Summary

Pain thresholds through thermal and mechanical stimulation are determined in patients with a chronic pain syndrome of different etiology and a healthy control group. For this purpose, heat is applied at 5 different skin points on the hand and lower arm using a modified Marstock thermode or a pressure algometer is employed with interchangeable stamps.

The pressure pain thresholds also show good intraindividual reproducibility, but the interindividual variance is greater than with heat stimulation. The threshold values likewise show no dependence on age, sex or time of the day. There are no significant differences between the pain patients and the control group. Both healthy subjects and patients with a chronic pain syndrome give a higher VAS rating than for heat stimulation and show a temperature decrease as the sign of an increased sympathetic tone. The lateralization tendency is less pronounced for pressure stimulation.
The poor correlation between heat and pressure pain thresholds, the absence of a threshold increase after mechanical stimulation in pain patients and the enhanced sympathetic tone associated with pressure stimulation point to a different processing of the two pain qualities at the central level.

Determination of the pain thresholds is done with the stimulation devices described in Parts 1 and 2.

This paper focusses on the demonstration of similarities and differences in the two stimulus qualities with regard to nociperception ...

METHODS AND TEST SUBJECTS

Twenty healthy subjects (11 males, 9 females) and 12 patients took part in both the thermal and the mechanical stimulation. Based on this group of test subjects, a comparison is made between several parameters of the two stimulation modalities.

RESULTS

1. Healthy subjects

Inter- and intraindividual observations. The cross-sectional values of the pain thresholds show only a very low degree of dependence ($r = 0.34$, $p \geq 0.05$); that is, a test subject who was in the upper range of values for heat pain does not necessarily reach higher thresholds for pressure stimulation and vice versa; Fig. 1. The correlation coefficients of the individual measuring sites vary between $r = 0.26$ (elbow) and $r = 0.44$ (hypothenar); p values ≥ 0.05 in each case.

Subjective pain assessment. A very good correlation was detected for the values of the visual analog scales ($r = 0.90$; $p \leq 0.0001$); Fig. 3. The mechanical stimulus is perceived

as distinctly more unpleasant, which also manifests itself in the intensity rating: the mean value of the pressure scale exceeds that of the heat pain by 0.76 (x_{heat} = 3.71; $x_{pressure}$ = 4.47; p = 0.0012); Fig. 2.

Skin temperature before and after stimulation. The skin-temperature differences vary both at the stimulated (ΔT_{heat} = 1.62°C vs $\Delta T_{pressure}$ = 0.14°C) and the nonstimulated skin surfaces (ΔT_{heat} = 0.63°C vs. $\Delta T_{pressure}$ = - 0.77°C) to a significant degree ($p \leq 0.0001$) in favor of thermal application (Fig. 4). The cross-sectional values of the temperature differences correlate very poorly for both stimulated (r = 0.16) and nonstimulated (r = - 0.03) sites.

Pain lateralization

2. Pain patients

Inter- and intraindividual observations. Even in the pain patients, the pain thresholds of the thermal and mechanical stimulation displayed only a low correlation (r = 0.21; $p \geq 0.05$).

Subjective pain assessment. The rating of the pain threshold on the VAS is only slightly higher after mechanical than after heat stimulation (x_{heat} = 4.53 $\pm$ 1.36 vs. $x_{pressure}$ = 4.73 $\pm$ 1.32; p = 0.6834). The correlation of the analog scales is very good, as in healthy subjects (r = 0.88; $p \leq 0.0001$).

Like in healthy subjects, the skin-temperature differences vary significantly at both the stimulated (x_{heat} = 1.91°C vs. $x_{pressure}$ = 0.67°C; $p \leq 0.0001$) and the nonstimulated (x_{heat} = 0.12°C vs. $x_{pressure}$ = -0.55°C; $p \leq 0.0001$) measuring points.

