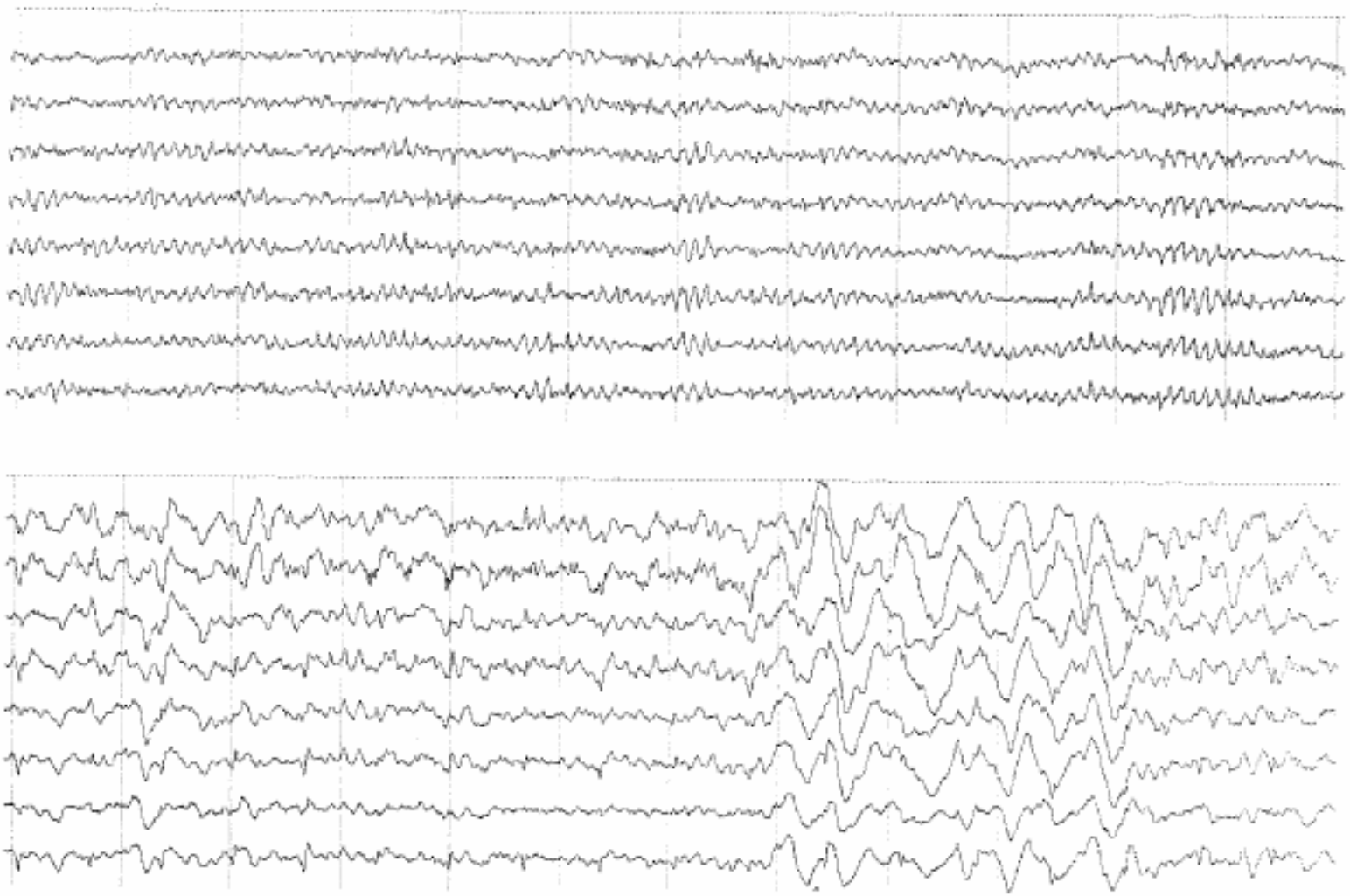


Illustration 90. Above: Frequency-variable activity of approximately 9/s with changing topographical accentuation under 100 mg/d perazine and 5 mg/d haldol with acute paranoid-hallucinatory syndrome (K. L., 56 y., f., EEG-nr. 158/92); below: After 2 weeks treatment with neuroleptics (at the end 250/mg/d clozapine diffuse-dysrhythmic EEG. (EEG-nr. 219/92)

The authors understood "Pathologisierung" or “abnormalization” primarily as phenomena based on synchronization that can be associated with our IBA/ILA-phenomenon (s. a. 3.1.) These phenomena include the anterior-accentuated rhythmic waves, occasionally in connection with sharper to sharp and sometimes also irregular slow waves. However, basically this could also be the pharmacogenic discovery of an otherwise latent constitution-related "trait"-feature (s. a. 4.7.).

> FLÜGEL and BENTE (1950) were the first to consider the question of a possible neuroleptics-induced behavioral and cognitive change ("pharmakogener Leistungswandel"). They coined the term "akinetisch-abulisches Syndrom" (akinetic-abulic syndrome) in order to subsume a lowering of spontaneous motor behavior, drive, interest, somatic, and emotional irritability in the presence of undisturbed consciousness. With clozapine such an "akinetic-abulic syndrome", regarded typical for phenothiazine neuroleptics cannot be found. Thus, the original assumption of a casual connection between such a syndrome and the antipsychotic effect cannot be upheld.

As discussed earlier (s. 2.2.1.3.), a clozapine-induced paroxysmal activity does not allow us to assume an increased seizure- risk in individual cases. However, a number of studies revealed a statistically somewhat higher risk for seizures under clozapine than under a medication with phenothiazines or butyrophenones (f. i. POVLSEN et al. 1985; HALLER and BINDER 1990). The determining, in the discussion often neglected, factor seems to us the daily dose. According to ERESHEFSKY et al (1989) only 1.4% of the patients treated with daily doses of maximum 600 mg have epileptic seizures compared to 14% of those treated with daily doses between 600 and 900 mg. DEVINSKY et al. (1991) found an incidence of 2.7% for doses up to 600 mg/d. These numbers must be viewed against the background of seizure risks in psychiatric patients under medication in general, which lies at 0.5-1% (ITIL and SOLDATOS 1980). The seizure risk also increases considerably if clozapine is combined with another neuroleptics (LIUKKONEN et al. 1992). Clozapine-induced seizures usually do not occur at the beginning of the therapy but only after weeks or months, i. e. in the chronic medication phase and thus unexpectedly. A seizure occurring under clozapine is by no means a reason to terminate the treatment. In most cases, a reduction of the dosage is sufficient to prevent further seizures. Also possible is the additional administration of an anti-epileptic such as phenytoin. Especially younger clinical colleagues have to be reminded time and again that decisions about a clozapine therapy cannot be delegated to the EEG-interpreter.

4.5.3. Thymoleptics

Compared to the effects of phenothiazines those of the thymoleptics are much more complex. This is caused by the simultaneity of formative tendencies of the A- and B-stage typical for thymoleptics. BENTE et al. (1965, a) tried to describe the complexity of the thymoleptic EEG-effects with the term "polyrhythmic frequency dissolution" (polyrhythmischer

Frequenzzerfall"). The authors understood this as a pronounced frequency-variable EEG with an only moderately pronounced, more or less discontinuous alpha-activity, continuous beta-pervasion and increased level of dysrhythmia due to diffusely interspersed irregular theta-activity. There is some indication that the picture of a polyrhythmic frequency dissolution depends less on a specific chemical structure than on the thymoleptic effects of a substance. Thus, a polyrhythmic frequency dissolution was observed not only under tricyclic antidepressives such as imipramine and amitriptyline but also under the chemically completely different tetrahydroisochinoline derivation nomifensine. As BENTE et al. (1976) were able to prove, such a picture occurs in healthy persons after approximately two hours of a single oral administration of 100 mg. Different from the placebo-group, a surprising initial activation of formative tendencies of the A-stage was observed, i. e. an increase in the alpha-activity in connection with a minor slowing of the dominating alpha-frequency. After a few minutes, there was a progressive increase of formative tendencies of the B-stage such as voltage decrease, desynchronization and increase of beta- and irregular theta-activity, so that finally the typical picture of a polyrhythmic frequency dissolution resulted.

These findings, too, support our suspicion of a regular two-phase character of the EEG-effect of psychotropic substances. Naturally, because of the general dependency of all EEG-effects from the baseline condition there can occur in individual cases totally different reactions. Thus, the initial increase of the alpha-activity under nomifensine has been observed only in persons with average, and especially underaverage, alpha-dominance in the baseline EEG whereas persons with above-average alpha-dominance showed an initial alpha-decrease (BENTE 1973). LEHMANN and HOPES (1978) reported similar observations for imipramine. It certainly would be worthwhile to distinguish whether the direction of the mostly unnoticed initial effect has any relationship to the clinical effect. As we all know, have imipramine, amitriptyline or maprotiline in healthy test persons a sedating or irritating effect, while they increase the drive and lighten the mood in endogenous-depressive patients (BENTE et al. 1965 a; DIMASCIO et al. 1968; HEIMANN 1974; ULRICH et al. 1984, 1983).

Contrary to neuroleptics, thymoleptics do not cause a performance decrease in attention/load tests in healthy test persons. However, a regular lowering of the fusion frequency of flickering light (HARTUNG et al. 1964) takes place. The authors explain this discrepancy, termed dissociative vigilance shift ("dissoziative Vigilanzverschiebung"), with a simultaneity of dampening and stimulating effects, where the latter become particularly important in attention/load tests and thus compensate for the dampening effects.

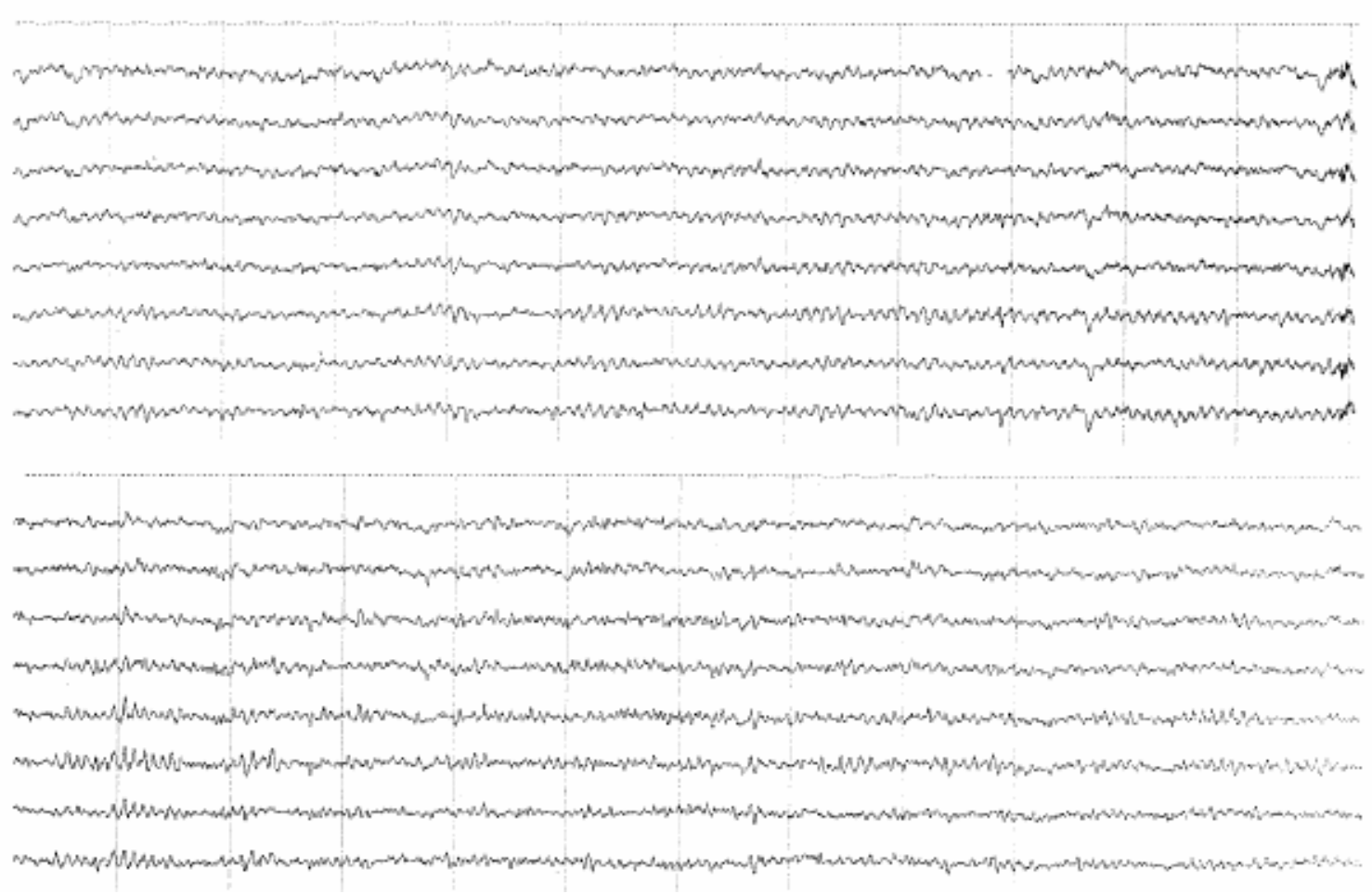


Illustration 91. above: Continuously anteriorized 10/s-activity. Dynamic rigidity - recorded medication-free during depressive state of a bipolar affective psychosis (K. A., 36 y., f., EEG-nr. 13/92); below: After 6 weeks of treatment with thymoleptics (in the end with150 mg/d clomipramine) picture of a "polyrhythmic frequency dissolution" with only sporadic alpha-groups, dominated by desynchronized activity with higher beta-proportion and interspersed irregular theta-activity (EEG-nr. 192/92).

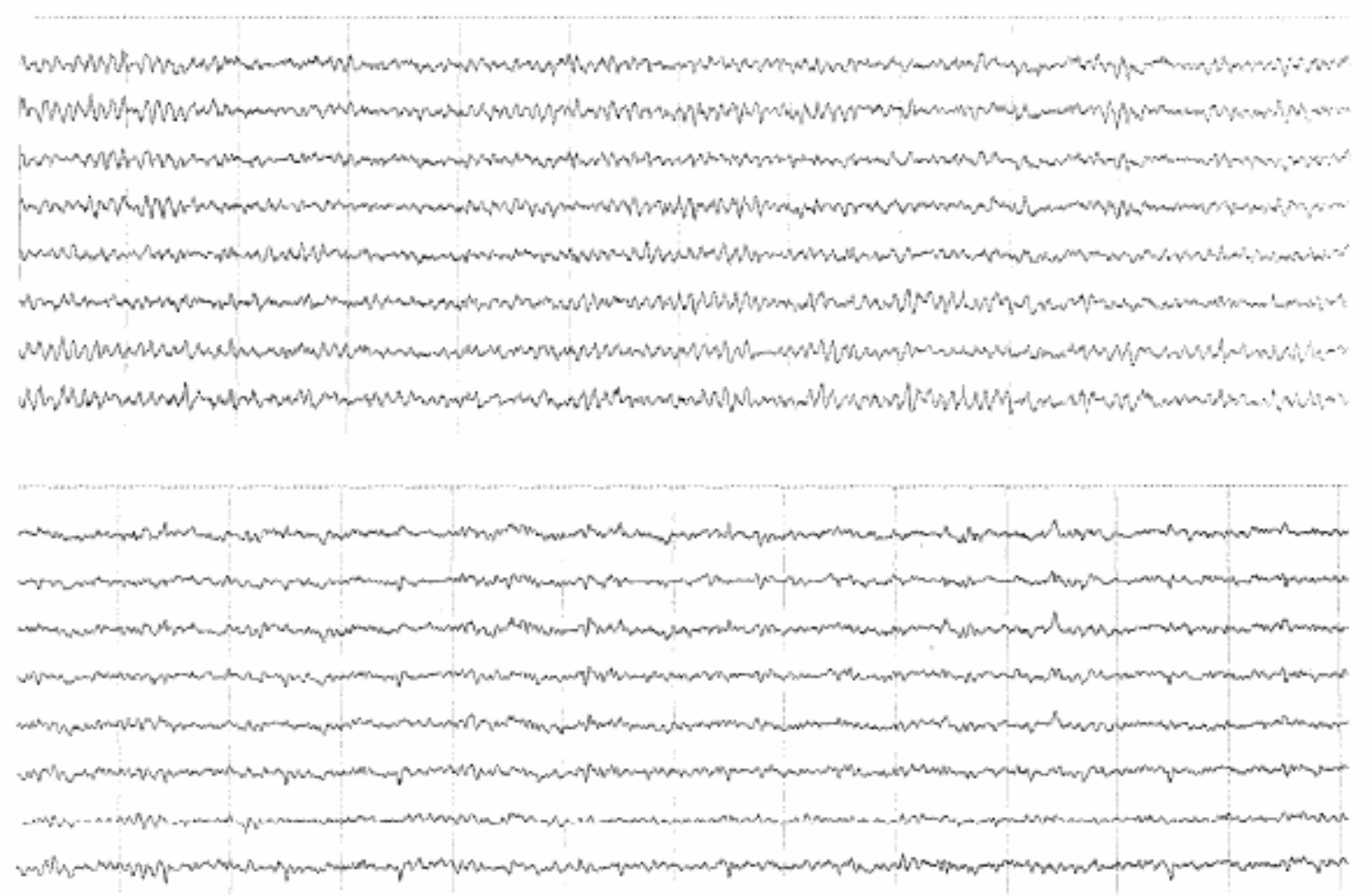


Illustration 92. above: Discontinuous 8-9/s-activity with intermittent anteriorization under 75 mg/d of perazine with depressive syndrome (L. L., 48 y., m., EEG-nr. 26/92); below: After 3 weeks of treatment with thymoleptics (in the end with 150 mg/d imipramine) picture of a "polyrhythmic frequency dissolution," corresponding to illustration 91, below (EEG-nr. 115/92).

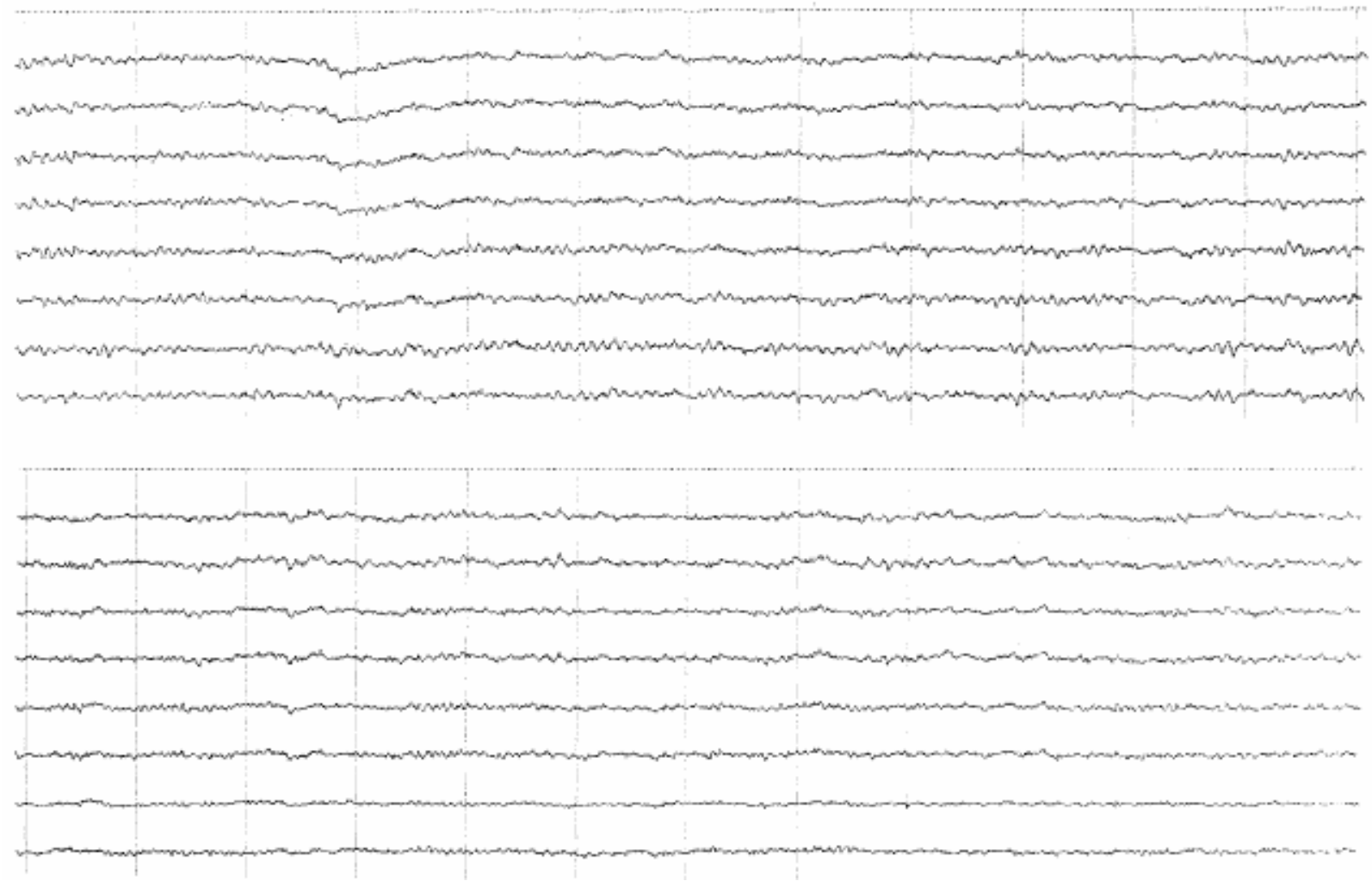


Illustration 93. above: Slightly discontinuous posterior-accentuated 10/s-activity with depressive syndrome (bipolar affective psychosis) recorded medication-free (A. A., 33 y., f., 127/93), below: After 6 weeks of treatment with thymoleptics (in the end with 150 mg/d clomipramine) picture of a "polyrhythmic frequency dissolution," corresponding to illustration 91, below (EEG-nr. 310/93).

The different clinical effects observed in healthy probands and depressive patients should correspond to equally different EEG-effects. Based on all the findings that suggest differences in the electroencephalographic baseline condition (s. a. 4.2.1.), this seems indeed to be the case.

According to BENTE, who tried to overcome the conventional hypotheses about action mechanisms that used to concentrate on just one particular biochemical partial effect by a systemic concept that was independent from the method, thymoleptics are able to resolve the syndrome-correlated dynamic restriction of central-nervous regulating mechanisms (BENTE et al. 1965 a.). Such a resolution was probably connected to the simultaneity of sedating and stimulating partial effects.

