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Anxiety, Arousal, and Autonomic Habituation

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Summary. The interaction of anxiety and autonomic activation as a factor in the development and persistency of pathological anxiety was investigated with the aid of self-rating procedures and a habituation experiment. The state of activation was varied systematically in 40 normal subjects by various experimental conditions and by the administration of a tranquilizer.

The degree of anxiety and activation were able to be differentiated in the investigated range of mean attentiveness. Anxious expectancy is perceived in particular as subjective anxiety. Fatigue and sedation, on the other hand, demonstrate subjective and autonomic desactivation. Corresponding differences can be demonstrated for the anxiolytic and sedative effects of tranquilizers. The time course of habituation is a more exact indicator than the amplitude of the orienting response.

Cognitively provoked apprehensiveness, thus, appears to be qualitatively different as compared to psychoautonomically caused anxieties of psychiatric disorders.

Key words: Anxiety – Arousal – Habituation – Autonomic nervous system.

Zusammenfassung. Bei 40 Normalpersonen wurde der Aktivationszustand durch unterschiedliche experimentelle Bedingungen und durch Applikation eines Tranquilizers systematisch variiert. Mit Hilfe von Selbstbeurteilungsverfahren und einem psychophysiologischen Habituationsexperiment wurden die Interaktionen von Angst und autonomer Aktivierung untersucht, die Entstehung und Persistenz pathologischer Ängste beeinflussen.

Im untersuchten Aufmerksamkeitsbereich können die Dimensionen Angst und Aktivierung differenziert werden. Eine ängstliche Erwartungshaltung wird bei mittlerem Aktivationsniveau vor allem als subjektive Stimmungsbeeinträchtigung wahrgenommen. Bei Ermüdung und Sedation kommt es dagegen zu subjektiver *und* autonomer Desaktivierung. Entsprechende Unterschiede lassen sich für die anxiolytischen und sedativen Tranquilizereffekte nachweisen. Medikamentös bedingte Änderungen der Aktivierungslage kön-

nen durch die Habituationscharakteristik der Orientierungsreaktion genauer erfaßt werden als durch deren Amplitude.

Durch die geringe Koppelung der subjektiven und der autonomen Angstreaktionen unterscheidet sich die kognitiv bestimmte Ängstlichkeit qualitativ von den psychoautonomen geprägten Ängsten psychiatrischer Erkrankungen.

Schlüsselwörter: Angst – Aktivation – Habituation – Autonomes Nervensystem.

1. Introduction

Tension and apprehensiveness are interpreted as an elevated state of activation (Lader and Wing, 1966). This association is inferred from the accelerated heart rate (Zuckermann et al., 1968), the amplified spontaneous fluctuations of the basal skin resistance (Katkin, 1966; Lader, 1975), EEG desynchronization (Tyrer and Lader, 1976), and other concomitant physiological responses of affective tension. Epstein (1972) interprets anxiety as an inadequate expectancy response. In this expanded concept of anxiety, not only abnormal activation, but also the associated limitation in perception and situation analysis prevents adequate coping strategies (Lazarus and Averill, 1974).

The orienting response and its habituation may be considered to be simple models of the processing of information relevant to a specific situation (Lynn, 1966; Graham, 1973). The physiological aspect of information processing which is impaired during anxiety can, therefore, be proved with the aid of habituation. In the case of a stimulus intensity at the threshold to aversive stimulation and in the case of experimentally induced uncertainty, the initial state can also be controlled pharmacologically in such a manner that adaptive or defensive reactions occur. While the orienting response can be understood as an optimal focussing on actually meaningful external factors, the course of habituation demonstrates the discrimination between psychobiologically relevant and irrelevant information. The orienting response, thus, serve to optimize the assimilation of information, while habituation filters out the irrelevant information.

At the threshold to aversive stimulation, the occurrence of an orienting or defensive response as well as the habituation thereof is dependent on the subjective state of expectation and the apprehensiveness of the test subject. Lader and Matthews (1968) and Bohlin (1976), however, postulate a generally desactivating and sleep-inducing inhibitory mechanism. In the case of intensive activation no inhibition occurs and, thus, no habituation. Accordingly, the habituation rate would be an expression of different activation and would only be an indirect expression of subjective apprehensiveness.

In the complex of orienting behavior, the autonomic response pattern is especially well suited for the examination of affectivity. The autonomic responses can be considered as an internal system for expression emotional states and, thus, determine the self-concept about the individual's own emotional state.

