The Neural Basis of Dip Listening in Treefrogs

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Introduction

- Difficulty communicating in noisy social environments is known as "the cocktail party problem."[1, 2, 3, 4]
- The cocktail party problem affects human and non-human species like treefrogs, which mate in large groups with many species of frogs.[1, 3, 5, 6, 7, 8]
- Female frogs select males based on the certain acoustic qualities of their advertisement calls. [1, 6, 9, 10, 11, 12]
- Natural fluctuations or "dips" in the amplitude of the noise may allow females to catch acoustic glimpses of males' calls. [1, 13, 14, 15]
- Behavioral studies show Cope's gray treefrogs, *Hyla chrysoscelis,* but not green treefrogs, *Hyla cinerea,* benefit from dip listening in the presence of background noise. Longer dips afforded by low frequency noise prove especially beneficial. [13, 14, 15]

Hypothesis

- Detection thresholds for *H. chrysoscelis* will decrease when calls are played in dips, while thresholds for *H. cinerea* remain unchanged despite call placement.
- Calls in the dips of the chorus shaped noise will be detected at lower thresholds than calls played at the peak of noise.
- Thresholds for calls played in low frequency modulated noise will be lowest.

References

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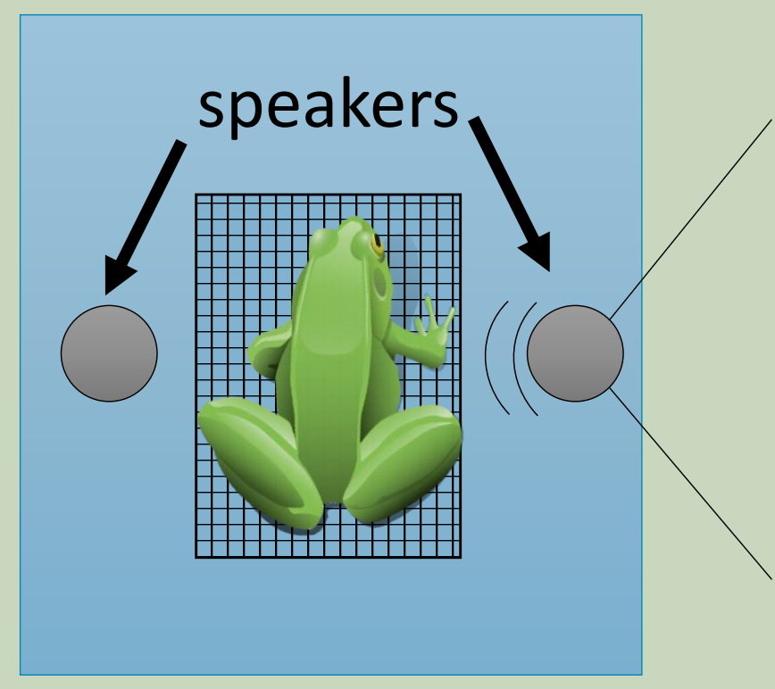
Methods

Craniotomy

- Remove skull and membranes near midbrain

Multi-Cellular Recordings

- Locate multi-cellular neural activity in midbrain
- Present signal and masker combinations
  - Call series ranging 61 dB to 85 dB in amplitude
  - Unmodulated FLAT noise or SAM noise of 1.25 Hz, 2.5 Hz, or 5 Hz
- Record electrophysiological responses using a single glass electrode