The formulation of theories about the action mechanisms of thymoleptics can be traced back to research with centrally active anticholinergics that were conducted in the early Sixties with healthy persons as well as, for exploratory reasons, with psychiatric patients. It was found that substances such as atropine, scopolamine as well as various synthetic anti-parkinson drugs show a feature common reaction pattern dominated by formative tendencies of the B-stage. The initial activation of formative tendencies of the A-stage typical for most of the other psychotropic substances seems to be missing for the centrally active anticholinergics (HEIMANN 1952; BENTE et al. 1964; ITIL and FINK 1968). As a behavior/experience correlate of the pharmacogenic gestalt/functional change, they defined an delirious change of consciousness ("amentiell-deliranter Bewusstseinszerfall") or a "hyponoic-hypobulic syndrome with intentional weakness, Korsakoff-like mnesic deficits as well as disorientation with regard to time and place" ("hyponoisch-hypobulisches Syndrom mit intentionaler Schwäche, Korsakow-artigen mnestischen Defiziten sowie zeitlicher und örtlicher Desorientiertheit" (Bente et al. 1964). With the fading of the psychic and brain-electric changes, a "centrally stimulating, drive-enhancing and irritation-relieving effect" was observed in patients with depressive syndromes (FLÜGEL and BENTE 1961). In analogy to the supposed indicator function of the neuroleptics-induced "abulic-akinetic syndrome," BENTE (1961) considered the "anticholinergic-deliriogenic potency" of centrally active anticholinergics as a measure for the degree of their antidepressive efficacy. The fact that all tricyclic antidepressants known at that time had a more or less pronounced anticholinergic effect lent a certain plausibility to this speculation. That in the meantime substances with non-anticholinergic and yet thymoleptic effects have been discovered does not mean that the authors erred. This is a situation similar to the neuroleptic-antipsychotic effect that, also different from what was assumed initially, is not related to the causation of an akinetic-abulic or extrapyramidal-motor syndrome. In agreement with our premise that excludes a one-on-one association of physiological and psychological facts (s. a. 2.2.6.) this is not surprising but, on the contrary, almost to be expected. As under neuroleptics we also have to expect a statistically increased seizure risk under thymoleptics. It is in this case even somewhat higher than under neuroleptics (s. a. 2.2.1.3.) By far the greatest seizure risk exists when thymoleptics are combined with more sedating and thus less antipsychotic neuroleptics. The paroxysmal, frequently spiky outbursts observed here constitute, different from the clozapine-induced, typically slower high-amplitude transients or sharp- and slow-wave complexes, a warning signal.

4.5.4. Lithium

The inadmissibility of drawing conclusions about the EEG-effects in patients from the EEG-effects of healthy persons became particularly evident for us through our experiences with lithium. As we also could prove quantitatively, (ULRICH et al. 1987, 1990) a lithium treatment of 2 weeks effects in the majority of cases in young healthy male probands who had to show an average alpha-activity to be included an increase of the formative tendencies of the A-stage. i. e. a change towards dynamic rigidity (DR). In a minority of the probands, however, an opposite effect has to be expected. There, a dissolution of the alpha-activity dominated by formative tendencies of the B-stage occurs, i. e. a change towards dynamic lability (DL). Contrary to the healthy probands the effect was extremely non-uniform in patients under treatment with phase-prophylactic lithium medication (ULRICH et al. 1983, 1987).

Table 7. Bivariate frequency distribution of patients with bipolar affective psychoses, classified according to the spontaneous dynamics of the EEG (DR = dynamic rigidity, DL - dynamic lability, PM = physiomorph) as well as the phase-prophylactic effect

	Relapses (hospitalizations) within an observation period of 4 years	
	no	yes
EEG-dynamics under lithium prophylaxis in euthymic state		
DR	1	8
DL	6	3
PM	14	3

Only 10% of the patient-EEGs could be clearly identified as dynamically rigid or labile. If we ask for the reasons for such different effects in healthy persons and patients, we must think in the first place of differences in the pre-medication baseline condition (ULRICH et al. 1993). Definite clarification would require a patient study of prospective nature where the baseline EEG and lithium EEG would have to be recorded in a medication-free as well as psychopathologically inconspicuous phase. A retrospective study (ULRICH and MÜLLER, unpublished) allowed us to confirm the suspected relationship between the EEG-dynamics under chronic lithium medication and the phase-prophylactic effectiveness.

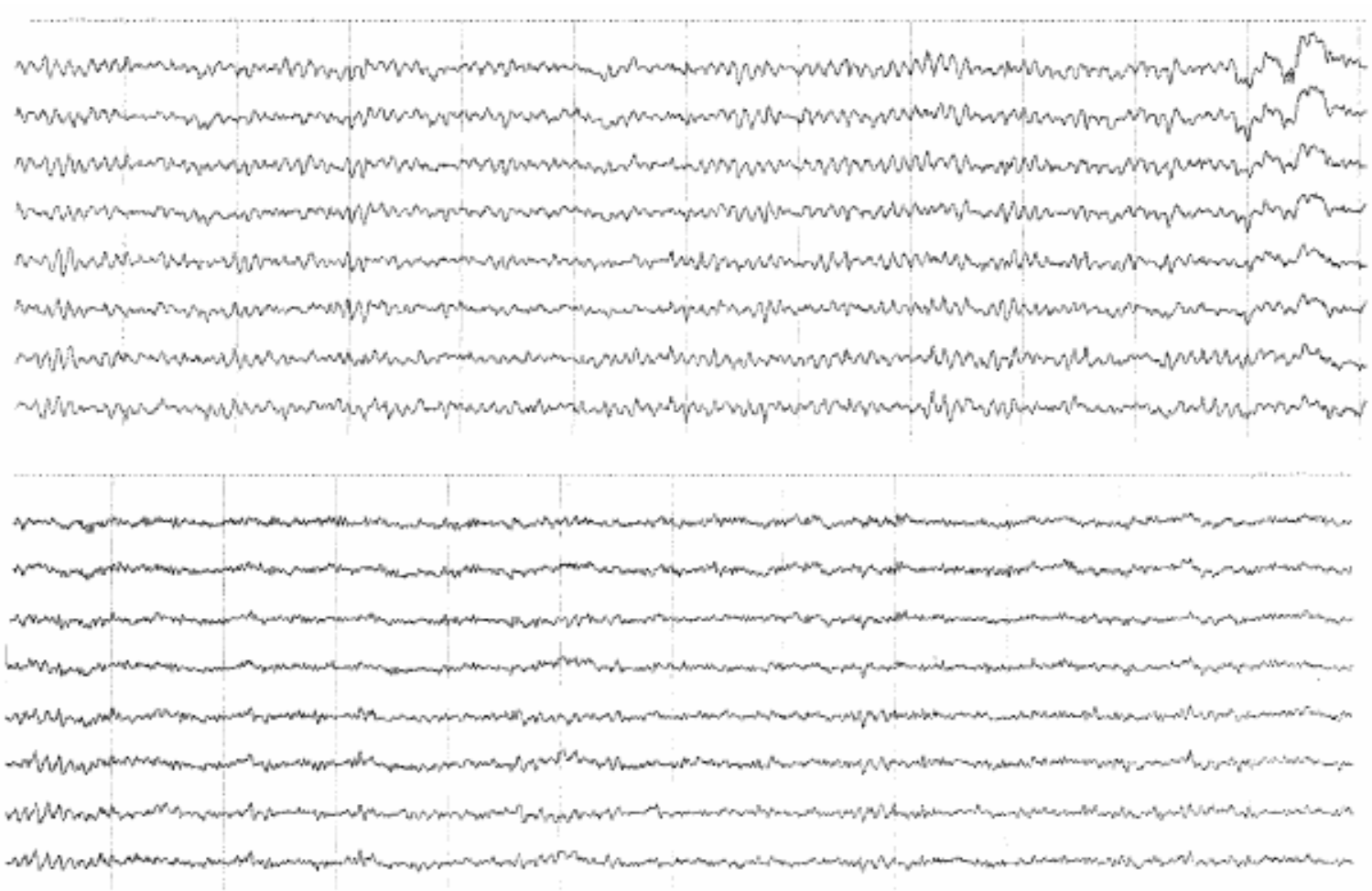


Illustration 94. above: Frequency-variable activity of approximately 9/s with continuous spreading to the frontal regions - Dynamic rigidity - recorded in the euthymic interval and medication-free from a patient with bipolar affective psychosis (K. B., 63 y., f., EEG-nr 701/93); below: Effect of a chronic (prophylactic) lithium medication with a plasma level of 0.76 mmol/l: dominating are low-voltage desynchronized activity phases corresponding to a stage B1 with fast beta-activity and only sporadic alpha-groups. Patient remained in euthymic state. (EEG-nr. 902/93)

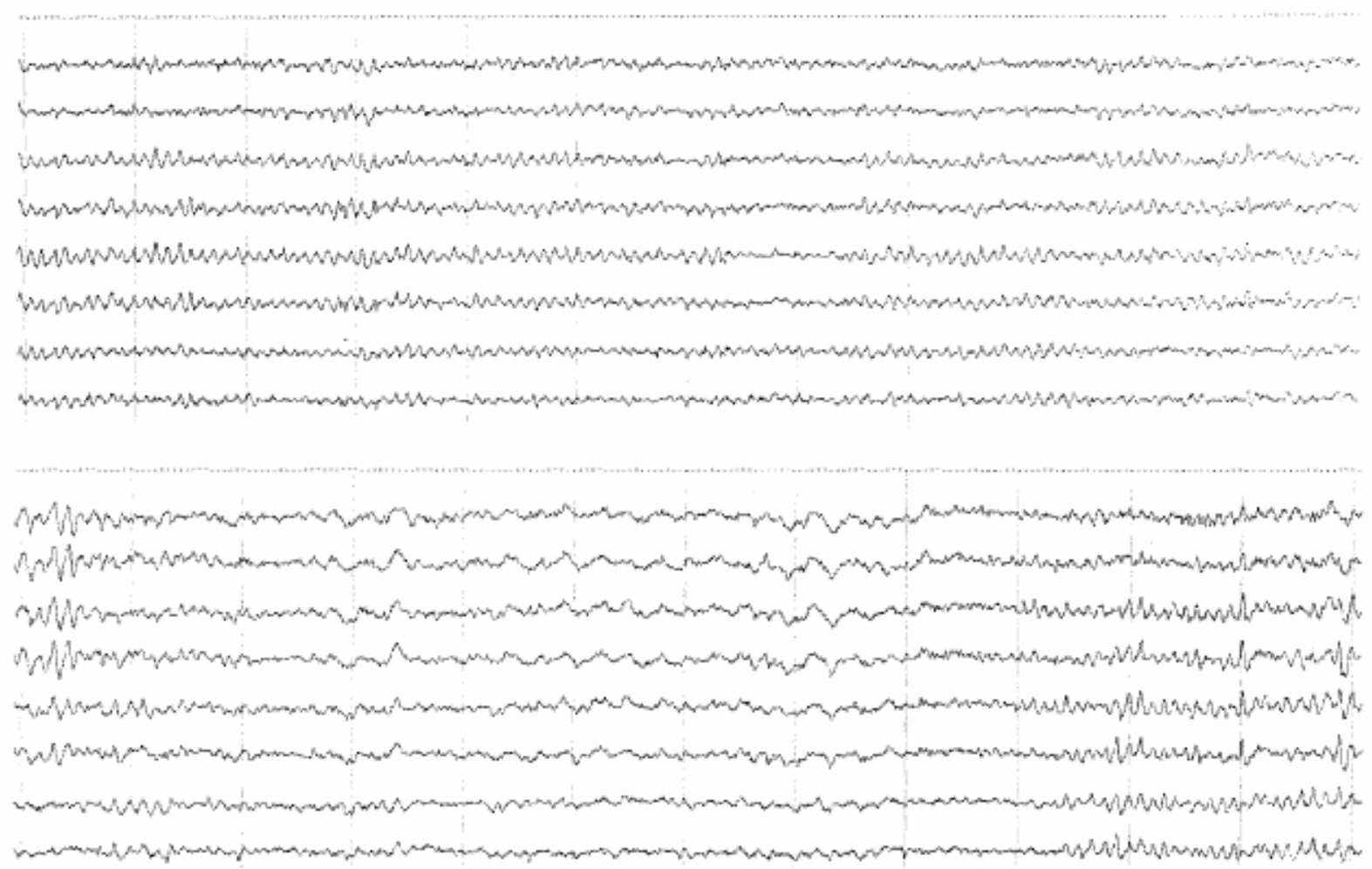


Illustration 95. above: Medium-degree anteriorized 9/s-activity. Dynamic rigidity - recorded in the euthymic interval and recorded medication-free from a patient with bipolar affective psychosis (R. R., 56 y., f., EEG-nr. 127/93); below: Effect of a chronic (prophylactic) lithium medication with a plasma level of 0.61 mmol/l: pronounced dynamic lability with abrupt transitions from A- to mid- and late B-stages. Patient remained in euthymic state (EEG-nr. 1010/43).

The relationships presented in table 7 were observed for 35 patients of our lithium ambulatory (Head: Prof. Dr. B. MÜLLER-OERLINGHAUSEN) with a diagnosis of a bipolar affective psychosis who were treated phase-prophylactically for at least 4 years (26 women, 9 men, age average: 55.7 ± 13 years, mean plasma level: 0.70 ± 0.14 mmol/l).

Paired comparisons (FISHER-test, double-sided) indicate that DR can be linked to a rather unfavorable phase-prophylactic effect. Especially clear here is the difference in the frequency of relapses between DR and PM ($p > 0.001$) but statistically also still significant between DR and DL ($p > 0.05$) whereas only an accidental difference was found between PM and DL. Because of the retrospective nature of the study, we cannot answer the question of exactly which EEG-dynamics in the baseline EEG allow the prediction of a phase-prophylactic effect. Regarding our earlier findings obtained from healthy persons as well as patients we cannot exclude by definition a single one of the theoretical possibilities. Clarification can come only from a study of prospective nature. The most plausible explanation seems to us that DR which is overrepresented in patients with melancholia (s. 4.2.1.) is the predictor variable we seek. With preexisting DR - be it a "trait" or a "state" feature - lithium works towards a dynamic labilization (ULRICH et al. 1993). Therefore, the physiomorph dynamics (PM) related to a favorable clinical effectiveness could represent the pharmacogenic modifications of a preexisting dynamic rigidity (DR).

Whether and how the lithium effect can be delineated from the neuroleptics effect has, to our knowledge, never been investigated systematically. Here, too, clarification would entirely hinge on the strict observance of their dependency from the baseline condition. Special attention should be given to the different effects lithium and neuroleptics have on one and the same person. Here, too, the usual group comparisons certainly will not help shed further light. We suspect that the intermittent left-anterior foci of slow waves (ILA), described by many authors (f. i. JOHNSON et al. 1970; ITIL and AKPINAR 1971; HELMCHEN and KANOWSKI 1971; REILLY et al. 1973; CZERNIK 1978; BENTE et al. 1982) are a lithium-typical feature.

In a retrospective study (ULRICH et al. 1983) we compared 70 outpatients who had been for some time under a phase-prophylactic monotherapy with lithium (age average: 45 ± 7.2 years, mean plasma level: 0.65 mol/l) with

- a group of endogenous-depressive inpatients treated with tricyclic anti-depressants (n = 34; age: 34.8 ± 7.6 years);
- a group of schizophrenic inpatients treated with neuroleptics (n = 83, age: 32.6 ± 6.1 years);
- a group of healthy students (n = 46, age: 26.5 ± 4.6 years).

19% of the lithium-treated patients showed a left-hemispheric, always anterior and 6% a topographically less defined right-hemispheric accentuation of slow waves. Paired group comparisons in each case showed a significantly higher frequency of the left anterior foci for the lithium-treated patients. These differences were not age-related.

> For ethical reasons we cannot answer the question whether this effect of a chronic lithium medication would also occur in healthy persons or whether it requires a patient-specific disposition. The long-favored explanation of lithium foci as pharmacogenic unmasking of latent foci resulting from circumscribed brain damage has been rejected meanwhile for lack of empirical proof.

As explained in the chapter about the pathological gestalt/functional change of the EEG (s. 3.1. and 4.1.4.) we consider the intermittent left anterior accentuated foci (ILA), independent of their respective genesis, as local manifestation of a global functional disturbance. As we further try to substantiate, (ILA) and the intermittent bilateral anterior groups of slow waves (IBA) are nothing but different phases of one and the same disintegration process. Therefore, if we combine ILA and IBA in the same category, the majority of lithium-treated patients will indeed show signs of the disintegration modus associated with this category (s. a. illustration 26). Although ILA and IBA typically appear in the same EEG, and it would be hard to find an EEG with ILA that does not also show more or less clearly IBA, it was the focal changes, i. e. ILA in particular that drew attention as lithium-typical EEG-phenomenon. Bilateral anterior-accentuated groups of slow rhythmized waves are mentioned as lithium-typical phenomenon only in the older literature (PASSOUANT et al. 1953; ANDREANI et al. 1958). We would like to remind the reader here of the confusing multitude of synonyms under which ILA appears in the literature (s. a. 2.2.1.4.; table 2).

4.5.5. Carbamazepine

Carbamazepine, introduced in the early Sixties as an anti-epileptic, has gained importance as a psychoactive drug only in the last decade. Its current main indications are, as for lithium, the prophylaxis of relapses of affective psychoses as well as the acute treatment of manic syndromes. Based on our observations of many years, we want to firmly reject the widely accepted opinion that carbamazepine has only minor EEG-effects, similar to those observed under tricyclic anti-depressants (SCHMIDT and GREIL 1987). Although the EEG in many cases shows only a moderate slowing of the dominant alpha- activity (s. a. HALDER et al. 1975; v. BÜLOW 1987; BESSER et al. 1992) we frequently encounter diffuse-dysrhythmic EEGs without significant alpha-activity under carbamazepine. While KETZ (1974) blamed thus modified EEGs on overdosing, other authors considered a spectral-analytically assessed increase of the theta- and delta-power as carbamazepine-typical for the therapeutic dosage range, too (WILKUS et al. 1978; BESSER and KRÄMER 1987; MARCIANI et al. 1992).

In this context we want to mention that diffuse dysrhythmias, although rarely, can also be observed under therapeutic serum concentrations of the anti-epileptic phenytoin. Such changes, also related to a dispositional factor (ROSEMAN 1961; RIEHL and McINTYRE 1968) must be separated from the very similar ones which are typical for the cumulative intoxications with phenytoin (ROGER et al. 1959). In case of doubt, the assessment of the plasma level will clarify the situation.

Several authors (PRYSE and JEAVONS 1970; JEAVONS 1972; RODIN et al. 1974; BENTE 1975; SACHDEO and CHOKROVERTY 1985) emphasize that carbamazepine, contrary to other anti-epileptics, frequently leads to an activation of epileptiform activity patterns with simultaneous decrease in the frequency of seizures (s. a. 2.2.1.3.).

The considerable interindividual variation range of the EEG-effects, also pointed out by BESSER et al. (1992), can certainly not be explained simply by different dosages or plasma levels. Although generally visually noticeable EEG-effects can only be expected with daily doses higher than 600 mg we see a distinctly increased degree of dysrhythmia in our clinical patients prophylactically treated for relapses, in individual cases already with daily doses of only between 200 and 400 mg. Thus, an individual-specific factor must play a decisive role. If we are looking for a pharmacon with a similar variation range of the EEG-effects we encounter clozapine. As discussed already (s. 4.5.2.), here, too, an increase of irregular theta- and delta-activity, frequently accompanied by an activation of paroxysmal potentials, is considered typical. As with carbamazepine inconspicuous and highly changed EEGs can be observed under the same dosage. Another similarity is the frequently stunning regularization of a pharmacon-induced dysrhythmia caused by psycho-sensorial stimulation.

Illustration 96a shows the resting EEG of a patient with grand mal epilepsy under 1200 mg/d carbamazepine. We are seeing a diffuse dysrhythmia under dominating irregular theta-/delta-activity. Alpha-waves can be defined only sporadically. Illustration 96b shows the change after opening the eyes. Compared to 96a, the proportion of high-amplitude delta-waves decreased and the alpha-proportion increased slightly. Illustration 96c shows the EEG recorded with opened eyes and standing. Compared to illustration 96a and 96b, a further regularization can be noticed.

