78.18. The Impact of Non-noxious Heat on Tactile Information Processing Capacity.

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INTRODUCTION

A significant number of studies that evaluated tactile-pain interactions employed heat to evoke nociceptive responses. However, relatively few studies have examined the effects of non-noxious thermal stimulation on tactile discriminative capacity.

In the current study, three features of tactile information processing capacity were evaluated under three different temperature conditions:

- ❑ Vibrotactile detection threshold (at room temperature, 40.5°C, and 43°C);
- ❑ Amplitude discriminative capacity (at room temperature and 43°C);
- ❑ The impact of vibrotactile adaptation on tactile discrimination capacity (at room temperature and 43°C).

EXPERIMENTAL DESIGN

Ten subjects participated in this study. (Age: 21-28, 6 females).

Four separate protocols were employed. 25 Hz vibrotactile stimuli were delivered on the index (D2) and middle (D3) finger of the right hand by a portable dual-site vibrotactile stimulator (Figure 1). A temperature-controlled metal hand plate was fabricated to deliver non-noxious thermal stimulation (40.5°C and 43°C).

The room temperature was controlled at 25°C during the experiment. None of the subjects reported pain or discomfort at either 40.5°C or 43°C.

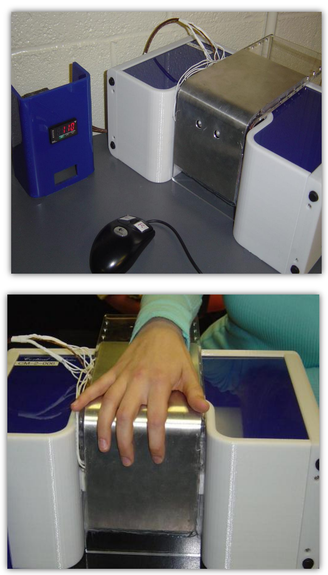

Figure 1: **Images of the vibrotactile stimulator with a temperature-controlled metal hand plate attached.**

❑ During an experimental session, the subject was seated comfortably in a chair with the right arm resting on an acrylic hand-arm rest attached to a portable dual-site vibrotactile stimulator. A temperature-controlled metal hand plate was fabricated to attach on the front top end of the hand-arm rest.

Protocol 1: Vibrotactile Detection Threshold.

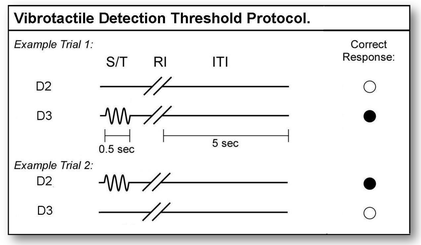

Figure 2: **Method**

A two alternative forced-choice (2AFC) tracking protocol was used to assess a subject's vibrotactile detection threshold.

Stimuli: During each trial, a 25 Hz flutter test stimulus was delivered to either D2 or D3 for 0.5 sec.

Task: Following each trial, subjects were queried to select the skin site that received the stimulus, and the test amplitude was modified in the subsequent trial based on the subject's performance.

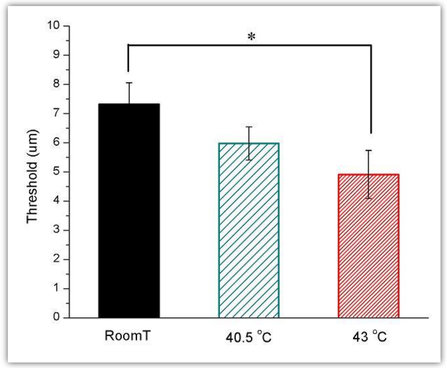

Figure 3: **Results**

Vibrotactile thresholds decrease with increasing temperature.

The group-averaged detection thresholds were plotted under three thermal conditions.

❑ At 43°C, the detection threshold was significantly lower than that at the room temperature condition.

❑ Concurrent non-noxious thermal stimulation results in an improvement of vibrotactile sensitivity.

Protocol 2&3: Amplitude Discrimination with/without Adaptation.

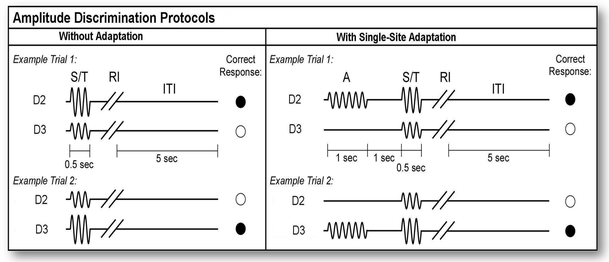

Figure 4: **Method**

Two 2AFC tracking protocols were used to determine a subject's capacity to discriminate between the amplitudes of two simultaneously delivered vibrotactile stimuli with or without a preceding conditioning stimulus delivered to one of the stimulus sites.

Stimuli: Left panel: Two 25 Hz vibrotactile stimuli, the standard (S) and test (T), were delivered simultaneously for 0.5 sec. Right panel: A 25 Hz conditioning stimulus at one of the two stimulus sites precedes the simultaneous delivery of the standard and test stimuli.

