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Perception and neural representation of tones in conditions of masking release

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488 Effects of Noise on Detection of Vowels by Nonhuman Primates

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Background

Vowel detection in noisy conditions can help understand detection of general complex signals. In macaques, the thresholds for pure tone detection increase by 1 dB per dB of broadband noise added, maintaining the signal to noise ratio. In humans, vowel detection has been shown to depend on the signal to noise ratio of the most intense formant peak, but it is not clear that these mechanisms are in play in macaques which attach no semantic significance to and have no previous experience with vowels.

Methods

To investigate some of the underlying principles of detection of complex sounds, we examined detection of vowels in various kinds of noise. Three macaques (Macaca mulatta) were trained in a reaction time lever release task with interleaved catch trials to report detection of vowels presented alone and in continuous noise. We manipulated the bandwidth and the frequency range of the noise in order to evaluate the signals and noise components that influence detection. Signal detection theoretic analysis was used to determine behavioral accuracy from hit rates and false alarm rates.

Results

We studied the effect of noise on reaction times as well as detection thresholds, but found that noise only influenced thresholds. Detection of vowels shows the classic sigmoid relationship with sound pressure level. Broadband noise shifted the thresholds of vowel detection by +1 dB for 1 dB of noise. The pattern of incremental threshold shift did not change significantly when a mixture of vowels was used as background. When the bandwidth of the noise was restricted to 4000Hz, the frequency range of the vowel signal itself, it still caused a shift rate of 1 dB/dB, not significantly different from broadband noise. When the 4000 Hz noise band was translated in frequency, the shift rate decreased as the overlap between the vowel and the noise band decreased. When the noise components corresponding to the formant peaks were individually notched, no single formant was found to have predominance in vowel detection. When the bandwidth of noise was increased, the effect increased continuously but saturated beyond the second formant; increasing bandwidth while fixing the high frequency end caused small changes until both first and second formants were encompassed by the noise.

Conclusion

These results suggest that detection of vowel signals may relate to the total pressure over a partial band of the signal rather than the individual formant peak or the total pressure over the whole signal band. (NIH_R01_DC_11092)

489 Perception and Neural Representation of Tones in Conditions of Masking Release

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Background

The audibility of sounds in natural acoustic environments is often hampered due to the presence of other masking sounds. The amount of masking can be reduced due to the presence of beneficial signal properties. Psychoacoustical experiments showed that a masking release can be found in the presence of coherent intensity fluctuations across frequency (comodulation masking release, CMR) or interaural signal phase disparities (binaural masking level difference, BMLD) compared to a condition where those properties are absent. It was shown (Epp et al., ARO 2012) that a release from masking is reflected in auditory evoked potentials evaluated at constant stimulus levels and that the P2 amplitude reflects the level above masked threshold better than the physical level of the stimulus. It is hypothesized that a psychoacoustical measure of the audibility of the signal also correlates with the auditory evoked potentials when evaluated at the same level above masked threshold.

Methods

To assess the psychoacoustical measure of audibility, thresholds were measured for masked tones. Masked threshold was varied with the introduction of comodulation, interaural signal phase disparity or a combination of both. Based on the individual data, the listeners were asked to rate the audibility of a masked tone at individually adjusted physical levels corresponding to constant levels above threshold. To assess the neural activity, auditory evoked-potentials were measured for the same stimuli as used in the rating experiment within the same listeners.

Results

Psychoacoustical results indicate a growth of audibility that is increasing with increased level above masked threshold. Conditions without a release from masking show a tendency for higher audibility than conditions with a masking release. Auditory evoked potentials show an increase in amplitude with increased level above masked threshold. The analysis of the evoked potential shows differences in sensitivity between N1 and P2 to comodulation and interaural signal phase. The electrophysiological data with constant level above masked threshold are in agreement with data of Epp et al. (ARO 2012) with constant physical stimulus levels.

Conclusion

The psychoacoustical data show that audibility is mainly determined by the level above masked threshold rather than the physical level of the stimulus. The higher audibility for conditions with a masking release might be some residual influence of the overall level of the stimulus on the audibility rating. The electrophysiological data support the hypothesis that the P2 component of auditory evoked potentials correlates closely with levels above masked threshold rather than with physical stimulus levels.