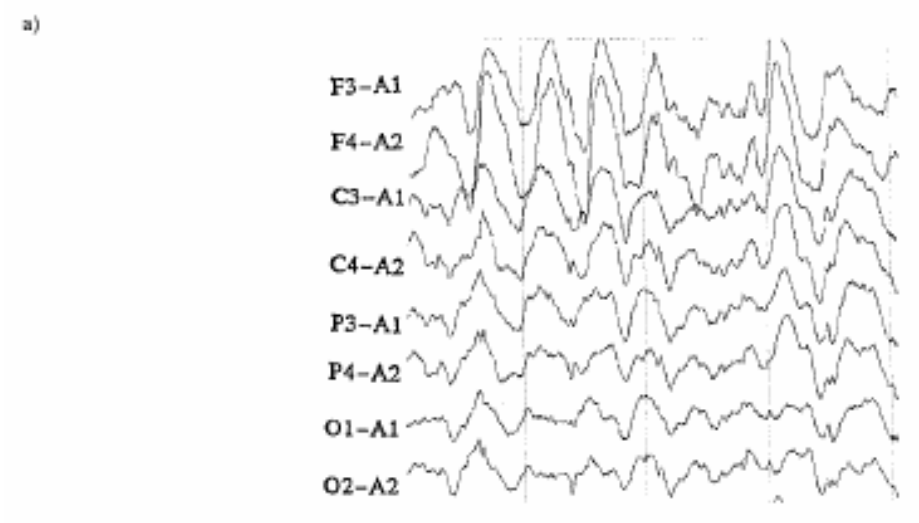
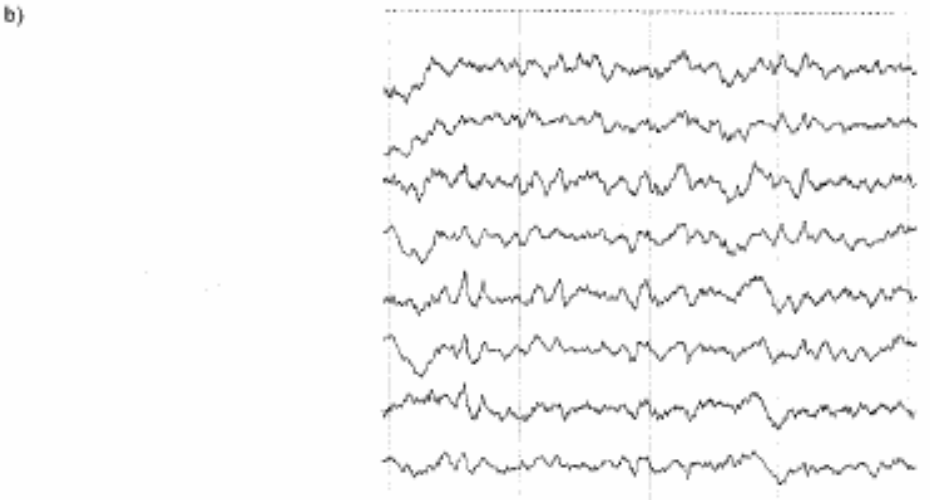
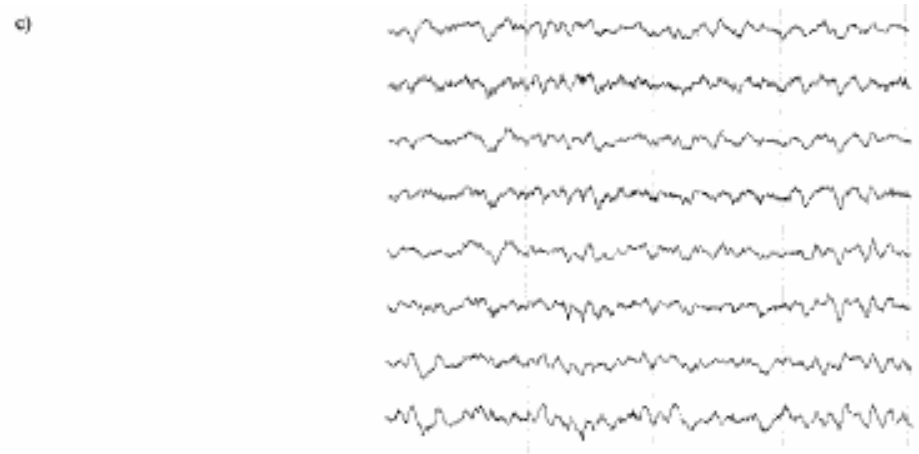


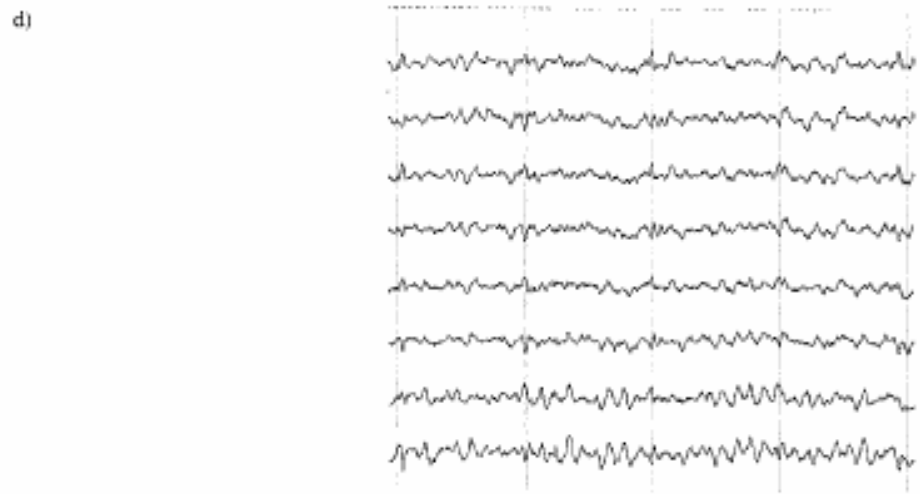
Illustration 96. Carbamazepine effect under various recording conditions. a) Eyes closed: diffuse delta-dysrhythmia with dominating polymorphous and high-amplitude, partially also sharp waves;



b) Eyes open: diffuse theta-dysrhythmia, singular alpha-waves;



c) Eyes open, patient standing: increase of fast frequency, as compared to b;



d) Eyes open, patient stands and does calculations (serial addition of single-digit numbers): further regularization compared to b and c, dominating is a posterior-accentuated alpha-rhythm.

The maximum attainable effect is shown in illustration 96d. This EEG was recorded under the conditions "eyes open" + "standing" + "calculation" (serial addition of single-digit numbers). That this represents indeed a pharmacon-typical effect is also confirmed by the results of a more recent study of primarily spectra-analytical nature conducted with epileptics (MARCIANI et al. 1992). Under various degrees of sensorial-cognitive load, a significant decrease of the theta- and delta-power was found, compared to the resting EEG.

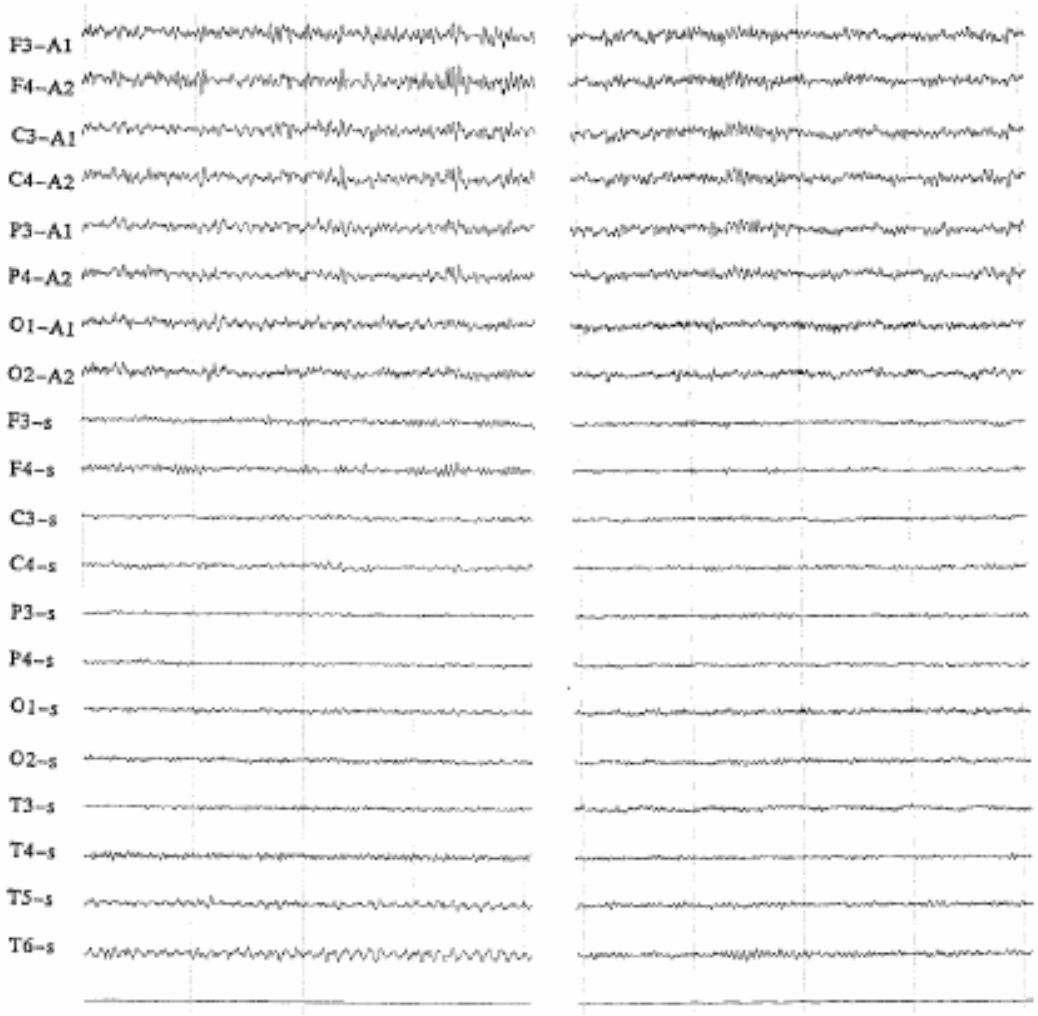


Illustration 97. Left: pharmacogenic beta-activity of approximately 20/s of anterior dominance; temporo-posterior a 9/s alpha-activity (2 cm ~ 1 s) dominates; uncontrolled self-medication with benzodiazepine because of anxiety syndrome (K. A., 19 y., m., EEG-nr. 555/93). Right: All derivation regions are dominated by a pharmacogenic beta-activity of approximately 18/s, intermittently temporo- posterior accentuated. Uncontrolled self-medication with clomethiazol in alcoholism (R. S., 54 y., m., EEG-nr. 665/93).

Incidentally, the pharmacogenic diffuse dysrhythmia convincingly illustrates the inappropriateness of the term "Allgemeinveränderung" (s. a. 2.2.1.2.). The user of this term will also have to describe carbamazepine and clozapine effects as medium or severe degree "Allgemeinveränderung." This, however, promotes erroneous conclusions or misunderstandings, since this term can hardly be separated from its associated connotation of a pathological performance change ("pathologischer Leistungswandel").

> The therapeutically used psychotropic effect that points in the direction of a mood-improvement obviously occurs with very low dosages (CLARENBACH et al. 1981; JANKE et al 1983) and does not seem to be dependent on a more massive pharmacogenic gestalt change of the EEG.

Even massive delta-dysrhythmias as we find them in epileptics under daily doses of 1600-2400 mg of carbamazepine usually do not have a behavior correlate. We must remember here that such changes are for the most part associated with the "resting" conditions, i. e. a defined, hardly naturalistic lab situation. Morphodynamically, the carbamazepine-induced dysrhythmia under resting conditions can be compared to an EEG of the sleep stages D and E. However, since our patients do not sleep and in most cases are not even tired we are faced with another example for the unfeasibility of a one-on-one association of EEG and behavior/experience phenomena. While these relationships, even under normal circumstances, are more or less vague we see here a systematic dissociation of the two description levels. It remains to be discussed whether the phenomenon described here constitutes a starting point for the explanation of the action mechanism.

4.5.6. Tranquilizers, Hypnotics, Narcotics

An increase in the beta-portion is considered typical for a multitude of psychoactive drugs with different main indications but who have a sedating and sleep-inducing effect in common. A prominent position among these substances is occupied today by the benzodiazepines that could not be missed any more in any medical discipline. The barbiturates, formerly widely used as hypnotics and in analgesic combination products are today applied largely as anti-epileptics. Here, phenobarbital and primidon still maintain their established position. A typical beta-superposition is, by the way, also caused by mephenytoin which distinguishes it from the clinically similarly working phenytoin (s 4.5.5.) Since it is almost a therapeutic staple, especially for detoxification treatment, we mention clomethiazol here and, without claiming to be complete, the tranquilizing meprobamat. All inhalation narcotics have the same effect as these prescription substances on the EEG. We want to mention here the halogenated hydrocarbons, chloroform and nitrous oxide.

The EEG-effects of all these substances in therapeutic dosages - for inhalation narcotics we are referring to the induction phase of narcosis - are rather similar. We typically find an EEG with an anterior-accentuated 15-30/s beta-activity which supersedes all other activities, often in connection with formative tendencies of the B-stage such as amplitude decrease and rarefication of the alpha-activity (see illustration 97, left). If an alpha-background activity is maintained, it sometimes is marked by an increase in frequency. With regard to the magnitude and the topography of these beta-superpositions, a wide array of graduations is possible. The beta-activity can also dominate over the entire convexity to such a degree that a preexisting alpha-background activity can no longer be defined (see illustration 97, right). We consider the custom of calling those EEGs beta-typical as unfortunate, because this obscures the difference with the rather rare EEGs with constitution-related fast background activity. Preexisting dysrhythmias are, contrary to the effects LSD 25 has on them (s. a. 4.5.7.), not regulated by the substances discussed here. Entirely to the contrary, typically latent foci of irregular slow waves associated with some well-defined injury often manifest themselves simply because of the drug effects. Before imaging techniques became available, neurology put this fact to good use in the diagnosis of circumscribed brain lesions. The reactivity of the pharmacogenic beta-activity to sensorial stimuli is variable, but on the whole less evident than that of the physiological alpha-activity. There are no regular relationships between the plasma level and the abundance of activity of the beta-superpositions. On one hand, massive effects can be observed after only minor single doses, while on the other hand, we sometimes do not find a significant beta-increase even after documented chronic abuse. Finally we must remember that because of the lipophilic qualities of such substances, the EEG-effect does not necessarily have to correspond to a specific plasma concentration. We for instance sometimes find beta-superimposed EEGs without being able to supply the chemical proof in the urine for it. Upon intense interrogation, patients in such cases sometimes remember taking a sleeping pill one or even two weeks ago.

The obvious question of what significance this highly impressive beta-increase has for behavior/experience has hardly found any interest, for as far as we can see. In any case, there are no indications of a relationship between the degree of the sedating effect and the amount of beta-superposition. On the other hand, a number of examples exist to prove that a hypno-sedating or narcotic drug effect is also possible without increase of the beta-proportion. Thus, paraldehyde, used as mild hypnotic, never leads to a beta-activation. An increase of slow waves can only be observed at higher dosages. A general slowing reaching into the beta-range is found with the short-term narcotic ketamine, the neuroleptic-analgesic dehydrobenzperidol and the central analgesic fentanyl. With increasing plasma concentrations exceeding the therapeutic range, we observe an increase of interspersed irregular slow waves with beta-inducing substances. Heavy barbiturate or benzodiazepine intoxications that frequently are the result of suicide attempts show a diffuse-dysrhythmic EEG without beta- activity. Their reappearance upon efforts of the intensive care unit indicates a positive prognosis.

The dependence of EEG-effects on the plasma concentrations of the common narcotics was also applied for the electroencephalographic definition of stages of different depths of narcosis (SCHNEIDER and THOMALSKE 1956). The induction stage is marked by an anterior 14 - 30/s beta-activity. During the stage of light narcosis irregular slow waves are subseding and the beta-activity decreases. The stage of medium narcosis is dominated by 2 - 3/s delta-waves and a decrease of beta- activity. Under deep narcosis, all beta-waves disappear.

Because of the potential of dependency and the related neuroadaptation common to most of the beta-activity inducing substances we can assume that the acute effects differ considerably from the effects after long-term consumption and after withdrawal. For barbiturate-addicts WIKLER et al. (1955) described the occurrence of a diffuse dysrhythmia with or without paroxysmal potentials on the second or third day of withdrawal as typical EEG-correlate of the clinical withdrawal symptomatology. Without being able to support this with numbers, some observations during routine diagnostics indicate that such changes also occur under benzodiazepine withdrawal.

4.5.7. Alcohol

A special position, with regard to the extent of EEG-literature is reserved for our most popular drug, alcohol. The acute effect investigated in numerous studies with volunteers manifests itself in a dosage-related activitation of formative tendencies of the A-stage such as slowing of the background activity under increased synchronization to diffuse dysrhythmia under full drunkenness.

On the other hand, totally different features are shown in the EEG of an alcoholic (DAVIS et al. 1941; FUNDERBURK 1949; LITTLE and Mc AVOY 1952; FUNKHOUSER et al. 1953; BENNET et al. 1956; VARGA and NAGY 1960; ARIKAWA 1970; NAITOH 1973; JONES and HOLMES 1976; NEWMAN 1978; MÜLLER et al. 1985; KRAUS 1992). There is general consensus that at least every other alcoholic shows a discontinuous alpha-rhythm with dominating low-voltage desynchronized activity phases with increased beta-, or in rarer cases also theta-activity. According to these descriptions, which coincide with our own observations, the formative tendencies of the B-stage dominate the EEG of an alcoholic being sober for a couple of days.

The fact that we are not dealing here with a rapidly passing effect tied to the immediate impact of the noxa but with a lasting feature indicates that this is a pathological functional change of the type of dissolution via the B-stage (s. a. 3.1.; illustration 26). But since desynchronized low-voltage activity - especially when it occurs in connection with an increase of beta-activity - is still considered, according to the concept developed by LINDSLEY (1961), as the manifestation of an increased arousal

level (s. a. 2.2.1.4.), our interpretation forms a diametral contradiction of the popular teachings. Today it is almost considered as established that in the EEG a possibly genetically determined increased arousal level, i. e. increased psychological tension and anxiety as "trait-marker" for alcoholism, is evidenced (TARTER et al. 1984). According to them, alcohol would lead - here they refer to the acute effect in healthy volunteers - to increased alpha-activity and thus counters constitution- related discomforts. The effects of alcohol perceived as psycholytic would make the attraction of thus disposed persons to the alcohol understandable (DOCTER 1966; NAITOH 1973; JONES and HOLMES 1976; PROPPING 1977; GABRIELLI et al. 1982. Meditative as well as biofeedback techniques surged as new kinds of therapy.

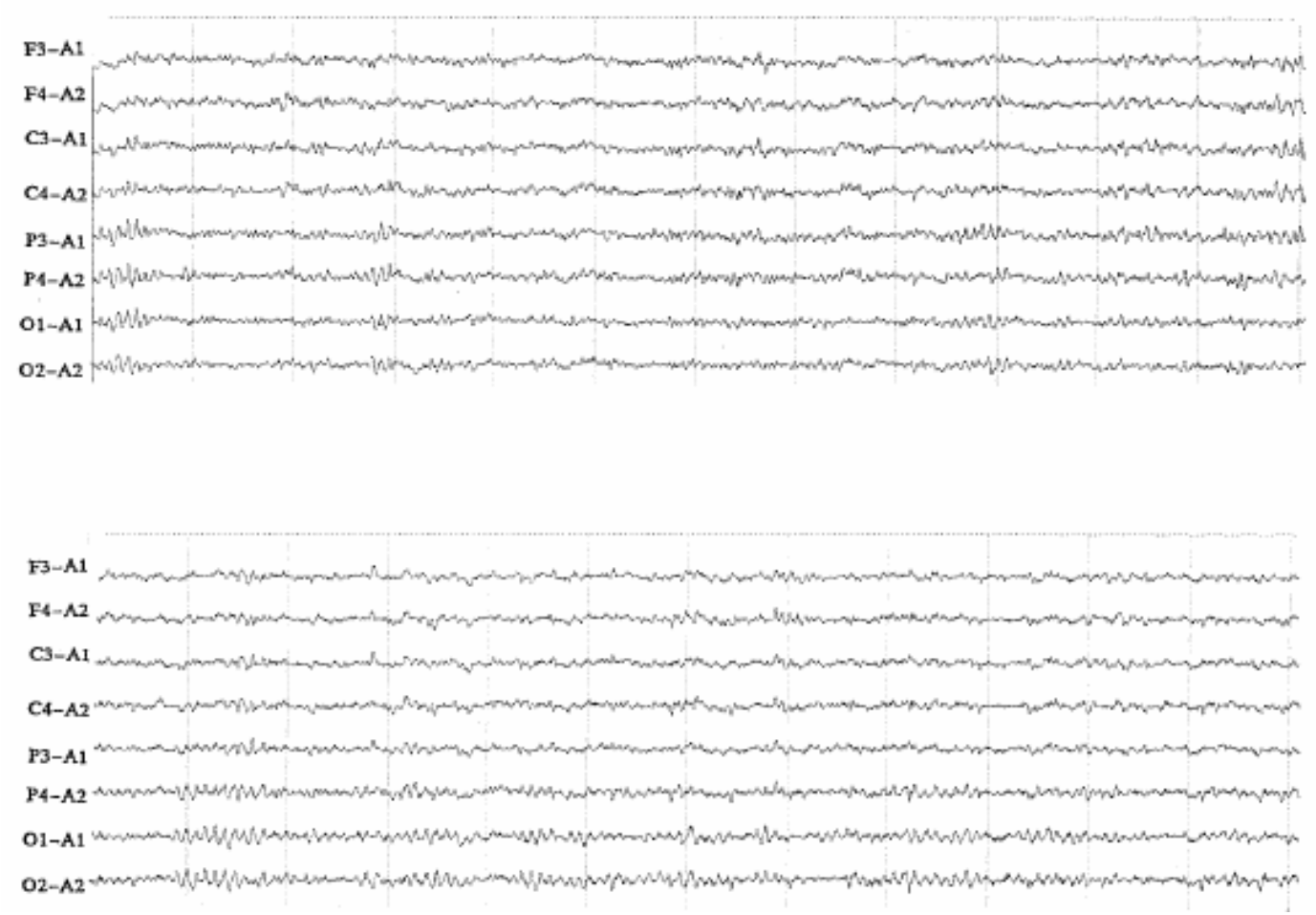


Illustration 98. above: Discontinuous, only sporadically occurring 9-10/s-activity; dominating are low-voltage desynchronized phases, partially with fast beta-activity, corresponding to a stage B1. Dynamic lability - recorded in medication-free state in alcoholic, sober for one week (M. N., 44 y., m., EEG-nr. 501/93); below: After 3 weeks of withdrawal as inpatient apparent increase in continuity of the now posterior-accentuated 9-10/s-activity (EEG-nr. 600/93). As far as we can see, only PROPPING (1977) considered the possibility that this supposed EEG-feature could be the result, not the cause of alcoholism.

It became evident very quickly, however, that the increase of alpha-continuity and amplitude attempted by such techniques was unattainable, especially in alcoholics (JONES and HOLMES 1976). Instead of examining at this point the "arousal"-interpretation that formed the basis of this hypothesis, the negative results were explained by the lack of cooperation of alcoholics. Moreover, all those well-documented findings, according to which a successful withdrawal is accompanied by a regression of the alpha-discontinuity (DL) or the restitution of the physiomorph vigilance dynamics should have been reason to reconsider (BENNET et al. 1956; VARGA and NAGY 1960; ARIKAWA 1970). Especially instructive are the curve examples provided by ARIKAWA. They document impressively how, only three weeks after the beginning of withdrawal, an alpha-rhythm was re-established via an intermediate stage of lacking topographic differentiation.

The reversibility of the DL upon the noxa withdrawal is a clear indication that we are dealing here not with a constitutional variant but with the manifestation of a pathological gestalt/functional change. This also agrees with more recent neuro-radiological findings. Thus a number of authors established with CT and NMR techniques the reversibility of brain shrinkage under abstinence conditions (CARLEN et al. 1978; RON et al. 1982; MANN et al. 1991; MANN and BARTELS 1992; SCHROTH et al. 1988; ZIPURSKY et al. 1989). The potential reversibility of a disturbed brain metabolism can be considered as equally established (BERGLUND et al. 1987; SCHROTH et al. 1988; VOLKOW et al. 1992). Because of the reversibility of the DL in the typical alcoholic-EEG, researchers will have to orient themselves in the future in their search for predisposing "traits" on EEGs of successfully detoxificated, i. e. long-term sober, persons. An interesting alternative are the studies with "high risk" persons such as the biological sons of alcoholics (f. i. POLLOCK et al. 1988). However, such efforts can be successful only if attention is paid not only to isolated features but also and in the first place to the morphodynamics. It is entirely possible, if not probable, that specific constitutional and possibly also inherited predilection types of the spontaneous dynamics can be defined.