Task: Subjects reported which of the two sites received the stronger stimulus. The difference between the amplitudes of the test and standard stimuli was adjusted on the basis of the subject's response.

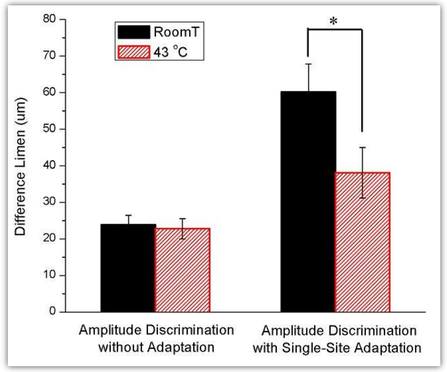

Figure 5: **Results**

Increasing temperature had little impact on a subject's vibrotactile amplitude discrimination capacity, but did attenuate the effects normally caused by pre-exposure to a conditioning stimulus on that assessment.

The group-averaged difference limens obtained at room temperature and at 43°C were plotted.

❑ The subjects' capacities for amplitude discrimination was significantly impaired with pre-exposure to a conditioning stimulus under both temperature conditions.

❑ The temperature increase resulted in a significant reduction in the impairment of subjects' amplitude discrimination capacity due to adaptation.

Protocol 4: Dynamic Amplitude Tracking.

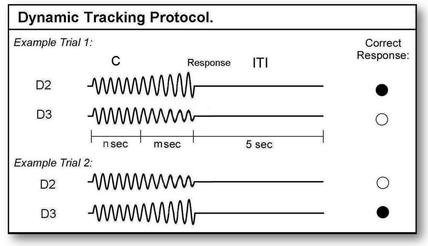

Figure 6: **Method**

A dynamic tracking protocol was implemented to further characterize the effects of adaptation on amplitude discrimination.

Stimuli: Two identical 25 Hz vibrotactile stimuli were delivered simultaneously for a fixed interval (0, 1.5, 2, or 3 sec), then the amplitude of the two stimuli were dynamically increased/decreased, in steps of 25um/sec.

Task: The subject was instructed to indicate the location at which the most intense stimulus was delivered as soon as the two stimuli felt distinctly different in intensity.

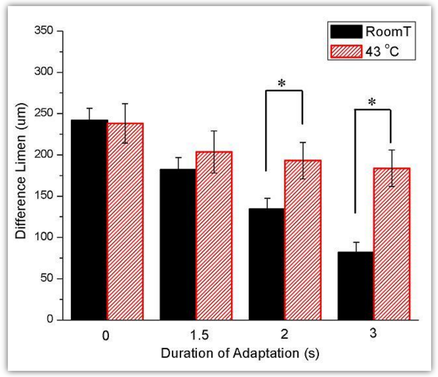

Figure 7: **Results**

Discriminative capacity, normally impacted in a stimulus duration dependent manner, is less impacted in the presence of a 43°C thermal stimulus.

The group-averaged difference limens obtained at room temperature and at 43°C were plotted.

❑ At room temperature, increasing the duration of the conditioning stimulation led to an improvement of performance (i.e., reduced DL).

❑ When the skin was heated to 43°C, the improvement in amplitude discrimination was significantly attenuated.

DISCUSSION

❑ The results strongly suggest that concurrent non-noxious thermal stimulation (43°C) enhances some aspects of vibrotactile sensitivity (i.e., detection threshold).

❑ It was proposed that the observed reduction of the impact of adaptation in the presence of warmth was most likely due to a change in the balance of excitation and inhibition that is prevalent among cortical neurons.

❑ The changes that occur with warmth are reminiscent of the changes in tactile sensibilities that are observed in autism: subjects with autism typically have increased sensitivity to a number of stimulus modalities, are not significantly different from controls in amplitude discriminative capacity, but show a reduced response to repetitive stimulation – or less of an adaptive response (Tommerdahl et al., 2007; Tannan et al., 2008).

❑ It is possible that subjects with less than optimal excitatory/inhibitory balance could perform better at the adaptation task in the presence of heat than without. (Figure 8)

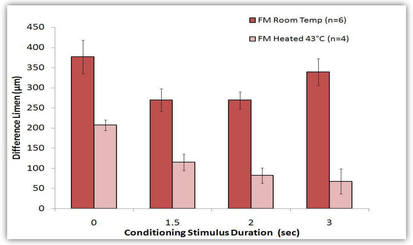

Figure 8: **Comparison of effects of temperature on dual-site conditioning on subjects with fibromyalgia.**

❑ Observations obtained from subjects with fibromyalgia (FM) demonstrated two significant differences from those obtained from control subjects (Figure 7).

1) At room temperature, FM subjects performed extremely poorly on the discrimination task and did not improve with increasing the duration of the conditioning stimulus.
2) The performance of FM subjects on the discrimination task did not degraded with increasing skin temperature, but actually improved to the point that FM subjects outperformed control subjects on the task while the controls were under optimal performance conditions.

❑ While the low-level of neuro-adaptation in the FM subjects is very suggestive of either a lack of inhibition or an excess of excitation, the impact that non-noxious heat has on these adaptation measures suggests that the change in temperature could be enabling a return to the balance between excitation and inhibition that is necessary for more typical-like cortical information processing.

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