Solving the “Cocktail Party Problem:” Modulated Background Noise Effects on Signal Discrimination in Cope’s Gray Tree Frog

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The Cocktail Party Problem is An everyday obstacle in hearing

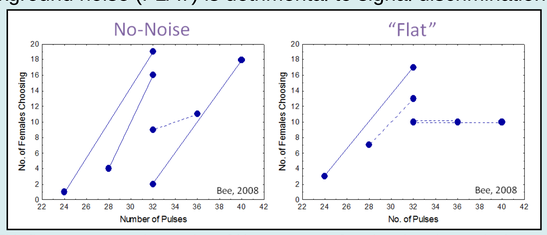
• The Cocktail Party Problem occurs when background noise in a social aggregation prevents a listener from discriminating a target signal (ie: a certain conversation).
• For humans with normal hearing, amplitude-modulation of background noise confers an increase in ability to understand (discriminate) speech signals. (Nelson, Jin, Carney, Nelson, 2003)
•Both humans and frogs face the Cocktail Party Problem!

How do frogs find their mates?

•Large populations gather in ponds (called choruses)
•Males in choruses signal to females via mating calls
- Mating calls are series of pulses delivered at a rate of ~45Hz.
- In mating choruses, amplitude of chorus noise is naturally modulated in background noise at frequencies near 2Hz and 45Hz. (Vélez and Bee, 2010)

•*Hyla chrysoscelis* females prefer longer male call length (more pulses).
- Implies greater genetic quality of male.
- 32 pulses is the mean pulse number of *H. chrysoscelis* mating calls. Calls in the figure below were between + / - 1 and 2 SD of the mean. (Bee, 2008)

•According to a 2008 study by Dr. Mark Bee, constant-amplitude background noise (FLAT) is detrimental to signal discrimination:



•This figure compares the number of *H. chrysoscelis* females choosing each alternative mating call in conditions of silent (no-noise) and constant amplitude (FLAT) conditions.
•Solid lines indicate that a statistically significant preference was shown for the longer mating call. Dotted lines indicate no statistically significant preference for the longer call.

Hypothesis and Predictions

- **Hypothesis:**
  - **Exposure to amplitude-modulated background noise will result in improved discrimination of calls compared to FLAT chorus noise.**
- Prediction:
  - SAM noise exposure will result in a higher number of females choosing the longer call compared to the FLAT condition in the aforementioned 2008 study by Bee.

Phonotaxis Experiments Reveal Female Mate Choice

Mating pairs of frogs were collected from ponds during their mating season.

Females were placed in a soundproof chamber and played two choices of mating calls (from speakers 180 apart) in the presence and absence of FLAT or sinusoidally-modulated background noise.

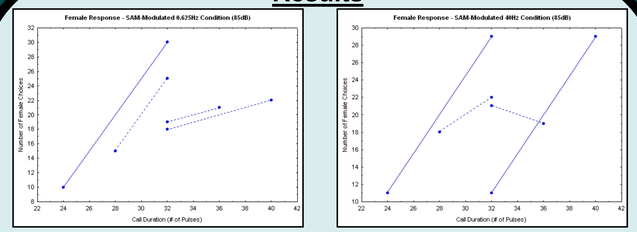
Females moved toward the speaker projecting the call of their choice (phonotaxis). We measured the number of females choosing each mating call in each condition.

Females listened to both mating calls projected from each speaker.

Experimental Conditions

•When background noise maskers were modulated, amplitude was altered in sinusoidal waves at frequencies of 0.626Hz and 40Hz.
-Known as Sinusoidal Amplitude Modulation (SAM)
•Background Noise Maskers:
FLAT (control), 0.625Hz SAM, 40Hz SAM
•Mating Call Choices Presented (# of pulses):
28vs32, 32vs36, 32v40, 36v40
- Call lengths chosen were within + / - 1 or 2 standard deviations of the mean.
•Notes:
- Mating calls were played at 85dB and 79dB.
- Background noise was played at 73dB.
- The background noise was projected from an overhead speaker, while the mating calls were projected from the ground-level.
-Sample size: 40 females tested in each condition.

Results



•Solid lines indicate that a statistically significant preference was shown for the longer mating call. Dotted lines indicate no statistically significant preference for the longer call.

Conclusions

• For calls projected at 85dB in the presence of 40Hz SAM, females showed a significant preference for the longer calls in 24vs32 and 32v40 conditions. This is an improvement in call discrimination when compared to Bee’s study (projected calls at 85dB in the presence of 75dB background noise) in 2008. For all 79dB call conditions and for calls projected at 85dB in the presence of 0.625Hz SAM, there was no improvement in call discrimination. Thus, results indicated partial support for our hypothesis.
• In the future, use of recorded naturally-modulated chorus noise may also support call-discrimination improvement in modulated chorus noise.

Implications of Future Successful Studies…

•Compared to individuals with normal hearing, it is more difficult for the hearing-impaired to understand conversations within noisy social settings. (Bronkhorst and Plomp, 1992)
•According to studies conducted by the NIH’s National Institute of Deafness and other Hearing Disorders, experiments such as this one will lead to the improvement of hearing technology.
-Data from similar studies in flies currently aids the production of “directional hearing aids” that amplify sound only in the direction the user is facing. (Miles and Hoy, 2006)

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