The significance of neuroadaptive mechanisms manifests itself in the addictive drug alcohol during the withdrawal delirium. It is not surprising that there are no systematic studies with regard to the EEG-correlates of withdrawal delirium and generally of delirium tremens, if one considers the difficulties interfering with an at least minimally technically acceptable EEG from such patients. A low-voltage EEG with some theta-waves and mostly lacking alpha-activity (SCHEAR 1985) is viewed as feature for alcoholic delirium and alcoholic hallucinosis. According to WIKLER et al. (1956) generally "mild but definitive dysrhythmias" occur in alcoholics during the withdrawal phase, without necessarily being connected to specific psychiatric syndromes. The pertinent curve examples show a pathological gestalt/functional change of the type ILA/IBA (s. a. chapter 3, illustration 26). In subacute metalcoholic encephalopathies such as pseudoencephalitis WERNICKE usually a diffuse dysrhythmia (FOURNET and LANGTERNIER 1956) and sometimes also asymmetrically accentuated periodic paroxysmal discharges (periodic lateralized epileptiform discharges = PLED, NIEDERMEYER et al. 1981) are found.

4.5.8. Opiates, Psychoanaleptics, Psychodysleptics

The two-phasic nature of the EEG-effects following a single dose that is common to many psychotropic substances has been substantiated in a number of studies for methadon (WIKLER and ALTSCHUL 1950), morphine (WIKLER 1954), heroine (ZAKS et al. 1969; VOLAVKA et al. 1970) and cannabis (LOW et al 1973). Upon the intravenous administration of opiates, initially a clear accentuation of formative tendencies of the A-stage occurs. This effect is naturally more pronounced the higher the portion of desynchronized low-voltage activity phases in the baseline EEG.

Former authors who paid attention mainly to the frequency features considered a slight slowing of the dominant alpha-frequency as a typical acute effect of opiates (ANDREWS 1941, 1943; ISBELL et al. 1947, 1948; MATEJCEK et al. 1986).

After a few minutes, formative tendencies of the B-stage increasingly dominate the picture. Dependent on the dosage as well as a constitutional disposition, also irregular slow waves up to the picture of a diffuse dysrhythmia or also paroxysmal potentials may occur. As other centrally dampening substances, opiates, too, can make the EEG-signs of a circumscribed brain lesion more distinct (SCHNEIDER and REMOND 1949). As already mentioned, we must expect, as a matter of principle, that psychotropic substances will induce neuroadaptive processes. This is especially true for the potentially addictive substances addressed in this chapter. With long-term consumption of consistently low to medium dosages far-reaching regression of the initial acute effects can be expected - of the psychotropic and electroencephalographic ones - whereas with long-term high dosages the neuroadaptive capacities are not sufficient for a complete recovery from the acute effects, leading to the chronic effect. The withdrawal of the substance induces a readaptation process. Until the baseline condition is regained, EEG-changes must be expected despite - or better because of - the missing noxa. The studies available about the topic of EEG-effects due to addictive substances often do not sufficiently take into account the various time frames required for those adaptation- and readaptation processes. Thus it is certainly not without significance whether for instance the acute effect of cannabis or cocaine is examined in probands without any drug experience or, as usual, in occasional drug users during a differently defined "drug-free" interval or maybe even in persons who presently are using the drugs. Since usually only the drug addict without inhibitions regarding the increase of his dosages gains medical attention, it is not surprising that relatively little is known about the EEG-effect in socially well-adjusted long-term consumers.

ALPER et al. (1990) made a particularly instructive contribution to the topic of neuroadaption by means of quantifying techniques. In habitual cocaine-users, an anterior-accentuated increase of the spectral alpha-power was found two weeks after the last drug consumption, i. e. during the drug-free period. The curve examples, recorded with ear reference, show a monomorph, relatively slow and anteriorly spreaded alpha-activity, i. e. the typical picture of a DR. The authors considered this finding a manifestation of a "distinctive syndrome of neuroadaptation" caused by the withdrawal. The performance

deficiency induced by the cocaine-withdrawal evidenced itself in lack of drive, depressive irritation and dysphoria, symptoms usually associated with a lack of dopamine (DACKIS and GOLD 1985; GAWIN and KLEBER 1986). Hardly anything at all is known about the acute effects of cocaine on the EEG. Since there are no medical indications for cocaine the chances for closing this gap in knowledge are slim. The acute effects observed under dopaminagonists such as amphetamines probably correspond largely to those of cocaine.

The dependence of the effects on the baseline situation that also exists for these substances is supported by older observations that the therapeutic effect of amphetamines in hypermotor children did not have an EEG-correlate (CUTTS and JASPER 1939; LINDSLEY and HENRY 1942) and that for persons with those deficiencies getting addicted to the drug is unlikely. Unfortunately, as far as we know, no recent research about this subject exists.

> Neuroadaptation probably also plays a role with nicotine. Withdrawal of the noxa led to an evident decrease of the dominating alpha- frequency in nicotine addicts that appeared to be reversible upon resumption of smoking (ULETT and ITIL et al. 1971)

Like ALPER et al. in cocaine-users, STRUVE et al. (1989) found an increased spectral alpha-power in longtime cannabis-users, as compared to a control group. The difference was more pronounced in the anterior than in the posterior region. Here, too, the EEG was recorded with ear reference and here, too, the assumption that the quantitative findings are expression of a DR could be confirmed by the curve examples. The authors do not deem an interpretation of the topographical aspect possible at this point of time: "Neurophysiological explanations for the marked hyperfrontality of alpha activity we report with heavy THC users do not readily present themselves nor are they expected to do so soon."

> The use of the term "hyperfrontality" expresses an affinity with neuroanatomic/ neuropsychological interpretation models that we consider inappropriate, as a matter of principle, for EEG-phenomena of the kind here described (s. a. 3.1.). But also for concerns about recording techniques we do not consider it fitting to talk about "hyperfrontality." In derivations with ear reference, the question whether the alpha-focus is frontal or temporal must be left unanswered for the present.

That long-term massive cannabis use leads to dynamic rigidity, via an accentuation of the formative tendencies of the A-stage, can also be deduced from older research about the topic (WIKLER and LLOYD 1945; MIRAS 1969; DELIYANNAKIS et al. 1970; RODIN et al 1970; VOLANKA et al. 1973b, FINK 1976). But here we should not ignore the fact that there also exist contradictory findings (f. i. JONES and STONE 1970; HOLLISTER et al. 1970). Quite possibly, here, too, the dependency of the effects on the baseline condition plays a role. Another source of variation might be the two-phasic nature of the EEG-effects that must be assumed for cannabis, too (LOW et al. 1973). Early on, it was noticed that the neuroadaptation with cannabis might be particularly pronounced. For instance, it was discovered that under long-term

administration of identical daily doses, the initially evident EEG-effect could no longer be proven after 6 days (WIKLER and LLOYD 1945; WILLIAMS et al. 1945). FINK (1976), who was particularly interested in tolerance development, found that long-term users did not present "abnormal EEG records" any more frequently than people in a control group. He stated that in acute tests longterm users showed a similar EEG-effect as occasional users. The only difference was that the effect occurred for the former only after comparatively higher dosages.

Our own observations, also of a quantitative nature (WINTERER et al., 1995) we owe to a 28-year old patient who was admitted for treatment with the diagnosis of "agitated depression" because of a diffuse complaint picture and relationship problems. He informed us about his long-term and regular cannabis use. Immediately before being admitted he had enjoyed another joint. Illustraton 99 a, b, and c shows representative EEG segments recorded each day at the same time and free of medication on the 2nd, 16th, and 28th day as inpatient. In comparison to the first EEG the second, after a two-week cannabis-free period recorded EEG shows an anteriorization of the alpha voltage maximum, corresponding to a stage A2. The third EEG, recorded another 12 days later is similar to the first one in its morphodynamics. In the average power spectra of track 02-A2 (illustration 100) but also of any other track these morphodynamically highly impressive differences are not reflected. As we attempted to substantiate in another context (ULRICH et al. 1990) development as well as regression of a DR can satisfactorily be objectivated by two measuring variables.

We regard the anteriorization quotient (AQ) as a measure for alpha-anteriorization. For that purpose we first determine, spectral-analytically, for successive 2s-epochs of an anterior and posterior lead of the left and right hemisphere respectively, the absolute alpha power (μV^2) across the frequency range 8-13 Hz.

The quotient is formed for the left side according to

$$\frac{F4/A2}{F4/A2 + 02/A2} = AQ_r$$

and for the right side according to

$$\frac{F3/A1}{F3/A1 + 01/A1} = AQ_l$$

The target variable is the average of 300 short-term (2s-) anteriorization quotients as calculated during a 10-minute recording under resting conditions. We express the persistence of the alpha-anteriorization through an amplitude-independent measure of variation of our 2s-anteriorization quotients, i. e. the variation coefficient (CV).

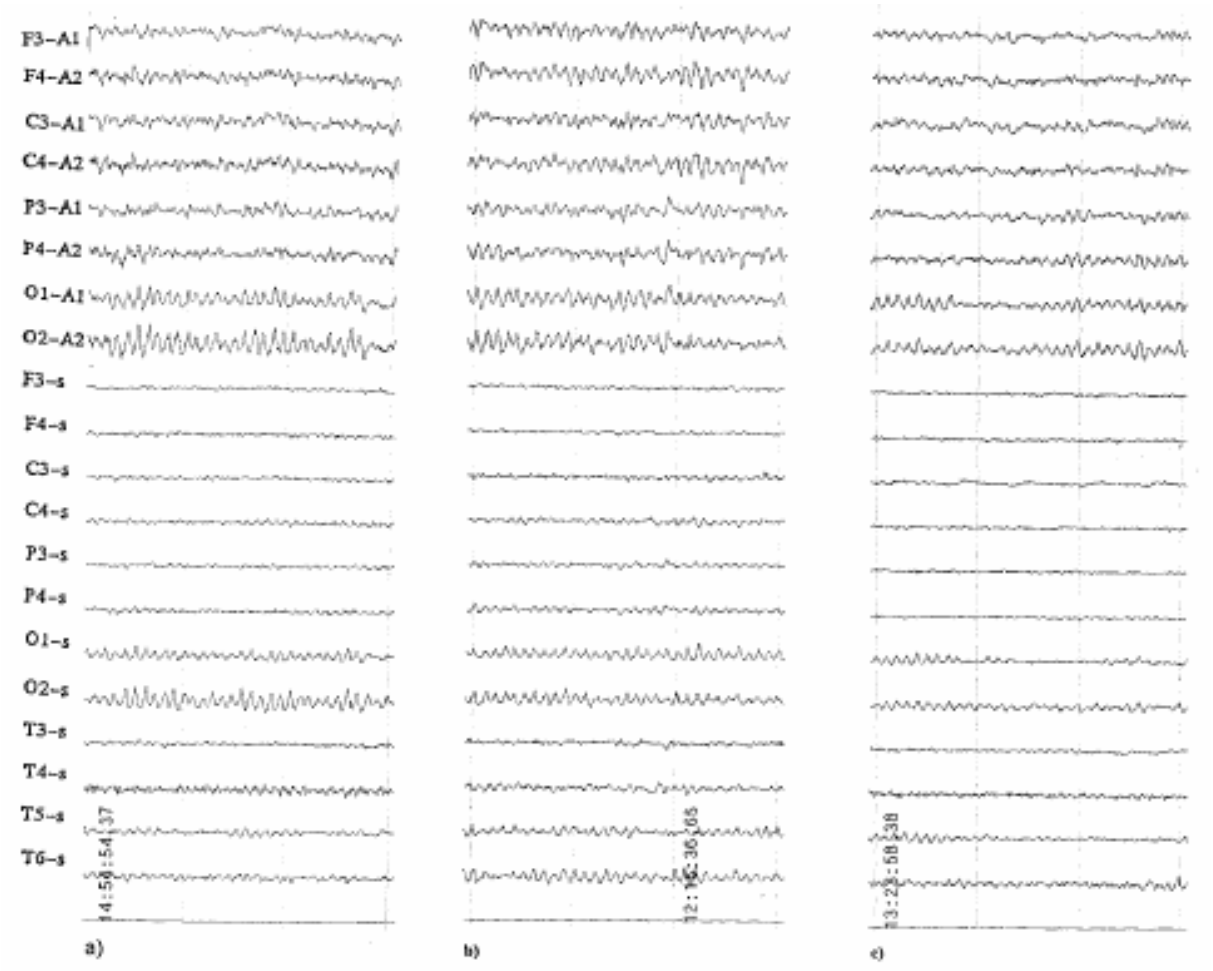


Illustration 99. Time course of EEG changes along with cannabis withdrawal. a) Alpha-typically organized EEG with a posterior-accentuated background activity of approximately 9-10/s (2 cm ~ 1 s) - recorded medication-free but with assumed residual cannabis influence (F. B., 28 y., m., EEG-nr. 1157/92). b) 9-10/s alpha-rhythm with an anterior spreading tendency. Picture of a minor to mid degree dynamic rigidity - after two weeks without cannabis (EEG-nr. 1204/92) c) After another two weeks without cannabis physiomorph EEG; no significant difference to the base-EEG (a) (EEG-nr. 1321/92).

The values listed in table 8 confirm and illustrate the impression based on the curve samples of an increase of the alpha-anteriorization in connection with a variability decrease of the alpha-topography from day 2 to day 16 and an almost complete return to the baseline EEG on day 28.

In relation to day 2, the increase of AQ_l on day 16 was 26%; the increase of AQ_r was 50%. Simultaneously, the CV-AQ_l decreased by 34% and the CV-AQ_r by 37%.

Since other possible causes such as psychoactive drugs could be ruled out, we can conclude that in our patient, the withdrawal from cannabis led to a passing pathological gestalt/functional EEG-change of the type of a dissolution via the A-stage (DR, s. a. 3.1.; illustration 26). With regard to the pathological performance change to be postulated here, it deserves mention that the patient, approximately one week after admittance, i. e. after a withdrawal period of one week, developed the fluctuating psychopathological picture of a minor-degree organic brain syndrome ("hypermotorisch-emotioneller Schwächezustand") sensu BONHOEFFER. This picture persisted for one week and then faded slowly. The indistinguishability of the EEG recorded while still under cannabis influence and the one after four weeks of withdrawal represents an empirical confirmation of the principle of neuroadaptation.

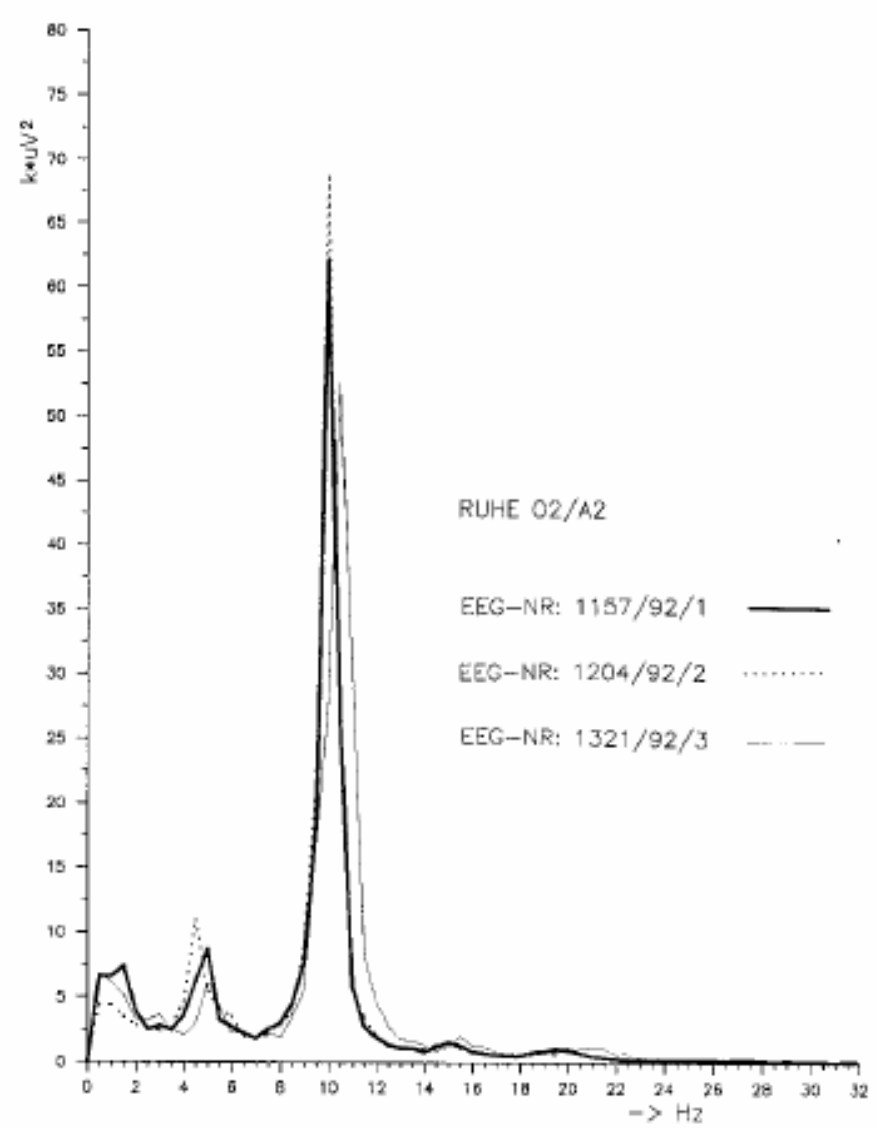


Illustration 100. Average power spectra (10- minute resting EEG) corresponding to 300 short-term spectra of 2s each of the track 02-A2 of the 3 EEG-registrations presented in illustration 99. The obvious morphodynamic difference between the first and the second EEG (illustration 99a and b) is in no way reflected in the respective spectra.

Table 8. Anteriorization quotients calculated from the absolute alpha-power for the left hemisphere:

$$AQ_l = \frac{F3/A1}{F3/A1 + 01/A1}$$

and for the right hemisphere:

$$AQ_r = \frac{F4/A2}{F4/A2 + 02/A2}$$

Depicted are the averages from 300 consecutive 2s-epochs of a 10-minute recording at rest, as well as the respective variation coefficients (CV)

	Time of EEG recording		
	Day 2	Day 16	Day 28
AQ_l	0,41	0,52	0,37
CV-AQ_l	0,35	0,23	0,38
AQ_r	0,28	0,42	0,31
CV-AQ_r	0,49	0,31	0,39

4.5.9. Psychotomimetics

A pronounced synchronizing initial effect in connection with an acceleration of the background activity followed by a desynchronization corresponding to a stage B is considered typical for hallucinogenics such as mescaline (WIKLER 1954; DENBER and MERLIS 1955; FINK 1969; BORENSTEIN and CUJO 1969), psilocybin (KOLARIK et al. 1966) and LSD 25 (BENTE et al. 1958; BROWN 1968; KOREIN and MUSACCHIO 1968; BORENSTEIN and CUJO 1969; FINK 1969). Several authors agree that the initial synchronization is accompanied by a disappearance of preexisting dysrhythmias or focal changes (f. i. BENTE et al. 1958; ITIL et al. 1968; KOREIN and MUSACCHIO 1968; BORENSTEIN and CUJO 1969). This is a peculiarity that could not be observed in any other substance with synchronizing effect. The desynchronization phase (stage B) that follows the synchronization phase (stage A) is considered the correlate of drug-induced hallucinatory experience (ENDO 1952). Since hallucinogenics generally do not lead to addiction, the occasionally discussed question about the chronic effect or the neuroadaptation is of lesser importance (BLACKLER et al 1986).

4.5.10. Nootropics

We talk about a therapeutically desirable nootropic EEG-effect when a preexisting pathological gestalt change has been counteracted (BENTE et al. 1978). This means that the nootropic EEG-effect as a matter of principle can only be observed in patients and never in young healthy probands. A methodologically central but generally neglectec aspect is that a recovery indicator that is applicable to all patients cannot exist. In the case of dissolution via the A-stage (DR), recovery is synonymous with a change in the direction of dynamic labilization, i. e. an increase of the alpha-frequency and a retreat of the anteriorized alpha-activity. In the case of a dissolution via the B-stage (DL), however, a dynamic rigidization, i. e. an increase in continuity, amplitude and synchronization of the alpha-activity indicates success. As previously discussed in another context (s. 3.1.), we would for instance have missed the doubtlessly existing and in the meantime also by other researchers confirmed nootropic effect of the calcium-antagonist nimodipine (ULRICH and STIEGLITZ 1988) if had neglected such premises. The same holds true for a study with the dopamine partial antagonist tergurid (ULRICH and SUCHY 1987).

However, the fact that the therapy goal must be determined individually for each patient based on the baseline condition seems to be beyond the imagination of most of EEG-experts as well as gerontopsychiatrists active in the field of nootropics.

4.6. The EEG in Meditation

An overview of the literature shows that EEG-changes observed under meditation vary too much to talk about the meditation EEG. However, many studies from various institutions agree about the existence of a triad of amplitude increase, decrease of the dominating alpha-frequency, up to the occurrence of a theta-activity, as well as alpha-anteriorization (KASAMATSU et al. 1957; HIRAI 1960; ANAND et al. 1961; KASAMATSU and HIRAI 1966; WALLACE 1970; WALLACE et al. 1971; WALLANCE and BENSON 1972; BANQUET 1972, 1973; ETSON et al. 1977; HEBERT and LEHMANN 1977; LEHRER et al. 1980). Especially instructive is the study by KASAMATSU and HIRAI (1966), because it contains a number of curve examples (their illustrations 4-8) that very impressively document the existence of a DR. Only 50 seconds after the beginning of a Zen-meditation an increase of the alpha-amplitudes in connection with an anteriorization can be observed. After 8 minutes, a stable stage of A2 to A3 as a correlate of the desired psychic condition is reached. Interestingly, the EEG-change extends beyond the end of the meditation for at least a few minutes in slightly less pronounced form. From the morphodynamic point of view, these changes can be associated with a pathological gestalt/functional change of the type of the dissolution via the A-stage (DR, s. a. 3.1.; illustration 26). Several authors also pointed out the occurrence of frontal rhythmic sub-alpha- and theta-groups (KASAMATSU and HIRAI 1966; WALLACE and BENSON 1972; HEBERT and LEHMANN 1977). Not least do the provided curve examples allow an association of these changes with the dissolution via the pathomorph variants of the A-stage (ILA/IBA, s. a. 3.1.; illustration 26). However, it would be wrong to talk about a pathological gestalt/functional change in the case of such meditation correlations since we are dealing with a deliberately induced state that uses physiological mechanisms that can be terminated at any time and that, of course, has no relationship to any disease.

As experiential correlate of the discussed EEG-changes, a very pleasant state of floating between wakefulness and sleep is mentioned. The fact that these peculiarities cannot be deduced from the gestalt/functional changes of the EEG is another empirical confirmation of the principle excluding a one-on-one association beween EEG and behavior/experience (s. a. 2.2.6.).