The aim of the investigation was to differentiate anxiolysis and sedation by subjective estimation and autonomic response patterns.

2. Methods

Test Subjects. Forty healthy male students were examined. Participation in the experiment was on a paid basis. Risk factors and actual existing diseases and disorders were excluded by internal examination and laboratory diagnosis. The age of the test subjects varied between 20 and 35 years with a mean of 25.7 years.

Procedure. The experiments were performed in an acoustically and electrically shielded laboratory. A sequence of 18 acoustical stimuli (1000 Hz, 80 dB, 1 s duration, 50 ms rise time, 30 s interstimulus interval) was produced over loudspeakers at a distance of 1.5 m. A dishabituative interval of 1 min was introduced between the 13th and 14th signal. The test subjects were in a relaxed, passive expectancy attitude. The heart rate (RR—distances of the ECG), peripheral skin circulation (finger photoplethysmogram), respiratory frequency (nasal thermistor) and skin resistance (SRL and SRR) as well as an EEG in the centro-occipital lead were registered during the habituation experiment and during an adaptation phase lasting 10 min. A report concerning the EEG analysis will appear at a later date (Strian and Klicpera, 1977).

After the habituation trial the changes in these functions were investigated under two anxiety-inducing conditions (imagining situations with concomitant anxiety, expectancy of a pain stimulus) (Klicpera and Strian, 1977). The biosignals were analysed by visual and automatic evaluation (Strian and Dirlich, 1973, 1977; Klicpera, 1976). The statistical analysis was performed by a direct group comparison using non-parametric methods (U-test). The time courses of habituation were examined with multivariate trend analysis (Finn, 1974).

The subjective feelings of the test subjects were determined during the experiment using various questionnaires. Those questionnaires were chosen which reproduce physical discomfort, emotional state, and situation-related response tendencies. The following questionnaires were used; discomfort list (BL–BL', according to von Zerssen, 1975), emotion inventory (EMI, Ulrich, 1974), stimulus response inventory (SRI, modified according to Endler et al., 1962). The questionnaires were completed prior to and subsequent to the physiological measurements. The first application occurred before the administration of medication.

Drug Treatment Design. A Thienodiazepin[1] was investigated in a double crossed placebo experiment. Each subject was given 10 mg Verum or a placebo at the same time of day (9:00 a.m.) at weekly intervals. The course of the experiment was randomly distributed by forming two equally large groups of test subjects.

3. Results

Heart Rate. The heart rate mean values and the heart rate dispersion values prior to stimulation do not show any differences between Verum and the placebo in either of the trials.

The typical, so-called biphasic heart rate response including acceleration and subsequent deceleration is observed in particular after the first stimuli. The differences between a predominantly accelerative defensive response and a predominantly decelerative orienting response as postulated by Graham and Clifton (1966) did not become evident in our findings. The heart rate response to the first tone is diminished in the first trial. This difference approaches the significance limit ($P < 0.10$) for the acceleration component (Table 1).

The second trial shows a diminished response under the placebo effect as a trend. The habituation of the heart rate responses does not produce any significant differences between Verum and the placebo. The heart rate reactions habituate very quickly. After the first tone there is a clear reduction in the

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Table 1. Parameters of the heart rate responses (beats per minute) in the stimulus groups — according to Roessler et al., 1969

	Trial 1			Trial 2		
	S 1	S 2–3	S 4–13	S 1	S 2–3	S 4–13
VARIAB	6.3	4.7	4.5	5.7	3.7	3.8
	5.7	3.6	3.9	7.1	4.5	4.5
DF-VAR	2.5	0.21	0.37	2.75	−0.3	0.49
	1.8	0.25	0.30	2.66	0.39	0.55
ACCEL	7.3*	1.6	0.6	4.6	0.6	0.8
	4.0*	1.5	0.3	5.9	1.5	1.3
DECEL	0.78	0.67*	−0.2	−1.15	1.13	0.18
	−0.81	2.70*	0.13	−0.63	−0.26	−1.18
PVDIF	6.5	0.9	0.79	5.7	−0.6	0.50
	4.8	−1.2	0.12	6.5	1.8	2.46

VARIAB = Poststimulus heart rate dispersion
DF-VAR = Difference of pre- and poststimulus heart rate dispersion
ACCEL = Acceleration parameter
DECEL = Deceleration parameter
PVDIF = Peak-Valley difference

