PERCEPTION OF HAND-TRANSMITTED VIBRATION: CAN VIBRATION OF ONE HAND MASK PERCEPTION OF VIBRATION IN THE OTHER HAND?

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1. INTRODUCTION

Vibration is often transmitted to both hands (e.g. from tools, machinery, steering wheels), yet the effects of hand-transmitted vibration are mostly studied by vibrating only one hand. When vibrating two hands, the absolute threshold for the perception of vibration is determined by the sensitivity of the most sensitive hand (Morioka, 2006).

Increasing the area of contact with vibration on one hand can reduce thresholds for perceiving vibration, often explained by 'spatial summation' in the Pacinian channel, one of four tactile channels mediating vibration perception in the glabrous skin (Verrrillo, 1962). The perception of a vibration mediated by one tactile channel (either Pacinian or non-Pacinian) can be masked if another vibration excites the same channel (e.g., Gescheider *et al.*, 1982), but there has been little research on masking between the hands.

The objective of this study was to examine whether the perception of vibration at one hand can be masked by vibration presented to the contralateral hand.

2. METHODS

Thresholds for the perception of vibration at the right hand were determined while applying masking vibration to the left hand.

2.1. Subjects

Ten males aged between 21 and 28 years (mean 23.3 years) participated in the experiment. All subjects were right handed, healthy, and had not been exposed to severe hand-transmitted vibration. The experiment was approved by the Human Experimentation Safety and Ethics Committee of the ISVR at the University of Southampton.

2.2. Apparatus

Vertical vibration was presented using two rigid cylindrical handles (30-mm diameter, 10-mm length) connected to two identical electrodynamic vibrators (MB Dynamics). Cross-axis acceleration was less than 5% of the vertical acceleration. A piezoelectric accelerometer (DJ Birchall) was mounted on each handle. Vibration stimuli were generated and acquired using *HVLab* Data Acquisition and Analysis Software (version 3.81). A rigid, contoured wooden seat and stationary footrests (mounted on their own vibrator systems, but not used in this experiment) were provided as shown in Figure 1.

Figure 1. A subject with the experimental apparatus.

2.3. Procedure

The subjects participated in two sessions on different days. Each session consisted of two parts to determine:

Part A: Threshold for the masker
Part B: Threshold of the test stimulus with the masker

All thresholds were determined using a two-interval two-alternative forced-choice (2IFC) tracking method with the up-down transformed response procedure and a three-down one-up rule. The sinusoidal test motions (presented to the right hand) had a frequency of 125 Hz. The masking stimuli (presented to the left hand) were $^{1}/_{3}$-octave bandwidth random vibrations centered on either 16 Hz or 125 Hz and

The subjects were presented with two observation periods, each of 1.0 second duration, separated by a 1.0 second pause. In Part A: subjects judged whether the first or the second observation period contained a vibration stimulus. In Part B: subjects judged which observation period contained the test stimulus presented at the beginning of each trial (see Figure 2). In both Parts, subjects responded by saying, 'first' or 'second'. The masked threshold was defined as:

$$\text{Masked threshold (dB)} = 20 \cdot \log_{10}\left(\frac{A_{N\text{dB}}}{A_{0\text{dB}}}\right)$$

where $A_{N\text{dB}}$ is the threshold (r.m.s. acceleration) of the 125-Hz test vibration with the masker at N dBSL, and $A_{0\text{dB}}$ is the threshold (r.m.s. acceleration) of the 125-Hz test vibration with the masker at 0 dBSL (i.e. the threshold of the masker).