4.7. The EEG as Indicator of the Maturation Level

4.7.1. General Points of View

An assessment of the current electroencephalographic organization level can occur only before the background of the ontogenetically realized maturation level. As explained already (s. 2.2.5.), the mutually conditional theoretical constructs of vigilance and maturation can be viewed as a relationship of orthogonal coordinates (s. a. illustration 3). We recapitulate at this point that we are observing the spontaneous dynamics of defined EEG-patterns as indicating this very vigilance. We associated the degree of differentiation and availability of the observed behavior as well as the inner experience with the electroencephalographic morphodynamics (s. a. illustration 25). While we were exclusively occupied thus far with the state-related varying phenomena, i. e. the electroencephalographic vigilance indicators, we now want to focus on the state-unrelated phenomena, also known as constitution-related. As with the former, here, too, we must answer two questions first:

- Which patterns can be considered to be indicators of immaturation, with which explanation?
- Which correlations can be established for these patterns on the description level of behavior/perception?

It seems plausible to us to assume that in adults, all those EEG-phenomena that in infants and adolescents mark physiologically defined maturation phases point towards a brain-functional immaturity. The attempt to arrive at systematics of electroencephalographic immaturity indicators assumes an intense familiarization with the ontogenesis of the EEG.

For the EEG, too, the progression from the undifferentiated to the differentiated, thus an increase of order and its maintenance, was considered a general biological principal of maturation. In the EEG of the new-born with a relatively low-voltage 1/2-2/s-activity - with superseding 10-30/s waves - no order of any kind is recognizable. Only a very coarse distinction is possible between the waking-EEG and the sleeping-EEG. Only after a period of 6 months can we talk about a subvigil intermediary stage in the form of groups and sequences of a rhythmic 2-4/s activity. We must remember that the interindividual variability of the speed of maturation differs widely, even within the normal range. Instead of discussing the ontogenesis of the EEG by means of the customary chronological ordering of isolated features we prefer a cursory sketch of the general developmental principles that allow to preserve a coherent overview.

In the first 10 years of life, development is determined by such formative tendencies that result in steady increase of amplitude, level of synchronization and frequency. It must be mentioned that this developmental tendency shows regional heterogeneities. Because of an accentuation of the posterior regions, a topographical differentiation occurs, too.

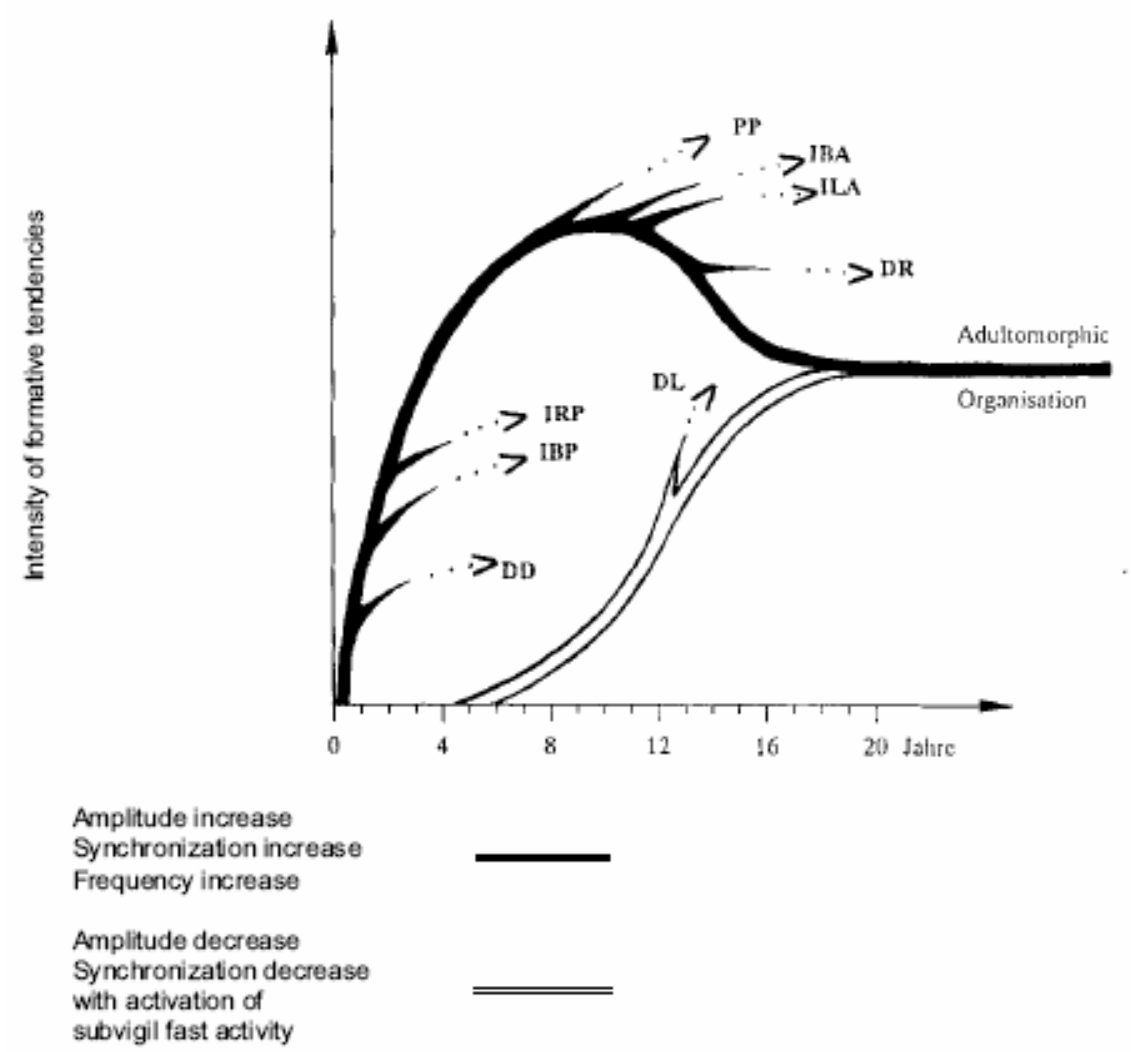


Illustration 101. Ontogenesis of the EEG. Ideal course and possible deviations.

To the degree that the amount of diffuse irregular slow activity is pushed back a more rhythmic and fast acitivity becomes dominant. There also exists a typical lateral difference. Approximately around the 3rd to 4th year, a passing intermittent right-posterior accentuation of irregular slow waves (EEG-OLOFSSON 1971) is found, corresponding to a topographical heterogeneity of the maturation process. Around the 9th year, the alpha-activity becomes posteriorly accentuated. The EEG differs from the adultomorph one only because of a more or less high amount of interspersed slow waves. That the development is by no means completed at this point is evidenced especially during the transition from wakefulness to sleep. This transition is marked until puberty and even beyond that point by groups and sequences of rhythmic high-amplitude, frontally-accentuated waves with a frequency of 6-7/s (in infants from 3-5/s).

This relatively uniform pattern represents the infantile and juvenile equivalent to the 6 intermediary stages, distinguishable in the adult EEG, i. e. the patterns A1, A2, A3, B1, B2, and B3 (s. a. 2.2.5.). Formally, this infantile drowsiness pattern corresponds to the phenomena, subsumed by us in the adult EEG under IBA (s.a. table 2). The often observed persistence of these patterns into early adulthood or even beyond can be retraced to an exaggerated and unrestrained effect of the formative tendencies for synchronization associated with infancy. This is confirmed, not least, by the fluent transition, observed in children and adults, from rhythmic to dysrhythmic paroxysmal activity that can be explained by a different degree of synchronization. The increase in synchronization is also evidenced in the coordination of the frequency and phase relationships of different derivation regions. An interesting, thus far hardly mentioned partial aspect here is the one of interhemispheric coordination.

DD	Diffuse dysrhythmia because of prevailing irregular slow waves
IRP/IBP	Intermittent right- or bilateral posterior-accentuated irregular (but also rhythmic) theta- and delta-waves
PP	Paroxysmal (epileptiform) potentials
ILA/IBA	Intermittent left or bilateral anterior-accentuated rhythmic theta- or delta-groups
DR	Dynamic rigidity
DL	Dynamic lability

Illustration 102. Relatively persistent EEG-features (traits) as indicators of a functional cerebral maturation deficit.

While the development of certain synchrony over the central region can be observed after only 4 weeks, the posterior regions reach a coordination only during the 3rd or 4th year of age. The two temporal regions remain independent of each other the longest (WERNER et al. 1977). Around the 4th year of age the formative tendency of the active desynchronization as a manifestation of a lowered vigilance level is added to the picture. The formation of the mechanism which is the basis of the adult B1-stage continues until about the 14th year of age. Finally, the morphodynamics of the adult EEG result from the functional integration of the mentioned developmental tendencies, which take about 4-5 more years. The electroencephalographic immaturation indicators shown in illustration 102 can be regarded as deviations, disproportionings or deficient integration of the developmental trajectories, that we tried to present in a model in illustration 101.

They can also be observed as combinations. Only DR, DL, and DD are mutually exclusive. Problems of delineation arise between ILA/IBA and PP, since both of these phenomena based on exaggerated synchronization show flowing transitions (see above). A close formal-genetic relationship exists also between DD and IBP or IRP. According to our model (illustration 101), these are degradation levels of an ontogenetically early deficit.

We pointed out earlier (see 3.1. and 3.2.) and restate here that most of the phenomena listed here as immaturation indicators, i. e. DR, DL, ILA/IBA, and DD can also manifest themselves state-related in the case of cerebral affections indicating a pathological gestalt change of the EEG.

Now we want to address the second basic question of this chapter, the question about the clinical and psychological significance of our supposed immaturity indicators. A common misunderstanding among laymen is to equate brain-functional immaturity with delayed intellectual development. According to popular opinion which can be traced back to the pioneers of the EEG, there exists no EEG-correlate for intellectual or mental impairment (f. i. OSTOW 1950; GIBBS et al. 1960). LA VECK and DE LA CRUZ (1963) who examined a large number of mentally defective people found a "normal" EEG in 34% of them. "Normal" EEGs were even not infrequent in the most severe cases of idiocy. The most frequently observed deviation from the norm was the diffuse dysrhythmia (DD). We admit that we have our reservations about such statements since they are based on the neurological norm concept, criticized by us as inappropriate for psychiatric questions (see 2.2.1.1.). For us, it is an equally unanswered but interesting question whether a subtle morphodynamic analysis does not reveal EEG- correlates of dementia after all - where we think foremost of our immaturation indicators. We do not want to go as far as to expect that it might be possible to diagnose a deficiency of intelligence from the EEG. Here, too, the principle applies that a one-on-one association of EEG and behavior/experience cannot be assumed. After all, we must remember that the features shown in illustration 102 can also be observed in absolutely healthy and intelligent persons. However, studies with healthy persons that could provide the desperately needed empirical foundation for the developmental-biological aspect in psychiatric research are extremely rare. One first important study, that remained without follow-up, however, was taken by DAVIS and DAVIS (1936). The authors divided healthy probands into those with rather continuous and regular and those with rather discontinuous and irregular activity. Since these features could be largely reproduced in repeated recordings, the authors assumed that they were constitutional and possibly hereditary. From this, they derived the following question that could also be considered as a research program: "If one is dealing with hereditary patterns and types, with what mental or neurological features and tendencies may particular cortical electrograms be related?" Without mention or in ignorance of this suggestion that never found any resonance, VAN PRAAG (1990) complained more than half a century after DAVIS and DAVIS that because of the search for the pathophysiological correlate of psychiatric diseases, people had neglected to also consider the physiological correlate of certain personality structures - "biological underpinnings."

Knowing those, he stated, is indispensable because a specific personality structure provides the disposition for certain psychiatric diseases. If we continue to pursue this highly plausible suggestion we could formulate the hypothesis that samples of remitted psychiatric patients differ in a feature way from samples of healthy persons with regard to the distribution of our immaturation indicators shown in illustration 102. Such a differentiation or characterization of psychiatric patients, thus far not even considered, opens the possibility of arriving at developmental-biological groupings beyond all

diagnostic classifications that could be meaningful for therapy planning and prognosis. We already pointed out (see 2.2.1.1. and 2.2.4.) that attempts to replicate a clinical-psychopathological classification through primary quantification of the EEG probably more likely reflect state-outlasting traits like our immaturation indicators than disease-specific pathophysiological processes.

4.7.2. The Individual Immaturation Indicators

In our developmental-biological model of immaturation indicators (illustration 101), diffuse dysrhythmia (DD, illustration 103 and 104) appears as the feature that is associated with the earliest developmental stage. This is the manifestation of impeded processes tending towards an increase in synchronization and frequency acceleration. The importance of DD as an immaturation indicator was noticed early on (LENNOX et al. 1940; HILL and WATTERSON 1942; HILL 1952; LIBERSON 1956; PICARD et al. 1956; COHN 1958, 1961; GASTAUT et al. 1960; WISSFELD and KAINDL 1961; HARRISON et al., 1968).

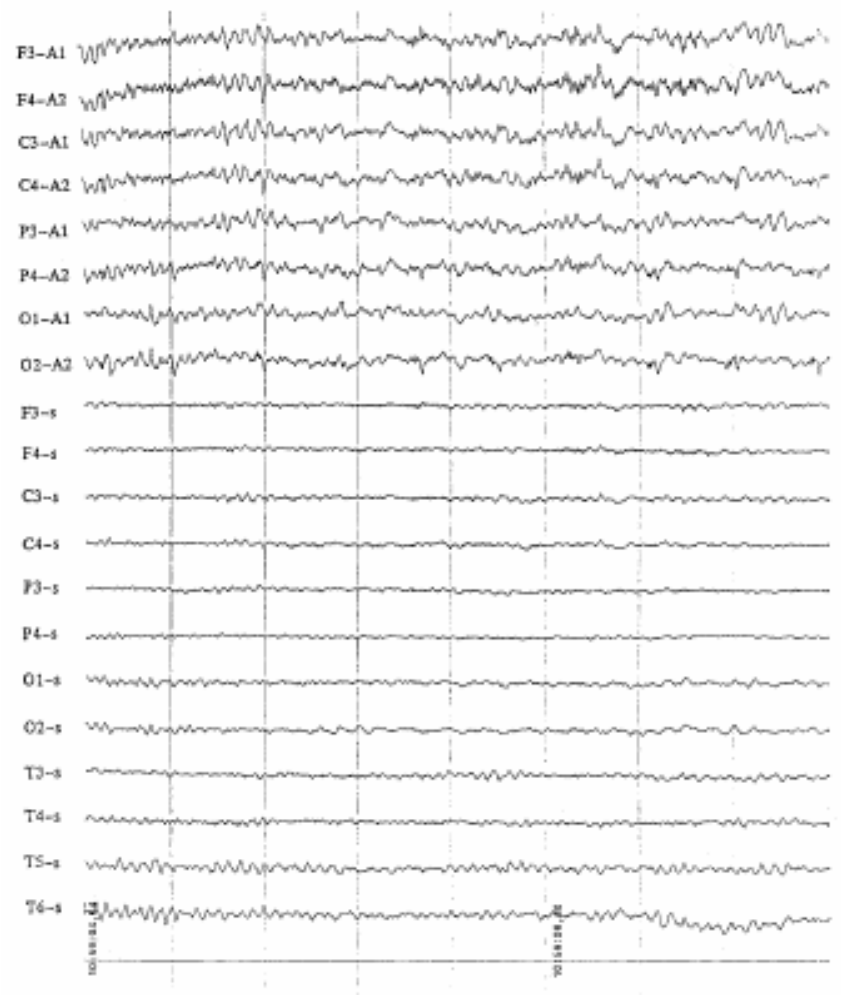


Illustration 103. Slightly diffuse dysrhythmia (DD) with occipital accentuation in patient with hebephrenia; interpreted as constitutional since it was recorded in a medication-free state (K. A., 20 y., m., EEG-nr. 1201/92). Illustration 103-113 identical derivation schema).

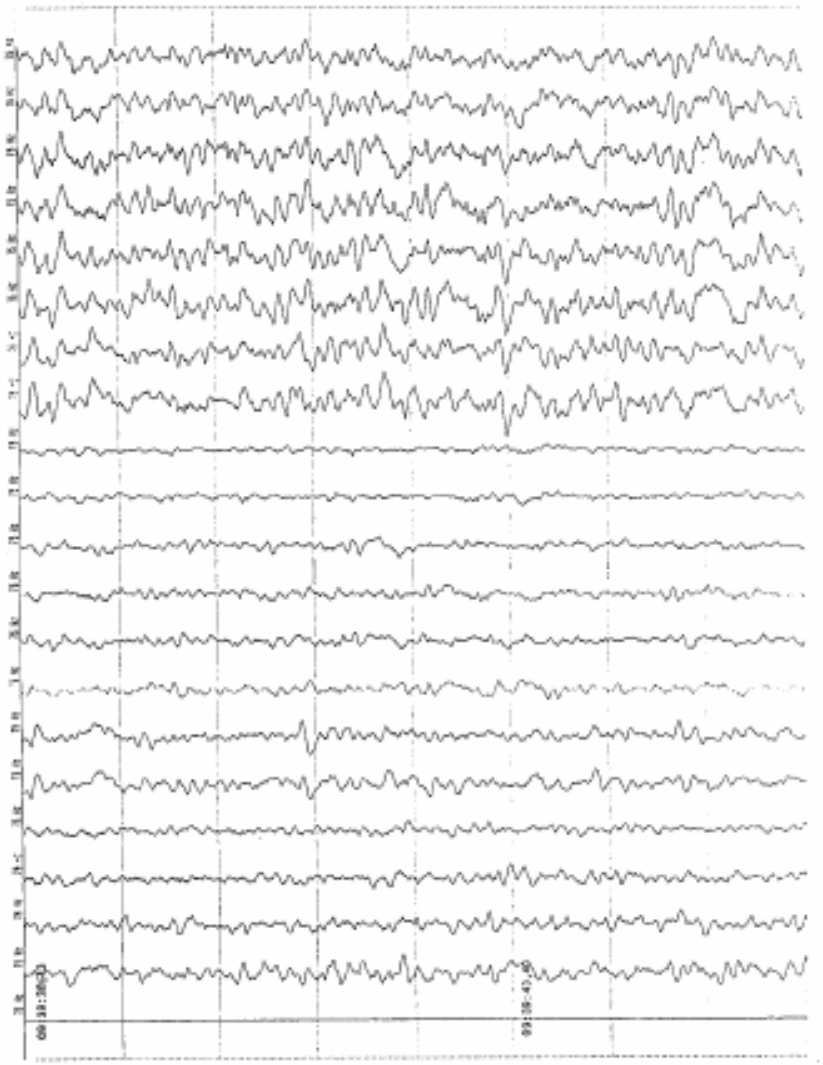


Illustration 104. Pronounced diffuse dysrhythmia (DD) with intermittent right-posterior accentuation (IRP) in a patient with personality disorder; interpreted as constitutional since recorded in medication-free state (J. E., 24 y., m., EEG-nr. 444/93).

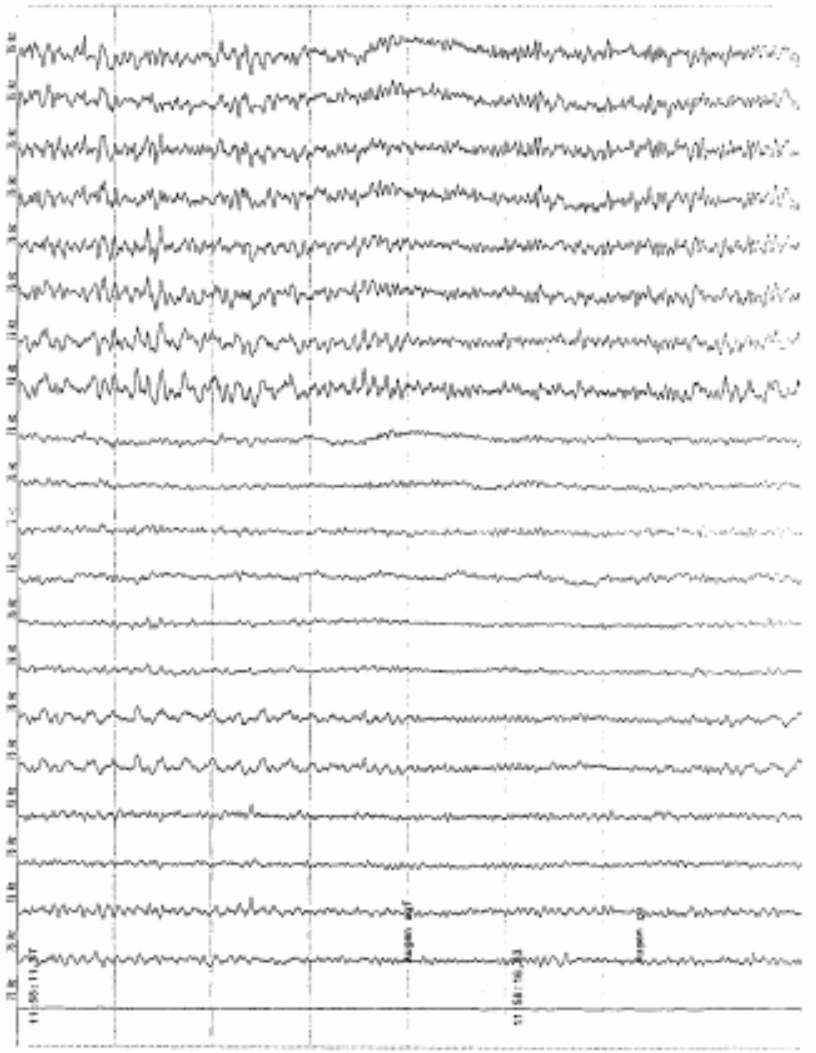


Illustration 105. Intermittent bilateral posterior groups and sequences of a 3-5/s activity (IBP) in patient with anxiety neurosis (10 mg/d diazepam). Picture of a so-called posterior theta-variant, interpreted as constitutional (K. K., 32 y., f., EEG-nr. 666/93).