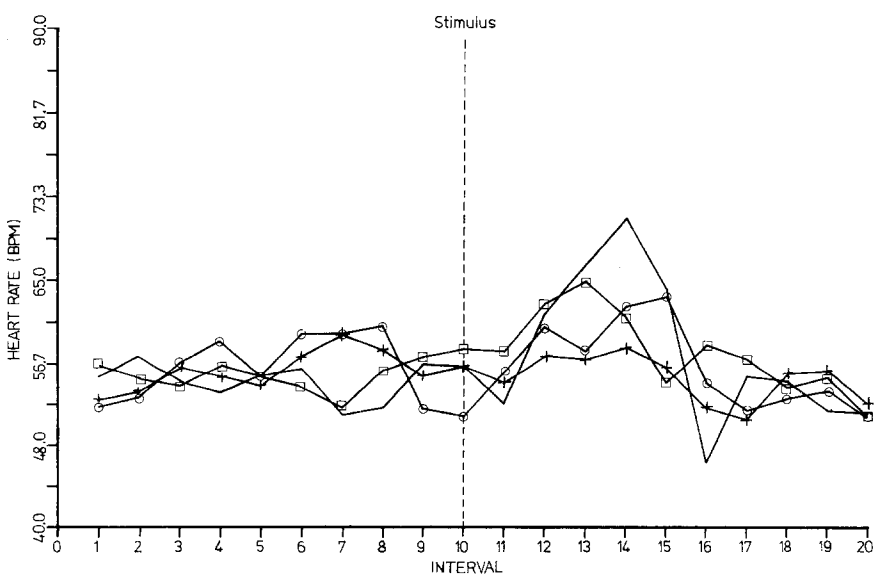

Fig. 1. The heart rate response in a test subject with a typical biphasic response pattern (acceleration with subsequent deceleration). ——— Stimulus 1—4; o——o Stimulus 5—8; □——□ Stimulus 9—13; +——+ Stimulus 14—18

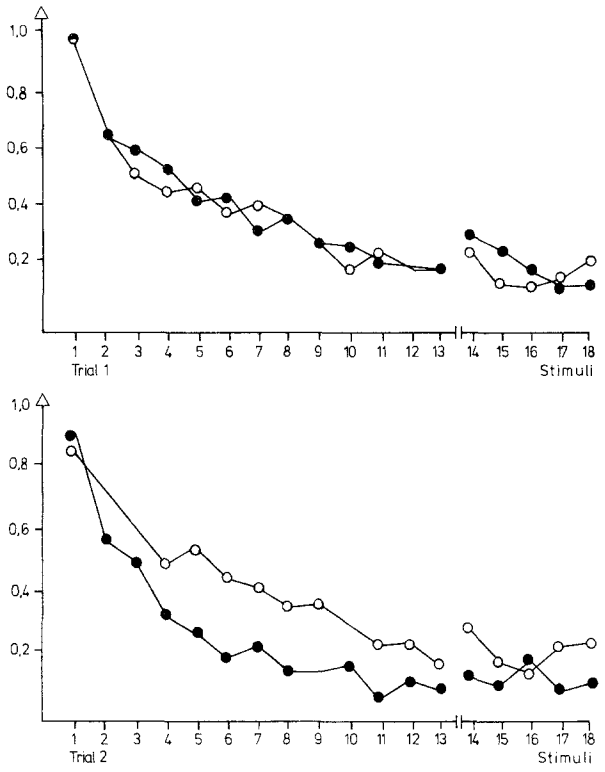

Fig. 2. The time course of habituation of the skin resistance responses during the sequence of acoustical stimuli. • Verum; o Placebo

response amplitude. In the following stimulus sequence, no uniform trend in the time course of responses can be ascertained (Fig. 1).

Skin Resistance. The amplitude of the orienting response declines from the first to the second trial. The orienting response, however, does not show any differences between Verum and the placebo either in the first or in the second trial. After using a range correction according to Lykken et al. (1966), it is found that the habituation of the skin resistance responses occurs more rapidly under Verum than under the placebo (Fig. 2). This difference was verified in the multivariate trend analysis covering both trials as being significant ($P < 0.01$). In univariate testing the difference in the time course of habituation approaches the significance limit in the second trial. During this trial, there is a more rapid readaptation of the tonic skin resistance under Verum than under the placebo ($P < 0.05$) (Fig. 3). The initial position of tonic skin resistance is at the same level for Verum and the placebo in the first trial. In the second trial, it is increased significantly under Verum ($P < 0.05$). In addition, reduced spontaneous fluctuations in the stimulus intervals become evident as a trend ($P < 0.10$) in the second trial. A significant dishabituation of the skin resistance responses can be proved only in a few test subjects. Likewise, habituation of high magnitude in response to tones 14—18 is only found in a few cases. In these test subjects a significant increase can be ascertained in the rise of the inclination lines which were calculated to determine the time course of habituation.