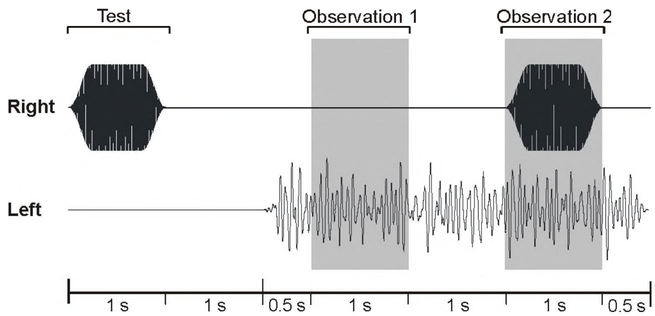

Figure 2. Example masked threshold test (Part B) with 16-Hz masker presented to the left hand and the 125-Hz stimulus to the right hand.

3. RESULTS

With the 125-Hz masker applied to the left hand, there were no significant differences in thresholds for the perception of 125-Hz vibration applied to the right hand (Friedman, p=0.766).

With the 16-Hz masker applied to the left hand, the threshold for perceiving 125-Hz vibration applied to the right hand differed over the six masker levels (0 to 30 dBSL) (Friedman, p=0.033). There was a slight decrease (1.6 dB) in the threshold when the masker increased from 18 to 24 dBSL (Wilcoxon, p=0.009) and a slight increase (1.4 dB) in the threshold when the masker increased from 24 to 30 dBSL (Wilcoxon, p=0.013) (Figure 3).

There were no significant differences in 125-Hz thresholds between the 16-Hz and 125-Hz maskers at any of the six masker levels (Wilcoxon, p>0.05).

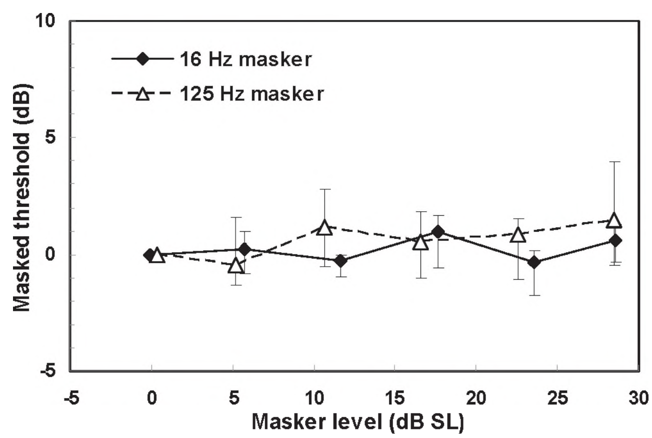

Figure 3. Median thresholds for 125-Hz vibration of the right hand while exposed to 16-Hz or 125-Hz masking vibration of the left hand. Vertical bars indicate inter-quartile range.

4. DISCUSSION AND CONCLUSIONS

In-channel masking has been demonstrated with hand-transmitted vibration when the masker is applied to the same hand (i.e. ipsilateral hand) as the test stimulus (Morioka and Griffin, 2005). However, in the present study, the detection of 125-Hz vibration presented to the right hand was not influenced by a 125-Hz masker applied to the left (contralateral) hand, suggesting that in-channel masking occurs unilaterally but not bilaterally. The absence of bilateral masking is consistent with other studies. More spatial pattern splits were identified when vibrotactile patterns were presented to fingers of both hands than when presented to fingers on the same hand (Craig, 1985a, 1985b). It has also been concluded that the effect of complexity on the recognition of vibrotactile patterns is reduced when the patterns are introduced bilaterally (Horner, 1992). These findings suggest the relevant properties of the tactile channels are exhibited in the peripheral system, because vibration stimuli that excite the same tactile channel can be differentiated when presented bilaterally but not when presented unilaterally.

If bilateral in-channel masking does not occur, the slight increase in the 125-Hz threshold when the 16-Hz masker increased from 24 to 30 dBSL cannot be explained by the masker being of sufficient magnitude to excite the Pacinian channel mediating 125-Hz vibration at threshold levels. It is more likely that high intensities of the 16-Hz masker increased the transmission of vibration from the hand to the arm (whereas the perception of 125-Hz hand-transmitted vibration is localized at the vibrating surface; Morioka, 2002), distracting attention from the 125-Hz vibration presented to the contralateral hand.

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