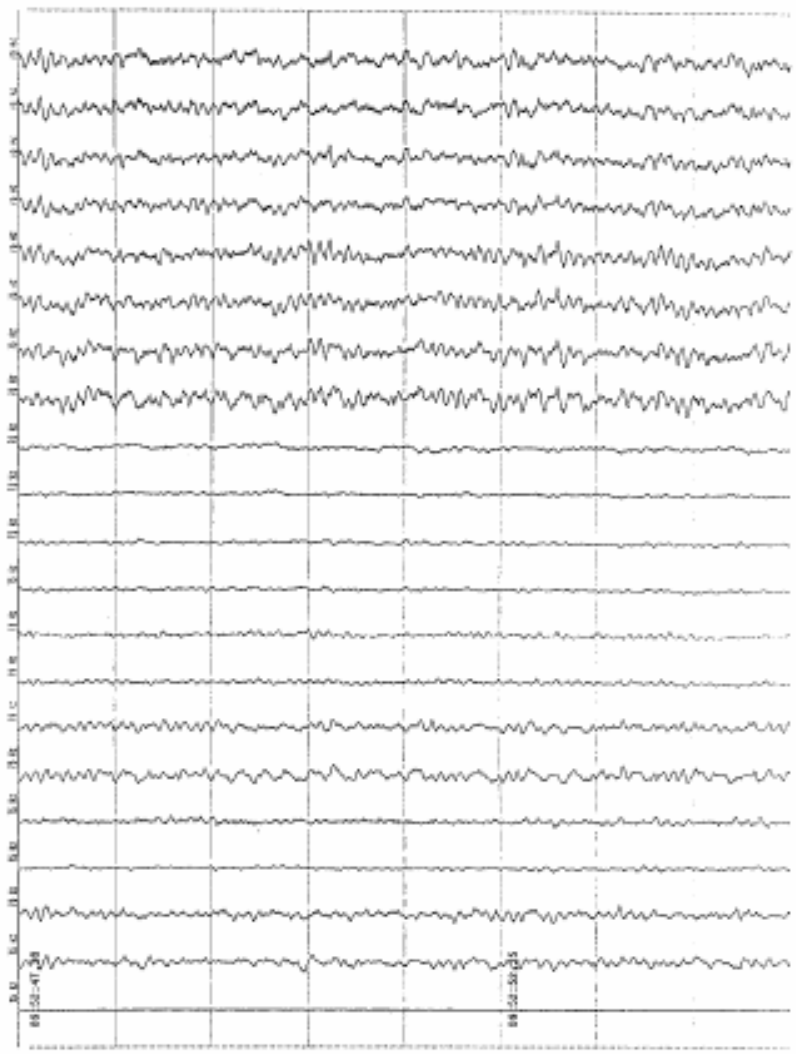


Illustration 106. Intermittent right-posterior (occipital) groups and sequences of irregular slow waves (IRP) in a patient with schizophrenic psychosis under 300 mg perazine (J. P., 22 y., m., EEG-nr. 387/92).

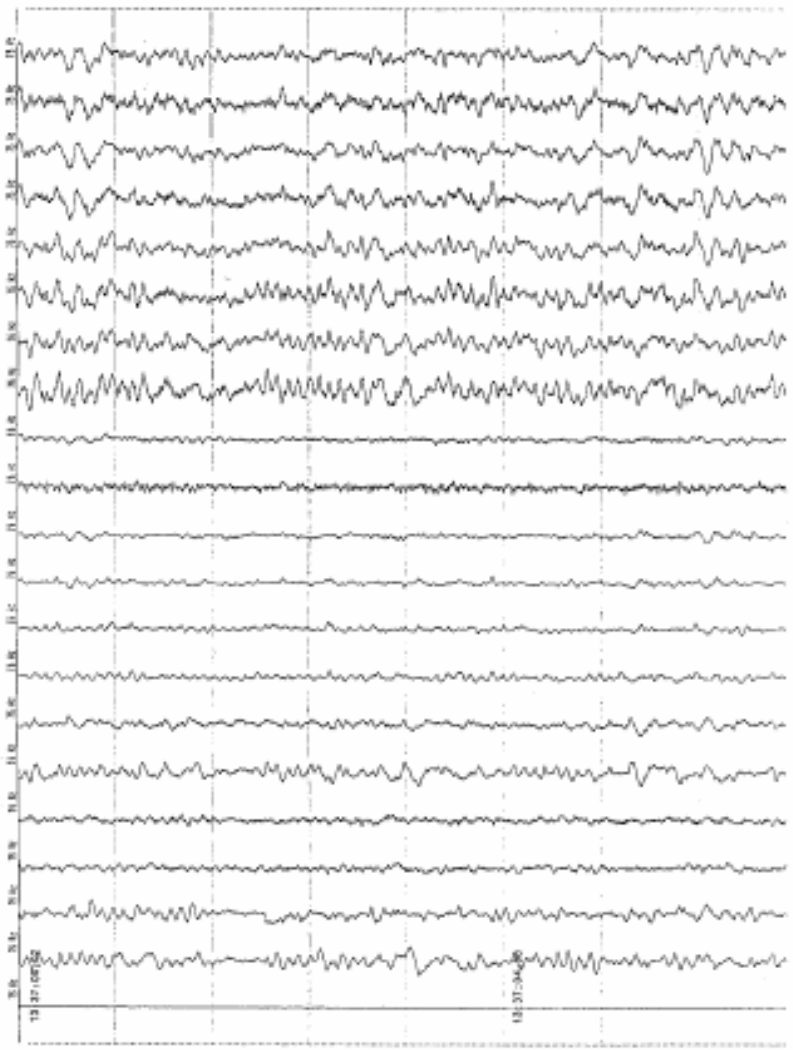


Illustration 107. Intermittent right-posterior (occipital and temporo-posterior) accentuated singular and grouped irregular slow waves (IRP) in patient with schizo-affective psychosis under 150 mg/d perazine and 100 mg/d clomipramine (K. A., 47 y., f., EEG-nr. 606/93).

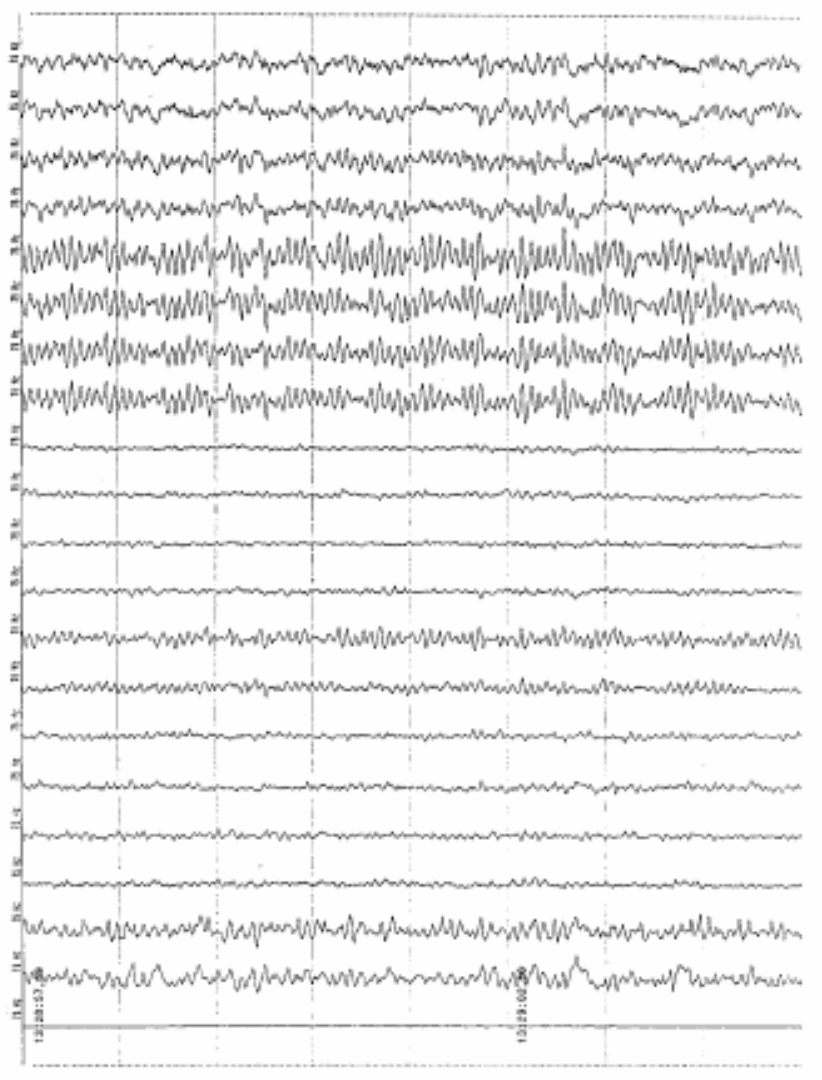


Illustration 108. Intermittent right-posterior (only temporo-posterior) accentuated singular and grouped irregular slow waves, partially also resembling sharp- and slow-wave complexes (IRP) in patient with schizophrenia simplex under 15 mg/d haldol (A. S., 34 y., m., EEG-nr. 303/93).

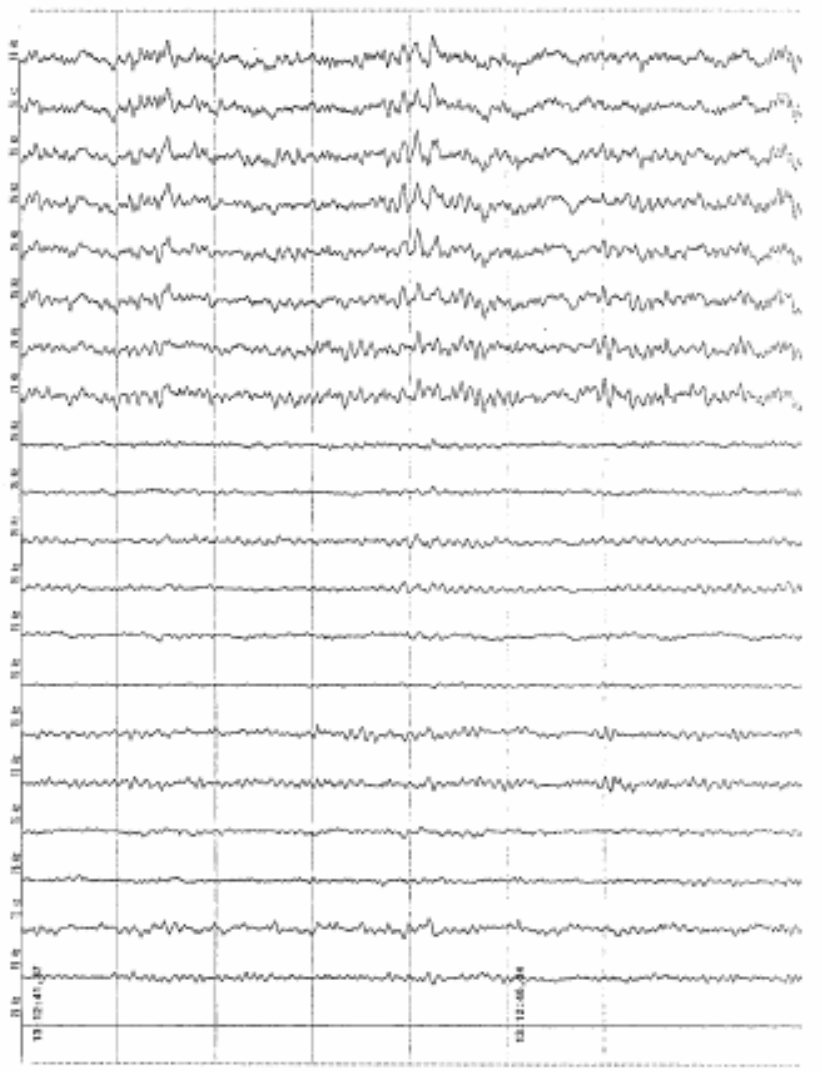


Illustration 109. Intermittent left-posterior (only temporo-posterior) accentuated irregular slow waves (ILP) in a patient with personality disorder, medication-free (N. N., 22 y., m., EEG-nr. 1001/3).

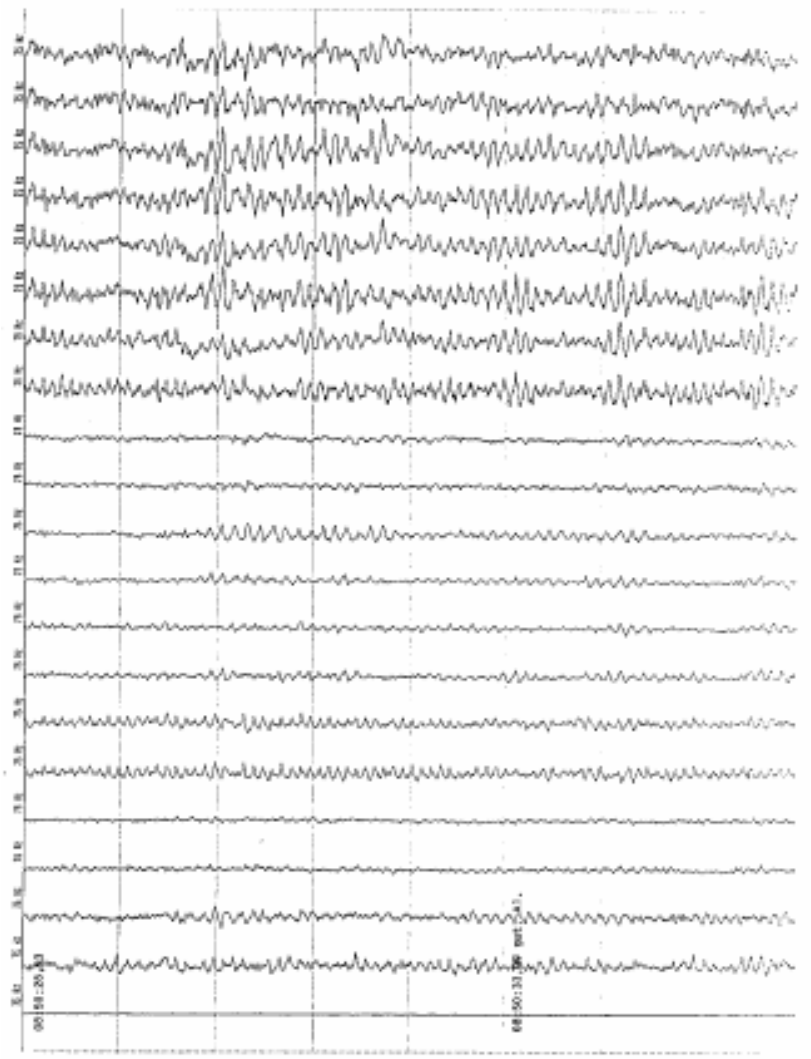


Illustration 110. Under dominating 10/s-activity intermittent left-anterior (fronto-central) accentuated groups of rhythmic and high- amplitude 7/s waves (ILA); interpreted as constitutional since it was recorded in a medication-free patient with anxiety neurosis (I. S., 42 y., f., EEG-nr. 707/93).

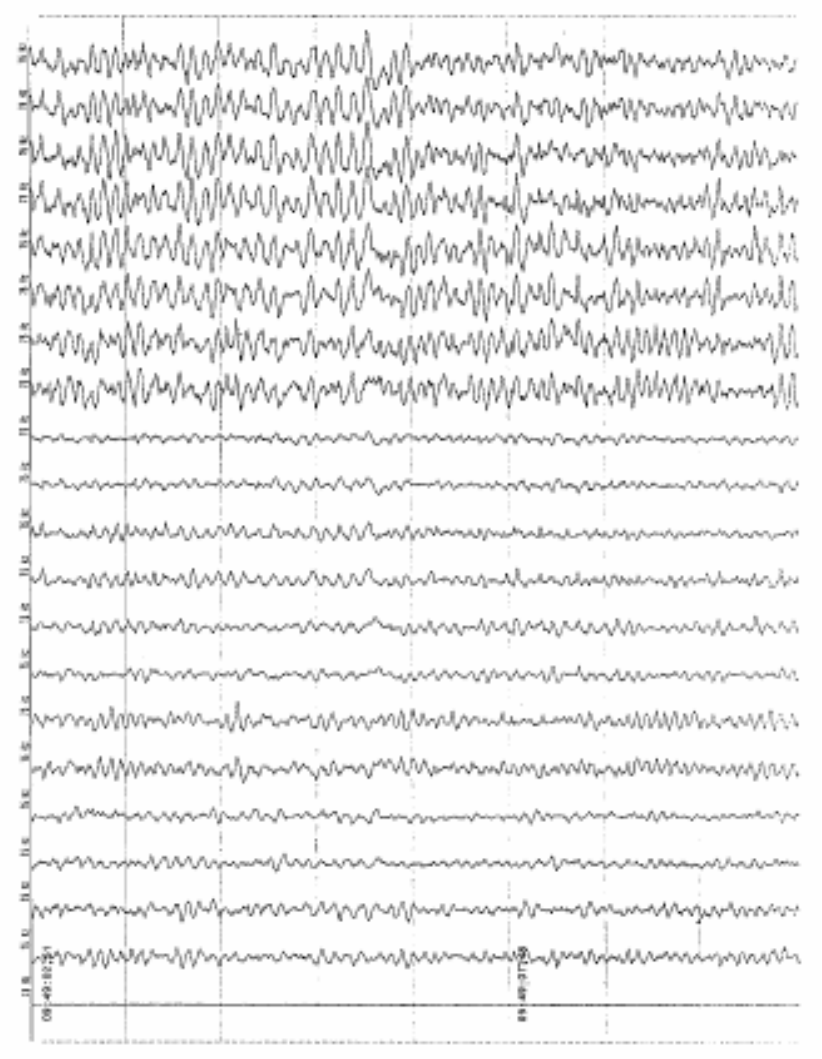


Illustration 111. Under a background activity of approximately 10/s, only discontinuously in the posterior region, bilateral symmetrical high-amplitude 6-7/s waves (IBA) with anterior accentuation in groups and sequences; interpreted as constitutional since recorded in a medication-free patient with personality disorder (O. P., 23 y., m., EEG-nr. 813/93).

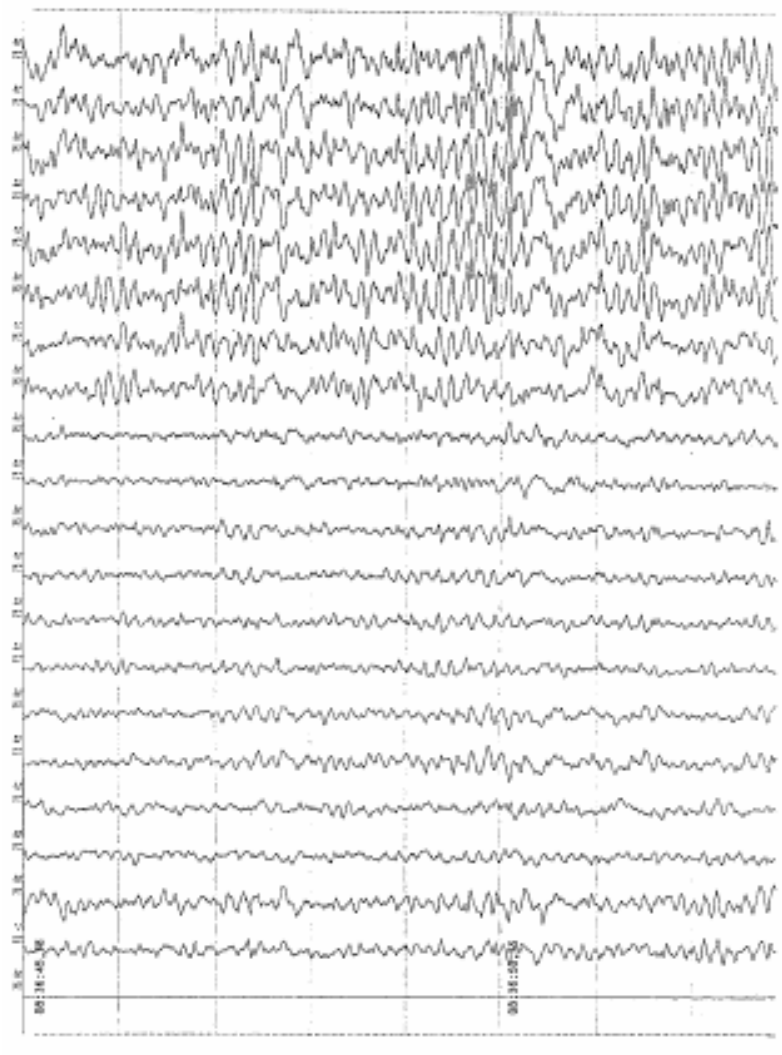


Illustration 112. Dominated by a rather frequency-variable, somewhat slow 7-8/s-activity and increased level of dysrhythmia due to diffuse interspersed irregular slow activity; intermittent anterior-accentuated bilateral symmetrical high amplitude groups of rhythmic waves that often assume paroxysmal characteristics; under 40 mg/d dipiperone recorded from patient with chronic schizophrenia (K. S., 54 y., m., EEG-nr. 111/93).

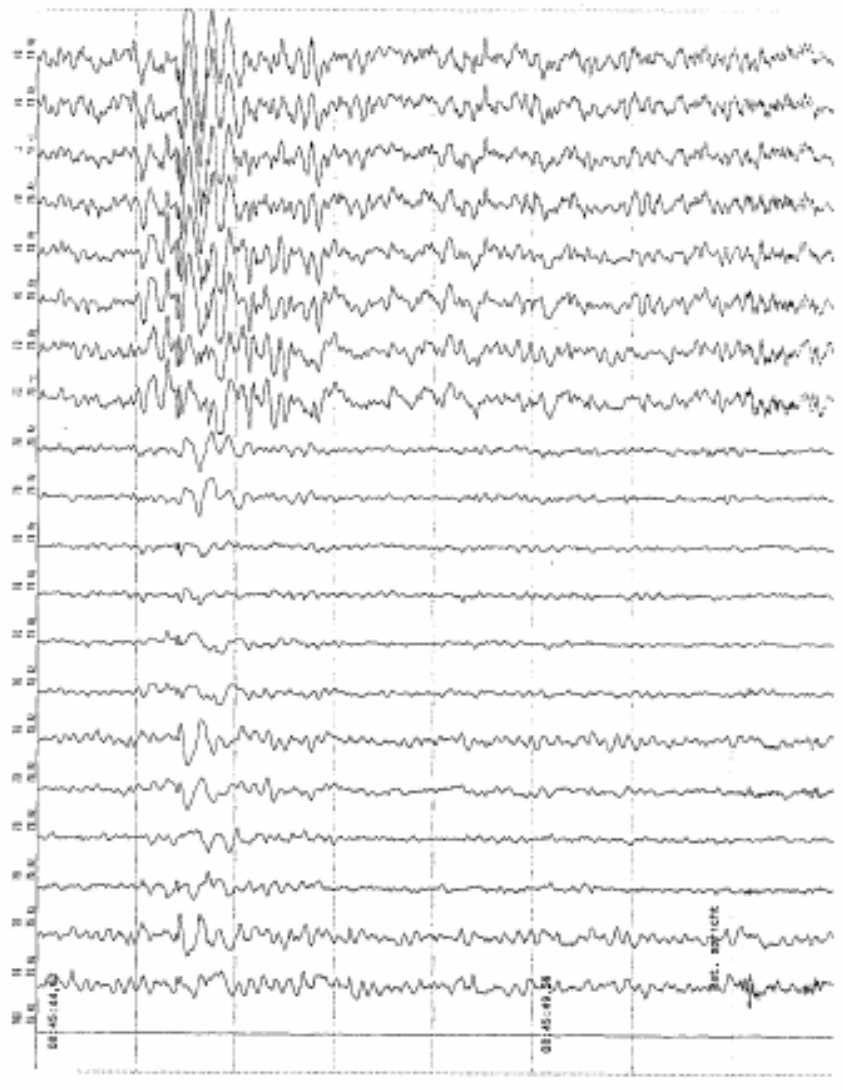


Illustration 113. Paroxysmal-dysrhythmic formation with SW-complexes; interpreted as constitutional since recorded medication-free in patient with disturbed impulse control (K. K., 28 y., m., EEG-nr. 1303/93; illustration 113-116 identical derivation schema).