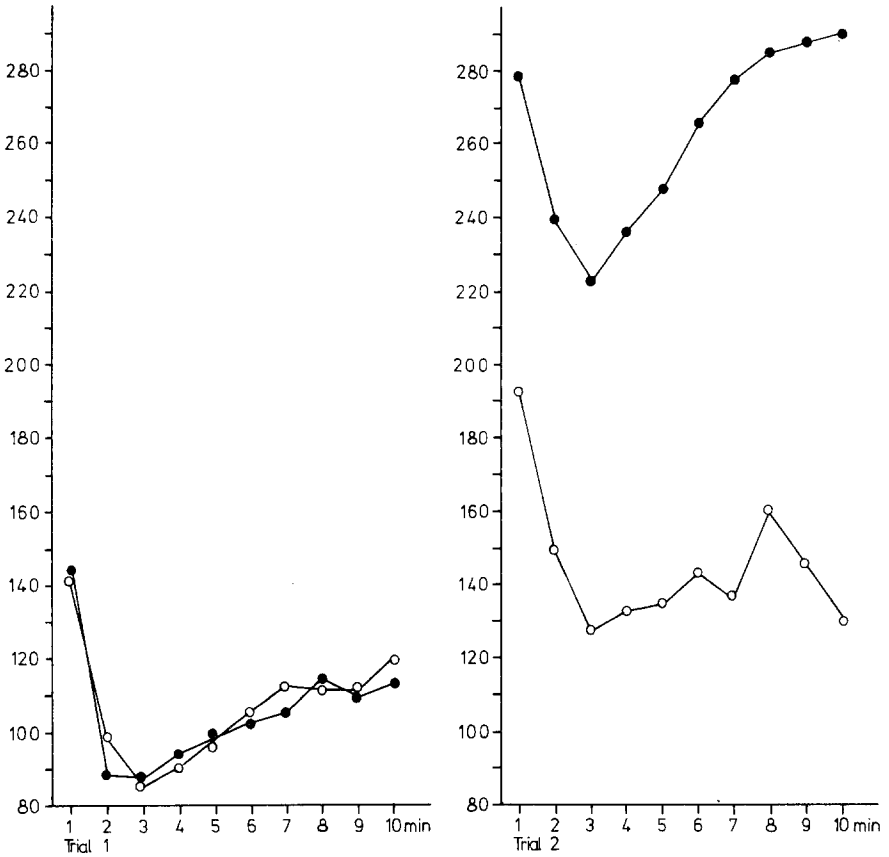

Fig. 3. The time course of the tonic skin resistance during the series of acoustical stimuli (mean values of 1 min measuring intervals). ● Verum; ○ Placebo

Peripheral Vasoconstriction. Consistent vasoconstrictions are found in about 60% of the test subjects (Fig. 4). The responses become habituated, however, in only one out of every five test persons. The administration of medication does not significantly affect the amplitude of vasoconstriction and habituation. In the trend, however, peripheral vasoconstriction is found to be less under the placebo than under Verum.

Respiration. The respiratory frequency at rest is not affected by the administration of medication.

Questionnaire Measurements. In their entirety, the questionnaires for Verum show a significant decline in the physical discomforts ($P < 0.05$) associated with tension and anxiety. The test subjects assessed their situation-adequate faculty of judgement as improved ($P < 0.05$; SRI, factor 1). On the other hand, the medication produced a significant increase in subjective fatigue ($P < 0.01$) and the physical sensations associated with fatigue ($P < 0.005$). In the first trial, a significant reduction in anxious mood ($P < 0.05$) occurs under Verum. The test subjects thought that they felt the tendency to avoid situations causing anxiety to

