

THE EFFECTS OF FINGER FORCE AND VISUAL DISTRACTIONS ON THE MEASUREMENT OF THERMAL PERCEPTION THRESHOLDS

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Introduction

The thermal perception threshold (TPT) test has been used by several investigators to measure the decreased sensitivity of the mechanoreceptors in persons exposed to hand-transmitted vibration.¹⁻³ The measurement of increased TPT at the fingertips is considered an alternative approach for the objective early detection of vibration induced sensorineural disorders, which may be the first sign of hand-arm vibration syndrome.⁴ An aesthesiometer is usually used to measure the TPT. The finger force required to keep the fingertip in contact with the temperature-controlled plate for the test has been either totally uncontrolled or controlled via visual feedback to a test subject.⁵ It is unclear whether the finger force should be controlled. If controlled with visual feedback, the test subjects may become distracted by having to watch the force meter during the test and this might adversely affect the assessment of the thermal threshold. To improve the test method, the specific aim of this study was to test the hypotheses that (a) the method for controlling finger force during the test would affect the magnitudes of the TPTs, and (b) that variation in finger force levels would affect the magnitudes of the TPTs.

Method

Twelve male participants were used in the study. The participants were students recruited from a local university and had an average age of 26.7 ± 4.1 years. Thermal perception thresholds were measured using an aesthesiometer (Institute of Sound and Vibration Research, UK). Nine different contact force levels were investigated: 0.5, 1, 2, 3, 4, 6, 8, 10, and 12 N. Two different methods of controlling the contact finger force were used. In Method 1, visual feedback was provided to the participants, similar to that used by Maeda and Sakakibara.⁵ In Method 2, the finger force is controlled automatically using a counterbalance system (Figure 1). The surface was initially maintained at 32.0 °C. The temperature of the plate was then raised or lowered at a rate of 1.0 °C/sec. Four trials were performed for each test condition. The sequence of the test conditions was randomized. The mean hot or cold thresholds and the neutral zone (the difference between the mean hot threshold and the mean cold threshold) were calculated for each test condition. A two way mixed model was used to perform the analysis of variance (ANOVA) with a compound symmetric correlation structure in the model residual matrix. Because of the numerous force levels post hoc comparisons were not adjusted for multiple pairwise comparisons.



Figure 1 Finger contact force maintained automatically with no visual feedback.

Results and Discussions

Results show that the participants have a faster response to changes in temperature with the no feedback method than they did with the feedback method (Figure 2). In a two way mixed ANOVA, the interaction between feedback condition and force level was found insignificant ($p > 0.1$). Examination of the main effects showed that the differences between the temperature thresholds for feedback vs. no feedback were significant ($F_{1/195} = 9.06$, $p = 0.003$ for cold test; $F_{1/195} = 15.36$, $p = 0.0001$ for hot test; $F_{1/195} = 19.16$, $p < 0.0001$ for neutral zone). In post-hoc tests of feedback vs no feedback for each separate force level there were no significant differences at any force level for the cold condition. For the hot condition feedback vs no feedback was significant only at 0.5 N. For the neutral zone feedback vs no feedback was only

significant at 0.5 N and 1 N. The effects of the finger force on the TPTs were also significant ($F_{8/195} = 1.98$, $p = 0.051$ for cold test; $F_{8/195} = 2.81$, $p = 0.006$ for hot test; $F_{8/195} = 3.17$, $p = 0.002$ for neutral zone). For the feedback-controlled hot measurements, the post-hoc analyses revealed significant differences between the TPT at 0.5 N and those at 3, 4, 6, 8, 10, and 12 N and between the TPT at 1 N and those at 3, 6, 8, 10, and 12 N ($p < 0.05$). For the feedback-controlled cold measure, the post-hoc analyses revealed significant differences between the TPT at 0.5 N and those at 3, 6, and 12 N and between the TPT at 1 N and those at 3, 6, and 12 N ($p < 0.05$). For the neutral zone, the post-hoc analyses revealed significant differences between the TPTs at 0.5 and 1 N and those at all other conditions ($p < 0.05$). However, the differences among the TPTs measured at the force levels greater than 1 N were not significant ($p > 0.05$).