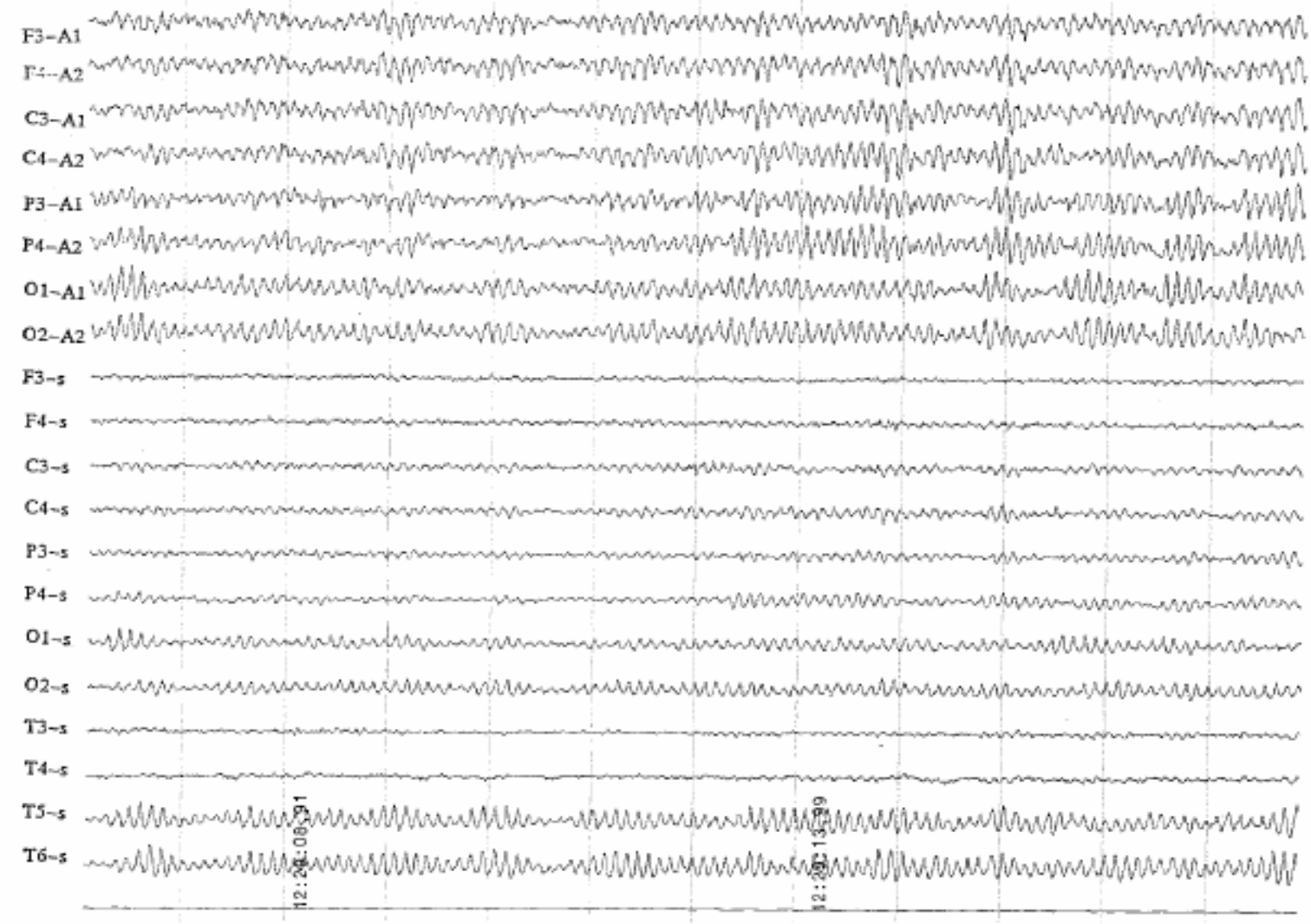


Illustration 114. Monomorph 9/s - activity with continuous anterior spreading. Dynamic rigidity; interpreted as constitutional since recorded medication-free in patient with compulsive disorder. (C.A., 39 J., m., EEG-Nr. 64/93).

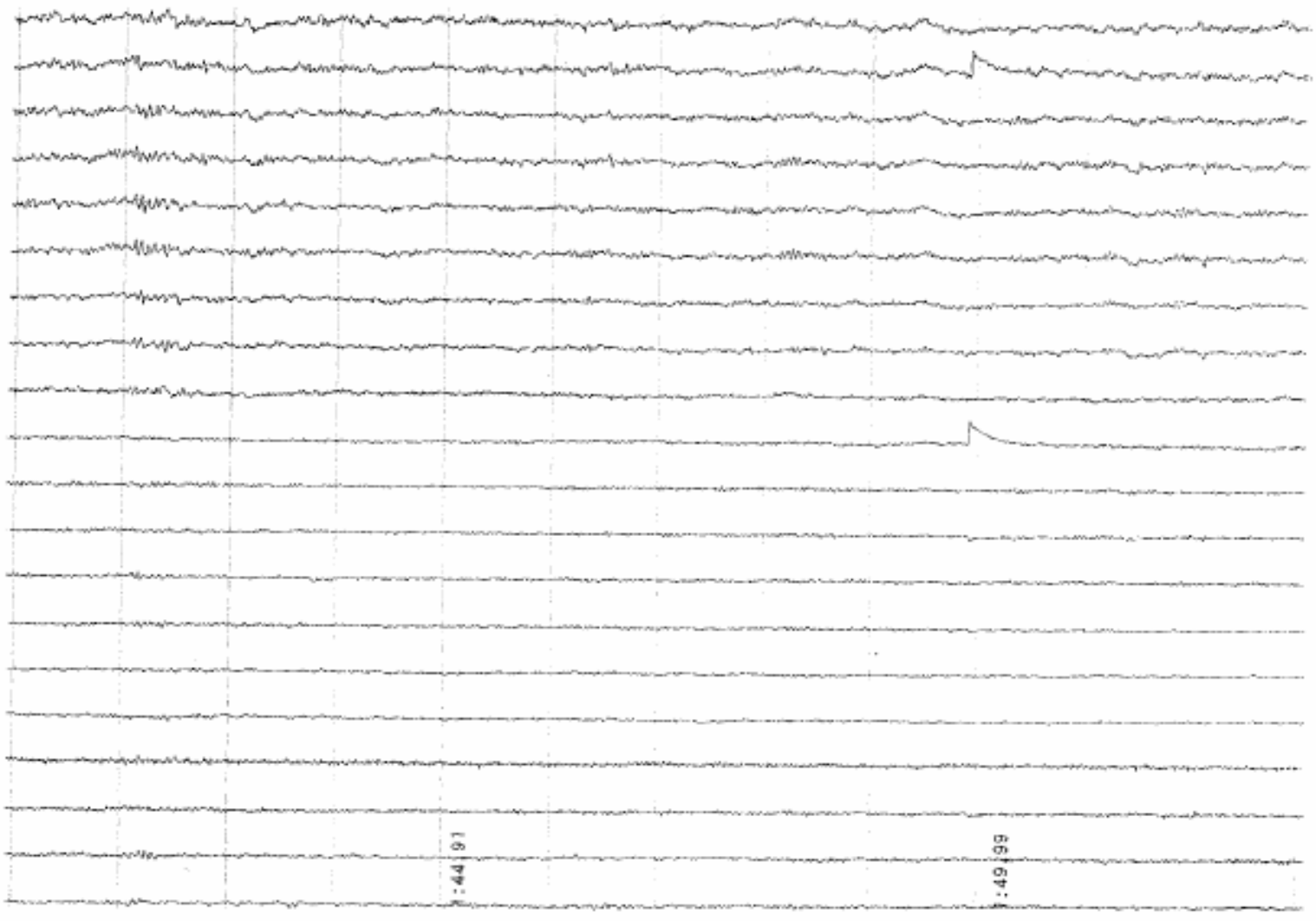


Illustration 115. A 12-13/s-activity appears only in short groups, typically for 1-2 s after closing the eyelid. Dominating is a low- voltage desynchronized activity corresponding to a stage B1. Picture of a dynamic lability; interpreted as constitutional since recorded medication-free in patient with asthenic personality (R. F., 28 y., m., EEG-nr. 87/93).

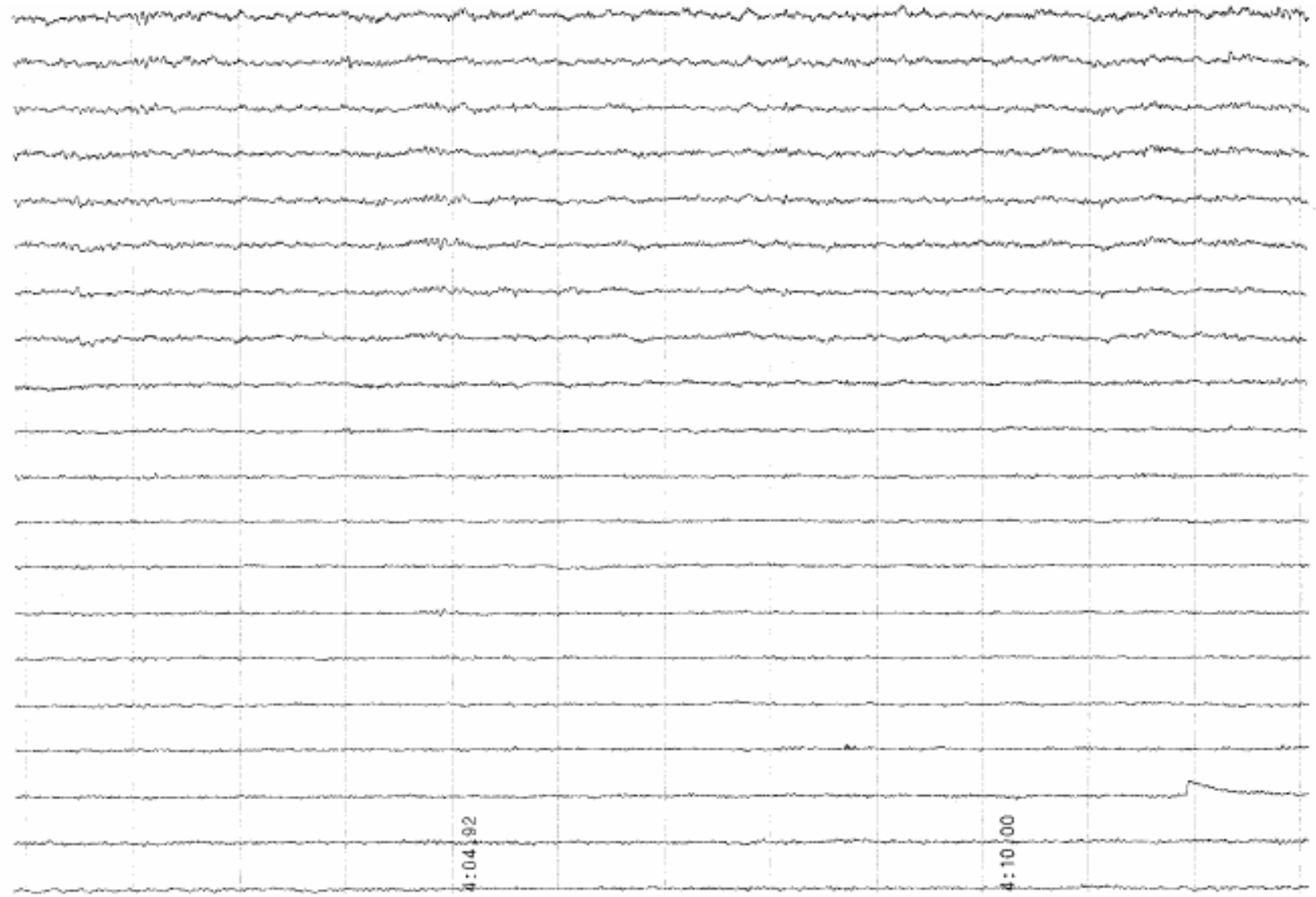


Illustration 116. Similar picture as in illustration 115, this time in patient with chronic schizophrenia under 4 mg/d pimozide; in this diagnosis also to be called "choppy activity" for historical reasons (P. S., 34 y., f., EEG-nr. 999/93).

HILL (1952) stated a prevalence of 0.7% ("theta dominant record") for the healthy average population. In adolescents with behavioral disorders he found the feature much more frequently. Because of the frequency of DD in patients with genuine epilepsy as well as their primary relatives it sometimes was considered a hereditary feature, predisposing for epilepsy and related psychiatric disorders (LENNOX and GIBBS 1940; LENNOX et al. 1940).

We consider the mostly intermittently appearing groups and sequences of slow irregular waves confined to the posterior derivation regions - be it the bilateral symmetrical (intermittent bilateral posterior = IBP; illustration 105), the asymmetric, usually right-accentuated (intermittent right posterior = IRP) or the rare left-accentuated (intermittent left posterior = ILP; illustration 109) variant - as a developmental-biological form of degradation of the DD. There is no lack of literature reporting features-correlated behavior and personality disorders (HILL 1952; GASTAUT et al. 1957; COHN and NARDINI 1958; AIRD and GASTAUT 1959; PETERSEN and SÖRBYE 1962; MÜLLER-KÜPPERS and VOGEL 1965; BERGES et al. 1966; KUHLO et al. 1969; NEUNDÖRFER 1970; HEINTEL 1975; ZANGMEISTER and BUSHART 1977; JURKO and COLLE 1982; ULRICH and OTTO 1984a, 1984b; KASPER and KICK 1987; ULRICH and BOHN 1988; SCHEULER et al. 1988; WENDLAND and FENZEL 1992).

The area of behavior correlates considered typical ranges from bland adjustment problems and habitual violence to delusional syndromes of atypical appearance. A powerful argument for the acceptance of IBP and IRP (or also ILP) as immaturation indicators are the often confirmed findings that the posterior-accentuated irregular 2.5-4.5/s activity that is considered development-typical in infants shows a right-accentuation until the age of six. This proves that the maturation process that leads to the adultomorph posterior-accentuated alpha-background rhythm takes place asymmetrically. Obviously, the left-posterior regions mature in these cases faster in comparison to the right-posterior ones.

Another argument for the interpretation of the IBP-/IRP (ILP)-phenomena observed in adults as immaturation indicators are the findings obtained from children. COHN et al (1958) found a slow posterior activity in 17% of psychologically inconspicuous children between the ages of 6 and 12 and in 62% of children of the same age group with behavior disorders. The much higher prevalence of this feature in children with behavior disorders as compared to children without this disorder can be considered as proven (f. i. SILVERMAN 1958; KELLAWAY 1958). This prevalence decreases with increasing age towards the end of the maturation process and finally remains constant. Because of the relative age-relatedness, proving this phenomenon certainly has a very different meaning in adults than in children or adolescents. Thus, it is only in adults that we are allowed to consider IBP/IRP (ILP) as immaturation indicators in the more concrete sense. During childhood and adolescence, the phenomenon, because of its potential reversibility, only permits the assumption of a delay in maturation. An evaluation of the possible clinical significance of IBP/IRP (ILP) requires prevalence comparisons between normal samples of behaviorally inconspicuous persons on one hand and samples of psychologically disturbed persons on the other hand.

A proportion of 0.12 or 0.24% of carriers of the feature among healthy candidates for a pilot career (VOGEL and FUJIYA 1969) can be contrasted with 5-7% of carriers of the feature among psychiatric inpatients under treatment (COHN and NARDINI 1958; ULRICH and OTTO 1984a, 1984b; KASPER and KICK 1987; ULRICH and BOHN 1988). The genesis of this phenomenon seems, as with all other immaturation indicators, to be independent of the nature of the influences that hamper the development.

As we tried to present as a model in illustration 101, the point in time when the respective influence occurs seems to be the decisive factor for the type of maturation deficit that is realized. The findings of MÜLLER-KÜPPERS and VOGEL (1965), claiming that an increased incidence of posterior dysrhythmias in a certain family indicates an autosomal-recessive hereditary mode, do not contradict our opinion. Assuming the validity of the mentioned observation, the spectrum of possible causes is expanded only to the hereditary aspect. The increased incidence in certain families in connection with behavioral peculiarities was also confirmed by JURKO and COLLE (1982).

Still under the conventional assumption that a focal EEG-phenomenon such as IRP as a manifestation of a residual cortical injury can be interpreted neuroanatomically/neuropsychologically, we questioned its clinical significance in two retrospective, controlled studies (ULRICH and OTTO 1984a, 1984b; ULRICH and BOHN 1988). With a representation of 5% among the inpatients of our hospital, IRP was found in 7% of the patients with schizophrenic disorders, in 2.4% of patients with neuroses and personality disorders and in 2% of the patients with affective disorders. Among the patients who because of the EEG- findings were examined computer-tomographically, not one single case indicated a structural lesion that was topographically associated with the EEG-focus. Among the patients with schizophrenic psychoses the IRP-carriers showed, compared to gender-matched control patients:

- a lower age - an earlier first manifestation of the psychoses
- more frequent anamnestic indications of perinatal complications
- a higher familial incidence of psychiatric disorders

A comparison of the AMDP-documented psychopathology showed a number of statistical differences in distinctiveness on the level of single symptoms that, taken as a whole, indicate an accentuation of hypermotor-expansive tendencies among the IRP-carriers. Based on the nosologic unspecificity of IRP, we discussed the possible significance of the feature on a prephenomenal level, maybe as indicator of a certain pathoplastically effective and prognostically relevant psychobiological matrix. We discussed possible relationships with the "precursory defect" ("vorauslaufender Defekt", JANZARIK 1959) and the "subtle neuro-integrative defect" (MEEHL 1962) and tried to prove that carriers of the phenomenon do not necessarily

have to develop psychopathological disorders. Further we examined the question regarding the relationship with the adult minimal brain damage syndrome (BELLAK 1979). For the evaluation of the individual significance of IBP/IRP (ILP), as, of course, also all other immaturation indicators, the degree of distinctiveness probably plays a role. Typically, the phenomenon will be more pronounced when accompanied by a spontaneous or pharmacogenic lowering of the vigilance level - and in some cases identifiable only under these circumstances.

The most important result of our studies regarding the IRP-phenomenon is, in our opinion, the confirmation of our thesis that specific locally delineable EEG-phenomena do not have a structural correlate (s. a. ILA, chapter 3.1.) and thus do not allow a brain-topographical/neuropsychological interpretation. However, such still common attempts at interpretation are not only inappropriate but, in addition, block the fecund and future-oriented, developmental-biological perspective.

To emphasize this once again seems very important to us, especially with regard to the neuroanatomic research focus in psychiatry reactualized through the modern imaging technologies.

In comparison to the posterior phenomena IBP/IRP (ILP), the anterior phenomena IBA/ILA (illustration 110, 111, 112) we have already encountered as state-related manifestations of a pathological gestalt/functional change (s. a. 3.1. and 4.1.4.) evidently attracted less attention as indicators of immaturation. Anterior-accentuated "runs of rhythmic bilateral 4-7/s activity" (s. a. table 2) were found by HILL (1952) in incarcerated violent perpetrators twice as often as in control groups. Since this phenomenon can be observed physiologically between the 5th and the 10th year of age (MUNDY-CASTLE 1951) and often persists into early adulthood, HILL regarded it as a sign of immaturation, a view shared by LIBERSON (1958).

We owe more detailed insights to the research conducted by WILLIAMS (1969). WILLIAMS, too, found that the phenomenon was clearly overrepresented in habitually violent persons. This author found the phenomenon either temporo-anterior or frontally accentuated. In two-thirds of the cases, it was bilateral-symmetrical while in the case of asymmetry, it was usually left-accentuated. The frequency, the author indicated, usually lies around 4-7/s but can be lower. A simultaneous occurrence of theta- and delta-formations in one and the same EEG represents the rule rather than the exception. This would prove that the frequency is unimportant for the functional significance of the phenomenon.

Especially interesting to us is the comparison of the posterior (IBP/IRP) phenomena with the anterior ones (ILA/IBA) which were also overrepresented in the examined sample of violent persons: the anterior phenomena indicated a closer correlation with the personality feature of violence than the posterior ones. This coincides with ELLIOTT'S findings (1976), claiming that the anterior phenomena are more closely related to the "dyscontrol syndrome." Although the afore-mentioned studies make no note of the asymmetrical, usually left-accentuated variant of IBA, i. e. ILA in particular, we still think ourselves justified in

assuming an intrinsic relationship between ILA and IBA. An important argument for this is, in our view, that these phenomena and transitional forms often appear simultaneously in one and the same EEG (s. a. illustration 110). As far as we know, only BLANC and LAIRY (1961) and BLANC (1962) examined the state-unrelated occurrence of ILA. The authors found ILA overrepresented in persons with character neuroses (néuroses de caractères) and assumed a basic "immaturation neuronique," with a predisposition for neurotic decompensation.

With our present, by no means yet sufficiently supported, state of knowledge we tend to regard flaws in social behavior as the primary deficit associated with IBP/IRP (ILP), and impaired impulse control as the primary deficit associated with IBA/ILA.

We also associated an impulse control impairment with paroxysmal (epileptiform) potentials (PP; illustration 112, 113). We positioned these in our model (illustration 101) in the immediate developmental-biological neighborhood of ILA/IBA. In diagnostically unselected samples of psychiatric inpatients, STRUVE and coworkers found a clearly higher rate of suicidal acts in the case history of those with PP in the resting EEG than in those without PP (STRUVE et al. 1972, 1973; STRUVE 1983). The suicidal acts of the phenomenon carriers were to a very large extent of the impulsive-reactive nature, as opposed to those of the non-carriers.

> Since suicidal acts based on an impulse probably have a lower success rate than carefully planned ones, it does not surprise us that, despite a lowered threshold, the suicide rates among the phenomenon carriers are are no higher than among non-carriers.