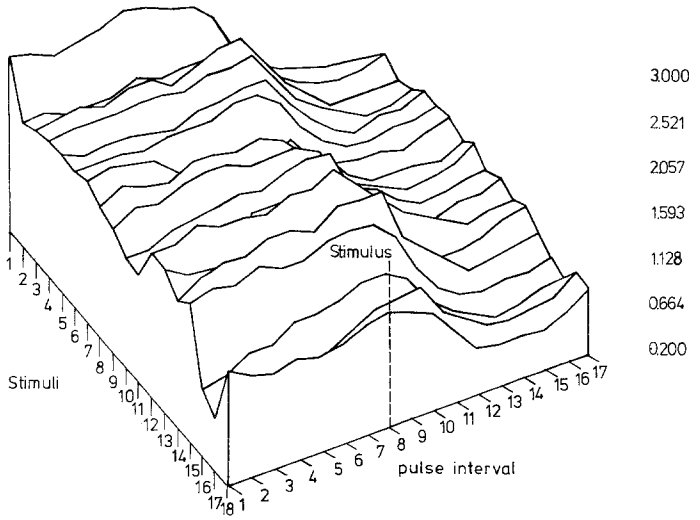

Fig. 4. Peripheral vasoconstriction in a test subject in response to the sequence of acoustical stimuli

a lesser extent ($P < 0.05$), while during the second trial only the increase in subjective fatigue ($P < 0.05$) and the physical sensations associated with fatigue ($P < 0.05$) was significant.

4. Discussion

A characteristic time course of habituation with a continuous decline in response during the administration of stimuli is to be found in the skin resistance responses, but not in the other autonomic functions. The rate of habituation of the skin resistance responses varies under Verum and placebo conditions. The orienting response demonstrates decreased reactions in all functions under Verum as a trend, but no differences at a statistically significant level. Hence, habituation is more sensitive than the orienting response in differentiating the effect of medication. The difference in the influenceability of the orienting response and habituation is understandable in view of the underlying, opposing processes: the orienting response constitutes more of a reflex adjusting mechanism, habituation as an adaptive mechanism occurs with greater context dependency and, thus, is subject to an organized control at a higher integration level. Greater disruptability of the adaptation mechanisms was described in psychiatric patients (Lader and Wing, 1966) as well as in patients with localized (Holloway and Pearson, 1971) and diffuse brain damage (Cohen et al., 1971).

In subjective perception, reduced apprehensiveness and reinforced sedation correspond to the drug-induced habituation increase as the overall effect. The different conditions caused by the cross-over designs, however, modified these subjectively perceived effects of medication (Poulton and Freeman, 1966; Marholin and Philips, 1976). In the first trial, the novelty of the experimental situation

led to uncertainty in the expectancy of the test subjects and, thus, greater tension. In the second trial, they were familiar with the experimental situation and were, therefore, more relaxed. The effect of medication in the first trial is experienced as a reduction of anxiety under the increased tension, while the sedative action is slight. Due to the greater relaxation in the second trial, the test subjects experience in particular greater fatigue. The perception of physical feelings of tension continues to decrease, while the anxious mood and the propensity toward avoidance behavior tend to increase. Anxiolysis, thus, commences precisely at the point of increased tension, while anxiolysis receeds into the background in the relaxed state or paradoxical effects even occur (Barrett and di Mascio, 1966; Janke and Debus, 1968; Boucsein and Wendt-Suhl, 1976). The results, thus, show clearly that sedation cannot be equated with anxiolysis.

Different factors due to the various conditions of the cross-over designs are also revealed in the autonomic response pattern. The drug-induced reduction in anxiety in the case of elevated tension demonstrates a trend, but no significant differences of associated physiological response measurements, while the effect of sedation is accompanied by significant, autonomic deactivation. Tonic activity and habituation, thus, permit a graduation of the state of relaxed wakefulness and can be regarded as an indicator of the sedative action of medication. Our results from an acceleration of the habituation process with arousal reduction under Verum indicate that the relationship between the habituation process and the activation level, which Bohlin (1971) proved for the range of high activation, also continues in the range of relaxed wakefulness.

The different experimental conditions in both trials also determine the interpretation of subjectively perceived anxiolysis. The first trial is experienced by the test subject in a state of anxious expectancy, but is not associated with intensive anxiety, since specific trigger mechanisms are absent. The uncertainty in the assessment of the situation does not lead to an activation of the autonomic functions. This cognitively provoked apprehensiveness, thus, demonstrates only a loose connection with the autonomic system and, thus, differs qualitatively from the individual stereotypes of psychoautonomic anxiety responses. By contrast, pathological states of anxiety in anxiety neuroses (Hart, 1974) and in depressive patients (Lader and Wing, 1969; Strian et al., 1977) are not only characterized by the intensity of subjective anxiety, but also by the degree of somatization in the autonomic system.

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