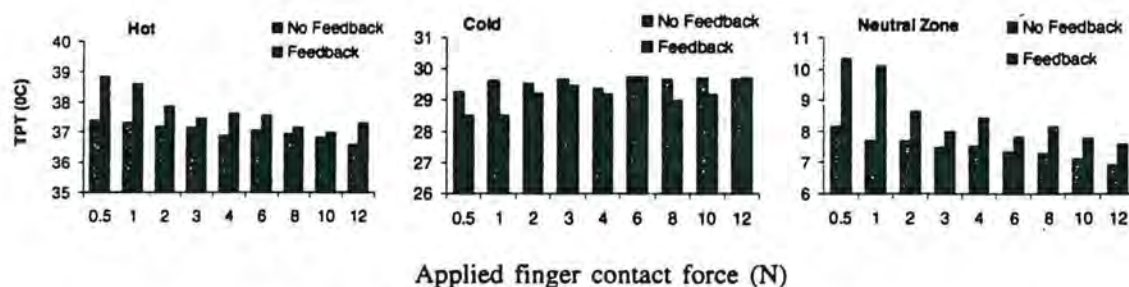


Figure 2. Thermal perception thresholds (hot, cold, and neutral zone)

The coefficients of variation (COV = standard deviation/mean) of the neutral zone TPT data measured at the middle force levels (2 to 8 N) were in the range of 0.366–0.541. They were generally lower than those at the two extremes of the force levels (0.501–0.549), regardless of feedback or no feedback condition. This is probably because it is more difficult for the subjects to maintain a stable force at the low (due to subtle adjustment) and high ends (due to possible fatigue).

In conclusion, this study found that the TPTs measured at greater than 1 N finger force are more sensitive than those at lower force levels, but at the higher force levels the TPT differences are not significant. Hence, it is not necessary to tightly control the finger force but it is better to use the middle range force for the test. The automatic force control device can help achieve more sensitive TPT measurements.

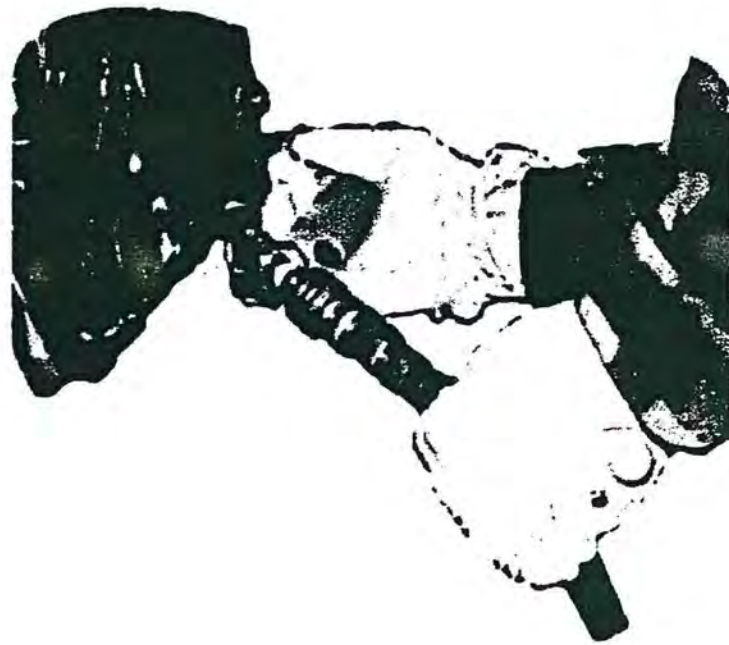
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