If an impairment of impulse control is the primary defect in the psychological domain of description, the carriers of this EEG-phenomenon naturally should show, in addition to the lowered threshold for suicidal acts, an increased incidence of the other reflections of this primary defect. Since STRUVE'S research was focused on the suicide risk and no other studies exist, we must be content with assumptions. For obvious reasons, the findings in epileptics are of special interest in this context. Impaired impulse control which manifests itself in destructive acts has long been observed in patients with genuine epilepsy (f. i. HILL and POND 1952; ERVIN et al. 1955; TREFFERT 1964). That such destructive acts can be directed not only outwards but also inwards was substantiated by GUNN (1973) in a sample of violent prisoners suffering from epilepsy. Among the epileptics, there was a significantly higher incidence of suicidal thoughts than among a matched sample of non-epileptics. That not the epileptic disease but the exaggerated neuronal synchronization at the functional substrate of the PP- phenomenon is hereby important is evidenced in the findings obtained by DAVIES et al. (1975) from schizophrenics. Compared to schizophrenics without PP, those with PP manifested a higher incidence of many variations of impaired impulse control, including impulsive suicidal acts. The differences between the groups were considerably more evident in the EEG derived under the influence of neuroleptics than in the premedication EEG. Whether someone develops PP under the influence of neuroleptics depends not only on the kind and dosage of the neuroleptic but also on an individual disposing

factor (HELMCHEN and KÜNKEL 1960; NEIL et al. 1978; s. a. chapter 4.5.2.). In the study by NEIL et al. 50% of the patients with PP under neuroleptics treatment did not manifest any PP prior to the treatment. This effect is extremely stable intra-individually.

> We want to remind the reader here of the fact that immaturation indicators such as DD, IBP/IRP (ILP) and IBA/ILA often become obvious only after a physiological or pharmacogenic lowering of the vigilance level.

Findings that schizophrenics with PP more often present an atypical psychopathological picture (BENTE 1963; VISSER et al. 1964; EMDE and METCALF 1969) indicate a pathological significance of PP exceeding the phenomenon of impaired impulse control.

Since STRUVE'S findings seem on the one hand to be relatively unknown and on the other hand have not remained uncontested (TUCKER et al. 1965; SMALL et al. 1968; VOLOW et al. 1979), we tried to form our own opinion through a retrospective study involving a sample of psychiatric inpatients with a variety of diagnoses (ULRICH and HEGEWALD, unpublished). Excluded were only those patients for whom no EEG or only one seriously disturbed by artifacts was available. Because of the special position of clozapine with regard to the induction of PP (s. a. 4.5.2.), we also excluded the patients treated with this neuroleptic. Of the remaining 1003 patients, mostly treated with psychoactive drugs, 51 (5.1%) showed PP in an EEG recorded under the customary resting conditions with additional hyperventilation. Only 5 of these 51 patients were epileptics. Thus, the prevalence of PP in our sample was approximately twice as high as in the sample studied by BRIDGERS (1987) with 2.6% that also involved psychiatric inpatients. In a sample of healthy young male applicants for pilot training the prevalence was only 0.5% (GREGORY et al. 1993). This corresponds exactly to the findings by GOODIN and AMINOFF (1984) for the general population. Thus we can conclude that PP is overrepresented in a psychiatric population by a factor of at least 5 to 10. After dividing our patients into those with PP and without and those with suicidal acts in the case history and without we arrived at the following distribution:

Table 9. Bivariate frequency distribution, divided into patients with (+) and without (-) paroxysmal (epileptiform) potentials (PP) in the resting EEG as well as into those with one or more (+) or no (-) suicide attempts in their case history. For 41 patients, no pertinent data were available.

		SA		
		-	+	
PP	+	25	25	
	-	631	281	(n=962)

According to the differences in the distribution, statistically, significantly more anamnestic notes about suicide attempts were found for patients with PP than for patients without PP ($chi^2 = 8.05$, $p < 0.01$). These findings basically confirm STRUVE'S findings. Assuming that the psychological defect of impaired impulse control indicated by PP should manifest itself not only inwards but outwards, we examined the relationship between PP and selected psychopathological features of the AMDP-system that we use routinely for the documentation of the admission psychopathology of our inpatients. We considered "aggressive," "irritated," "increased drive," "motor restless" and "affective labile" as possibly relevant features. In none of these cases was a significant relationship discovered.

> For the evaluation of this negative result, we must make the restriction that the AMDP-system as an instrument for the registration of the psychopathological cross-sectional picture and its time course is hardly suitable to provide a reasonably reliable picture of personality traits. A definite answer for the question we stated above requires a prospective study design, using special personality inventories.

Of course, theoretically, the higher frequency of suicide attempts in persons with PP could also be caused by a basically depressive disposition, a possibility that was not investigated by STRUVE et al. Trying to compensate for this omission under the existing methodical limitations, we considered the AMDP-feature "depressed mood" as an indicator of a state-unrelated depressive basic disposition. It was remarkable that the hypothesis of a relationship between "depressed mood" and the frequency of suicide attempts could be maintained for patients without PP (chi2= 11.01, $p < 0.01$), with an intraspecific association coefficient of + 0.76, according to COLE (LIENERT 1973), but not for the patients with PP (association coefficient: - 0.16). The highly significant difference between the two association coefficients ($p < 0.001$) indicated that suicide risk cannot be traced to a uniform personality feature but that at least two psychological primary defects

can be distinguished. According to our findings, depressive personalities are overrepresented among suicidal persons without PP, and persons with impaired impulse control are overrepresented among suicidal persons with PP. Such a differentiation involving the EEG could have some bearing on the question as to whether a suicidal person should be treated with psychotherapy or with pharmacoprophylaxis such as serotonergic substances. To avoid a possible misunderstanding, we finally want to emphasize that suicidal persons without PP are by far more numerous than those with PP - according to table 9 approximately 10 times as much.

The dynamic rigidity (DR) and the dynamic lability (DL) were, if regarded at all, viewed rather as norm variants than as immaturation indicators. Only for the more extreme forms (illustration 114) in one or the other direction (illustration 115) was the possible maturation deficit considered but not investigated (HILL 1952; PICARD et al. 1957; GASTAUT et al. 1960; DONGIER et al. 1965). This might also be caused by the difficulties of arriving at categorizations with a continuous distribution of the feature. Primarily quantitative approaches are hopeless a priori (s. a. 2.2.2.).

REMOND and LESEVRE (1957) divided a sample of healthy persons into those with a relatively continuous (group I, 19%) and those with a relatively discontinuous (group III, 32%) alpha background activity and besides that also formed an intermediary group (group II, 49%). A more pronounced continuity of the background activity was regularly accompanied by a relatively slower and monomorph frequency of approximately 8-9 Hz and an anterior spreading tendency. The relatively discontinuous EEGs of group III were dominated by low-voltage and desynchronized activity phases with variable beta-amount, sometimes with interspersed theta-waves. The intermediary group II was characterized by a continuously posterior weighted spindle-form modulated 9-11/s-activity. We repeat that we classified the formative tendencies associated with group I under the term dynamic rigidity (DR) and those associated with group III under the term dynamic lability (DL) (see 3.1.; illustration 26). The vigilance dynamics of the intermediary group II can be termed physiomorph. It now became evident that the persons with physiomorph vigilance dynamics had the comparatively best results in a variety of psychological tests. Persons with DR (group I) differed from the two other groups in a slower psychological speed, lower reactivity and higher passivity. The persons with DL (group III) were comparatively more reactive, emotionally less stable, more impulsive and more neurotic in general. These classifications confirm the observations of earlier authors. It was STRAUSS (1945), for instance, who found a lower continuity, amplitude and regularity of the EEG related to personality-bound anxiety, difficulty of adaptation and increased mental fatigue. SAUL et al. agreed with these findings and emphasized in addition that the EEG- features corresponding to the neurosis cannot be influenced through psychoanalytical treatment. As an extreme form of DL, we consider those by no means rare low-voltage-desynchronized EEGs that are often falsely blamed on "psychic tension," where an alpha-rhythm can be found only temporarily in short groups of 1-2 s duration, most frequently upon the closing of the eyelids (illustration 115).

> As we tried to prove in another context, the low-voltage desynchronized activity must be associated with a subvigil intermediary stage B1 and not with an arousal reaction (s. a. 2.2.5.).

Although this phenomenon did not go unnoticed - for instance, its special relationship to a neurotic symptomatology was pointed out (PINE and PINE 1951; PICARD et al. 1960; DONGIER et al. 1965) - we recognize, here too, a further need for research. The contrast between the personality features of persons with relatively rigid and those with relatively labile EEGs, pointed out by REMOND and LESEVRE (1957), could create the impression that only persons with unstable EEG have a disposition for neurotic disorders. The reason for this is probably that traditionally extravert-active peculiarities of behavior are much more likely to be called neurotic than introvert-passive ones. However, according to personality-psychological categorizations, adaptive deficits in the sense of passive-phlegmatic slow movement behavior with adjustment difficulties and possibly depressive disposition can also be found in persons with DR.

The quoted findings underline our biperspectivistic concept stating that morphodynamics can be associated with the current system's state as well as with personality characteristics.

As we remarked before (s. 4.7.1.), psychiatric EEG-research has thus far largely ignored the question of disposing factors. Besides the hypothesis of depression-predisposing morphodynamics that was confirmed by numerous findings (s. a. 4.2.1.) we recognize an enormous need for research with regard to schizophrenic psychoses. To this very day, no study existed that systematically investigated the "choppy activity" (illustration 116) that was considered typical for schizophrenia by DAVIS (1941, 1942) and that, based on the given characterization, could casually be subsumed under DL. Although a reference to "choppy activity" can be found in nearly every article about the topic schizophrenia and EEG, the important question, whether the feature varies with the state or must be considered as state-unrelated, i. e. constitutional, has not yet been answered. Because of our own observations, though not yet systematized, we cannot share DAVIS'S (1942) assumption that the "choppy activity" might be a manifestation of an ongoing cortical excitation. It is our impression, based on routine evaluating, that "choppy activity," or DL, as observed in schizophrenics, is a relatively stable feature, which can also be found during psychosis-free intervals and is unchanged over a period of many years. The same is true for the EEG associated with schizophrenics with a continuous, monomorph, slightly anteriorized and seemingly rather slow background activity that point towards DR. Without being able to prove it with numbers we consider a certain rough relationship between the EEG- dynamics and the type of the psychosis as a given. For instance, we frequently see a relatively slow EEG pointing towards DR in rather symptom-free hebephrenic psychoses. In catatonic pictures, IBA or PP is overrepresented. A DL ("choppy activity") is found primarily in the remaining majority of the cases, i. e. in the paranoid-hallucinatory forms. The treatment with neuroleptics, of course, makes the systematic study of these relationships considerably more difficult, if not impossible. Therefore, a medication-free recorded EEG is an indispensable requirement in electroencephalographic schizophrenia research.

Although there was already wide agreement about this in the Sixties (IGERT and LAIRY 1962; BENTE 1963; FEIGENBERG 1964; HELMCHEN and KÜNKEL 1964; ITIL et al. 1966, 1975), no follow-up occurred. Instead, important findings of this time were forgotten. Thus it still is considered true that the relatively slow, monomorph EEG pointing towards DR as we find it in hebephrenic and chronic forms suggests a relatively poor drug effect. Also dubious is the effect of neuroleptic drugs in patients with DD or IBP/IRL (ILP). On the other hand, neuroleptics have a rather positive effect in patients with discontinuous background activity marked by a prevalence of low-voltage subvigil B1-stages corresponding to DL and in patients with IBA and PP. As explained previously (see 4.3.), we were able to confirm and specify the existence of a relationship between vigilance dynamics and the therapeutic reactivity to neuroleptics with quantitative methods in a study involving acute schizophrenic patients (ULRICH et al. 1988). While we considered only success or non-success for this correlation study we, in the meantime, find another approach intriguing that is, in accordance with the procedure applied by REMOND and LESEVRE (1957), based on a classification in three categories depending on the pre-medication EEG-dynamics. Analogous to the findings obtained by these authors, a hypothesis can be formulated and tested, claiming that schizophrenics with physiomorph dynamics who also supposedly possess a comparatively better psychological ability for adaptation have a better therapeutic reactivity and prognosis than the patients diagnosed with dynamic lability and dynamic rigidity. Possibly even a graduation physiomorph - dynamically labile - dynamically rigid can be established here. After all, our view of "physiomorph vigilance dynamics" as indicator for a favorable drug effect was confirmed, among other things, by our already presented findings (see 4.5.4.) about the phase-prophylactic effect of lithium in patients with affective psychoses (ULRICH et al. (1993).

5.

What must be done?

In our introduction, we mentioned the sine qua non, and we repeat it here: a psychiatric institution needs its own EEG-lab. Furthermore, we addressed the communication barriers between the treating physician and the evaluating EEG clinician whose role may interfere in a fruitful cooperation. Once a problem is recognized and verbally defined, solutions for it can be envisioned. Therefore, in conclusion, it seems helpful to familiarize the reader with the observations gained over many years and to view the problems from many different perspectives, as well as with the conclusions we reached.

Readiness for Dialogue / Ability for Dialogue

Both can be improved with regular, at least weekly meetings providing physicians with an opportunity to receive additional explanations about written findings or clinically relevant conclusions. The EEG-clinician, on the other hand, can ask questions and find out about facts which seemed irrelevant from the clinical perspective but might be essential for the interpretation of the findings record or from a scientific point of view. Of utmost importance to these meetings is an open and pressure-free atmosphere. It is the role of the senior partner today to counteract the unfortunately increasingly frequently observed uncritical passivity of young scientists - taking notes (!) instead of joining in the discussion in a controversial- constructive way. More than ever, it is advisable for teachers to emphasize to the students the basic dependency of all our statements upon the point of view we choose. Whether the insecurity thus caused will provoke independent thinking or lead to an invincible communication barrier will depend largely also on the general spirit of the place.

Normally, the dialogue between physician and EEG-clinician happens in writing. A request for an examination is answered by a findings record. To avoid misunderstandings, certain rules must be respected. An EEG-request must be preceded, as a matter of principle, by a neurological and a psychiatric examination. The most important findings and possible psychoactive medication, as well as the problem statement, must be communicated as clearly as possible to the EEG-clinician. The findings record, divided into a descriptive and an evaluating part, must be formulated equally clearly and concisely. Here, emphasis must be placed on the clinical consequences. If there are none, this should be specifically stated. For understandable reasons, the unfortunate widely popular indulgence in meaningless descriptive terminology is extremely irritating (s. a. 2.2.1.4.). The bad habit of considering the evaluation not as a conclusion for the treating physician, formulated in clinical language, but as an absolutely redundant summary of the description in EEG-terminology is the rule rather than the exception.

Statement of Indication for an EEG-examination

While requesting an EEG-examination without clearly stated clinical questions can be justified if it is limited to a neurological diagnosis by exclusion, an indication should be required for all EEG-examinations exceeding this goal.

The in itself logical principle that a diagnostic measure ordered by the physician needs a rational justification under all circumstances seems to weaken especially in the EEG-sector nowadays. The shift in importance from the observing and evaluating subject physician to the supposedly superior, objectively measuring technical equipment, already extensively criticized, might play a decisive role here (s.a. 2.2.2.). Regular meetings about special cases in an open-minded atmosphere are also an excellent opportunity to ask why in a certain case an additional EEG was requested, a question that in a written dialogue often is conceived as criticism or reproach by the EEG-clinician. The problem of the rational justification of diagnostic procedures based on high tech is particularly acute in university hospitals due to relatively inexperienced colleagues who are still in training and are necessarily entrusted with the care of patients. All too often, personal insecurity can be detected behind a rationally unjustified request for an EEG-recording. It is one of the educational tasks of those responsible for the training to clearly and determinedly counter such tendencies, always to be expected. Of course, the EEG-clinician must be in agreement about this with the head of the institution, since he or she depends on that superior's full support in the matter.

> A clear indication that there is a need for conversation and clarification about the purpose of the EEG is, in our view, the significant increase of EEG-requests before visits by the department head and an equally significant decrease during a prolonged absence.

The EEG is abused and therefore discredited when it is used as a form of supportive psychotherapy (MATTHEWS 1973). The very popular but only seemingly rational laconic justification for the request "verification of findings" is, to us, totally unacceptable. Such a statement is hardly apt to strengthen the rapport between colleagues, since the EEG-clinician most likely will consider this a control of his personal retest reliability. The variation of combining the request for the "verification of findings" with the question about the stability of certain findings, that is more acceptable for the EEG-clinician, however, does not make much sense if asked in isolation, i. e. without additional questions, since most EEG-phenomena, by their mere nature, cannot be observed at just any point of time. It is a different matter if there are concerns about the influence of technical circumstances. In such a case, however, it can only be the EEG-clinician himself who recommends or orders a technical control.

Consequences of an EEG-examination

Closely related to the statement of an indication is the concern about the consequences the result of the examination might have for the patient. If - again in a dialogue among colleagues - the conclusion is reached that an EEG-examination would remain without consequences in any case, then no medical indication exists for it. Attempts, occasionally encountered, at justifying that this, after all, is an examination that causes no mentionable stress or danger for the patient is in our view totally unacceptable.

Tolerating it would implicitly open the floodgates for an irrationality that has always been closely related to medical pragmatism. Not only unacceptable but even unethical is for us any indication of an EEG-recording made purely on economic reasons. Unfortunately, those not only play an important role in the independent practice but also in public institutions such as specialized ambulatories that must finance themselves by selling their services. However, economic considerations are not only allowed but even mandatory if we consider how much recording capacity is wasted by ignorance, deeply rooted habits, or both at the cost of meaningful examinations that eventually benefit research.

Who is responsible for evaluation?

With the last mentioned grievance, we touch upon a basic question of organization, i. e. the qualifications required of the head of the EEG-lab. In accordance with a generally accepted understanding of the roles, the EEG and its evaluation lie, as a technical service, in the hands of a so-called "functional physician" - at university hospitals usually the lucky proprietor of a permanent position. Since a "functional physician" is expected to provide his services promptly and without problems, but is also expected not to show much enthusiasm for research, it must not come as a surprise that the urge to gain new scientific knowledge is limited in our EEG-labs. In addition, because the services expected from the "functional physician" include the training of younger colleagues, the common EEG-labs will, in general, rather contribute to the cementation of the status quo than develop into fertile grounds for innovative research impulses. A defensive attitude towards every form of criticism of the status quo, combined with the endeavors of maintaining the already since long dubious nimbus of objective fact statements, is typical. A positive side effect of the development of neuroradiological imaging techniques that seem to make the EEG superfluous in many regards is, in our opinion that it made possible the discussion and reevaluation of the position the functional diagram EEG should have in diagnostics and research.

Besides the "functional physician," other research-oriented colleagues have always evaluated EEGs. This would actually be the ideal, at least for the university setting, if not - again unfortunately more the rule than the exception - upon reaching the career goal, the interest in the vehicle to get there would vanish. According to a widely popular, unexpressed but extremely erroneous prejudice, the evaluation of EEGs being an auxiliary diagnostic service is an inferior activity. For reasons of prestige, this activity is delegated to subordinates, often beginners. Parallel with the disregard for the EEG-evaluation runs the prejudice that half a year of working in the EEG-lab is sufficient to master all aspects of clinical electroencephalography. This contrasts with what we tried to prove (s. a. 2.2.2.), i. e. that a long process of forming one's own impressions is required if one is to become familiar with such a complex topic like the EEG and its intrinsic regularities.

Research Organization.

As we tried to explain in detail in Chapter 2.2., the answer to the questions on the organization of the necessary research must be methodology-oriented. In our view and in a wider sense, this requires an openness towards useful technological innovations. We must walk a very fine line here. On one hand, the already extensively criticized method-oriented actionism looms here, often combined with an infantile instinct for playing games and thus, ultimately, the classical apprentice sorcerer situation. On the other hand, we also must beware of the "alternative" animosity for technology and of a disregard for empirical research in favor of the construction of abstract theories. Undoubtedly, the second risk for the moment is the infinitely less likely one. An important progress which, according to us, was not appropriately appreciated in today's flood of competing innovations of doubtful value, is the "paperless" EEG. Today, the acquisition costs for such equipment are already lower than those for equipment with paper of comparable channel capacity. Its significant advantages are the digital recording and storage of the EEG-signals. Besides the possibility of reproducing the same recording segment in any imaginable variation of montages, the quantitative processing is considerably less complicated, too. In view of this progress available to us today, the old request for systematic longitudinal studies can be raised again, and with more emphasis this time. Personnel- and time-intensive research barriers such as the handling of huge amounts of registration paper, magnetic tape recording and analog-digital transformations no longer apply today. However, to utilize these tremendous advantages for research, we need the cooperation of the clinicians. Of pivotal importance will be a redistribution of the available recording capacities.

We will have to discuss whether - and in how far - we can record medication-free EEGs in patients and how repeated recordings can be organized, depending on changes of the clinical picture.

In addition to the willingness for cooperation between the clinical staff and the EEG-lab that should be expected, it will be of major importance whether or not the EEG can be reintroduced to the clinician as a central psychiatric research tool.

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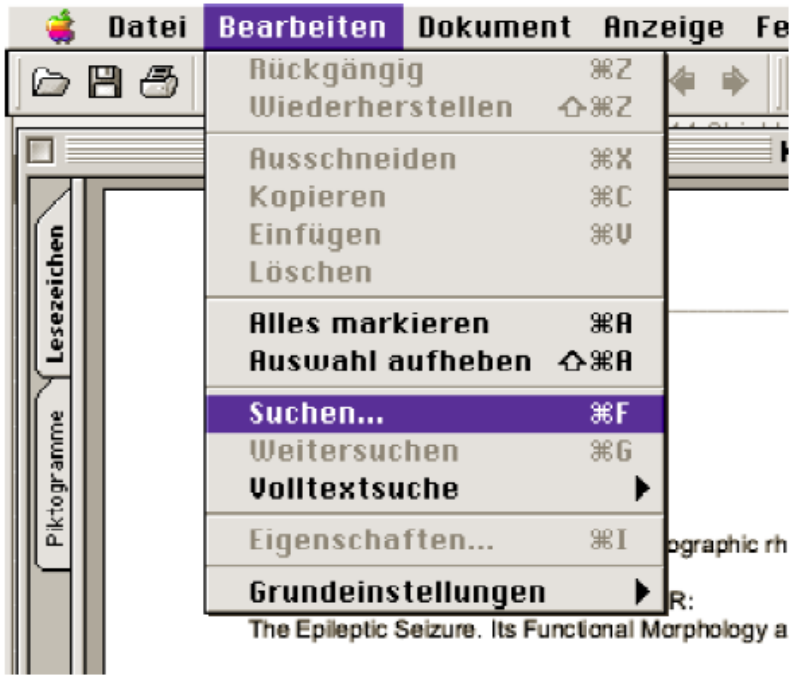

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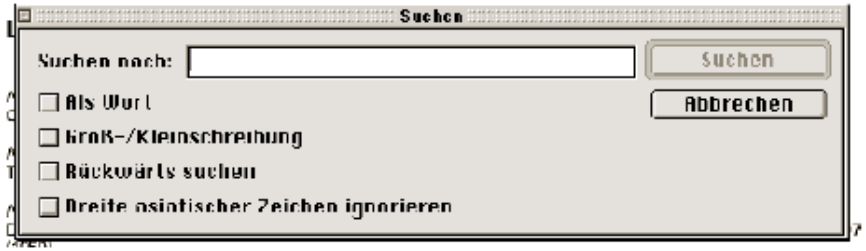

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