Conveying directional information through vibrotactile stimulation

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Introduction

A crucial aspect in the design of navigational aids for the blind is the transmission of information to the user. Vibrotactile stimulation is a preferred means, as opposed to auditory stimuli that may interfere with the use of environmental auditory cues for situational awareness. Conveying directional information is of particular importance and has traditionally be achieved with several tactors being positioned around the waist of the user, with each tactor coding for one direction. In contrast to that approach, we have explored ways of representing directions with nearly continuous angular resolution using only two tactors. Such pairs of tactors could be integrated into handles of rollators for frail elderly blind people or could be placed into pant pockets, making the cumbersome use of vibration belts obsolete. Because pilot experiments revealed that information transmission through vibration amplitude lacks accuracy and reliability, we tested three different temporal coding schemes.

Methods

33 seeing subjects participated. The three coding schemes were based on a time shift, on the modulation duty cycle, or a combination of modulation duty cycle and modulation frequency. Stimuli were applied to the thenars of both hands while the subject was seated in front of a monitor that was placed horizontally on the table, displaying a large semicircle on which a marker could be moved by means of a rotary knob. The subjects indicated the perceived direction by adjusting the marker position accordingly. For each coding scheme, four 30-trial runs were performed. The subjects were only informed after the first run about the rationale behind the respective coding scheme, leaving them naïve during the first run. For analysis, we fitted a third-degree polynomial to the response-versus-stimulus data to account for systematic deviations.

Results

When naïve, half of the subjects interpreted the time shift code in a manner opposite to our intention. Such a discrepancy was much rarer for the other two coding schemes. After the schemes were explained to them, subjects almost always recognized the general direction correctly. The deviations from the stimulus direction (median values across subjects) ranged from 20° (time shift coding) to 27° (duty-cycle coding), with larger values for some individual subjects. Deviations from the individually fitted polynomial ranged from 17° (time shift coding and combined duty cycle and frequency coding) to 20°. Taking into account outliers, combined duty cycle and frequency coding proved most reliable. With time shift coding and combined duty cycle and frequency coding, non-naïve subjects improved systematically across the “non-naïve” test runs.

Conclusion

Using just two tactors for conveying high-resolution directional information is a feasible and reliable approach, especially when the individual response-versus-stimulus relationship is taken into account. Practice may result in further improvements.

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