Pain lateralization

DISCUSSION

1. Healthy subjects

The correlation of the pain thresholds after heat and pressure stimulation is very low. This holds true for both the cross-sectional values ($r = 0.34$) and the individual measuring points on the elbow ($4 = 0.26$) and the hypothenar ($r = 0.44$). This means that a test person who was in the upper range of values for thermal stimulation does not necessarily also reach higher threshold values for mechanical stimulation. This observation suggests that the type and quality of stimulus are of decisive importance in the nociceptor processing. Wolf and Jarvik also found that the pain thresholds correlate significantly for similar pain qualities at various body sites, while stimuli of different quality did not show a good pain-threshold correlation (2,4).

The pressure pain is perceived as distinctly more unpleasant by most test subjects, which is also clearly reflected in

the VAS scale (44.7% vs. 37.1%). Since the VAS inquires after pain intensity, a significant difference would not actually be expected in the pain-threshold ratings for thermal and mechanical stimulation; However, at the retrospective evaluation, the pressure pain, which is perceived as more unpleasant, does apparently receive a higher rating on the VAS via the affective-emotional level. Still higher evaluations of the pain threshold after pressure stimulation are reported by Peters (3) at 54.4% (SD = 27.2%). The correlation of the two analog scales is very good (r = 0.90); that is, a test subject who places the pressure-pain threshold in the lower range of values likewise rates the heat pain rather low. In the final analysis, pain-intensity evaluation must be regarded as the sum of sensory and affective perception components as well as of certain cognitive functions of a "central seat of control".

The skin-temperature differences vary significantly in favor of heat stimulation at both the stimulated and nonstimulated measuring points. First an explanation is attempted for the stimulated skin points: 1. For heat stimulation, thermal energy is applied for about 20 seconds at each skin point during one session, which could conceivably cause the mean 1.72°C warming. 2. Through the mechanical stimulation, mechanical stimuli are repeatedly transmitted to the subcutaneous tissue, which would warm slightly via a vascular reflex in the sense of a vasodilatation. This value

(Δ T = 0.18°C) is probably so low because the noxic stimulus triggers a contrary sympathicotonic reaction with a consecutive cutaneous vascular constriction. The interpretation of the measuring results is more difficult at the nonstimulated skin points, particularly for heat stimulation: 1. The mean 0.65°C warming must be interpreted as a general relaxation reaction even though a sympathicotonic vasoconstriction has not yet occurred. According to Blumberg (1), thermal stimulation only leads to a constriction of the cutaneous vessels at VAS values of at least 50%; the rating reached in our experiment is only 37.1%. 2. The significant cooling (Δ T = - 0.77°C) in conjunction with mechanical stimulation can only be seen as a vasoconstriction resulting from a sympathicotonic reaction due to pressure pain. The results of the different skin temperatures are a further indication that different noxic qualities also evoke distinct reactions; that is, they are probably modulated in a different manner at the central level.

With respect to <u>lateralization of the pain sensation</u>, it is noteworthy in all three groups (dextrals or sinistrals and ambidextrous subjects) that the tendency towards lateralization is greater at distal than at proximal measuring points, and this observation is more pronounced for thermal than for mechanical stimulation. The comparison for the elbow and hypothenar (see contingency charts, Tables 1 and 2) shows a

very poor correlation between thermal and mechanical stimulation. This result likewise points to a different processing of the two pain qualities.

2. Pain patients

A dependence of the pain thresholds after thermic and mechanical stimulation is no more detectable in patients with a pain syndrome than in the healthy subjects (correlation $r = 0.21$). In the evaluation on the VAS scale, the pressure pain is likewise rated higher than the heat pain, but the difference is less marked than in healthy subjects ($\Delta_{\text{pain pat.}} = 0.2$ vs. $\Delta_{\text{control}} = 0.76$).

As an explanation for the more unpleasant perception of pressure stimulation, a different modulation of the two noxic qualities must also be assumed here, particularly at the affective-emotional level.

The variations in skin-temperature differences after mechanical and thermal stimulation, the extent of which corresponds approximately to that in healthy subjects, can likewise only be attributed to a different activation of sympathetic influence.

The side difference in the pain sensation is more marked after heat than after pressure stimulation in the pain patients as well. The dependence of this observation on the measuring point (distal/proximal) is not as pronounced as in healthy subjects. An interpretation of these results does not appear useful, since highly speculative tendencies are inevitable.