Unmodulated FLAT Noise

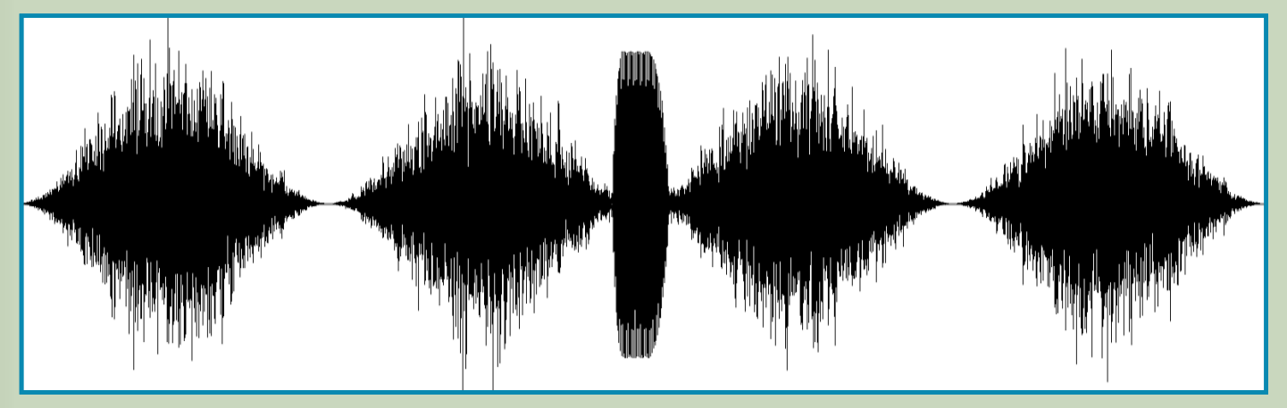
OR

SAM noise of 1.25 Hz, 2.5 Hz, or 5 Hz

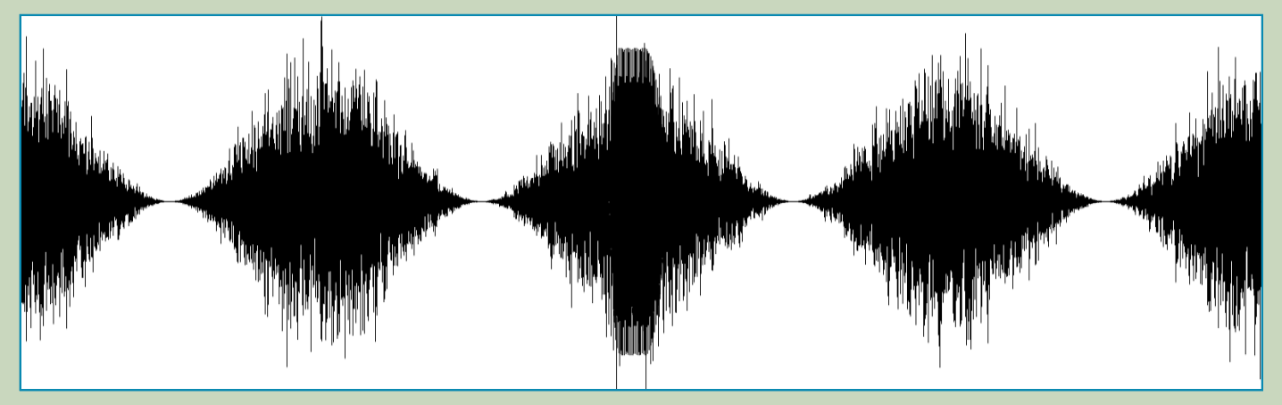
+

Synthetic species-specific call

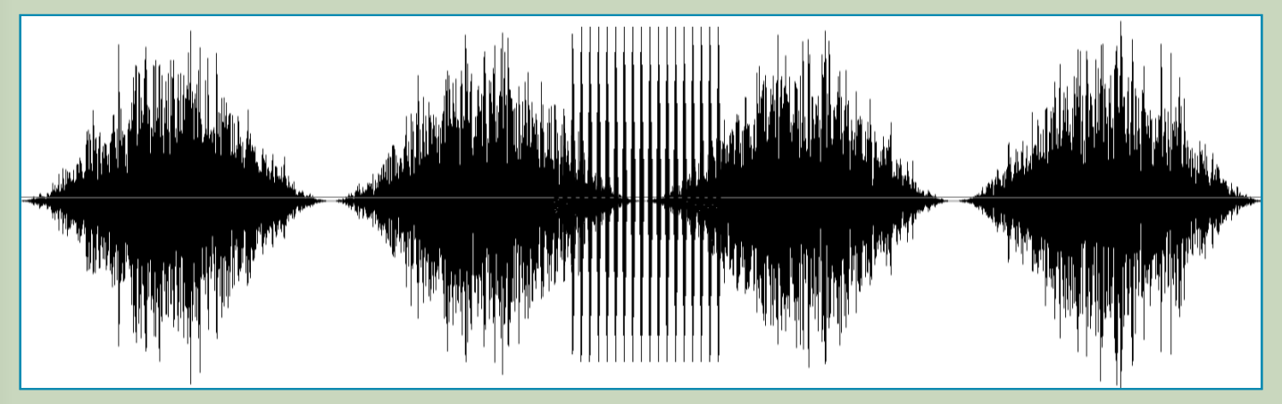
H. cinerea call in the dip



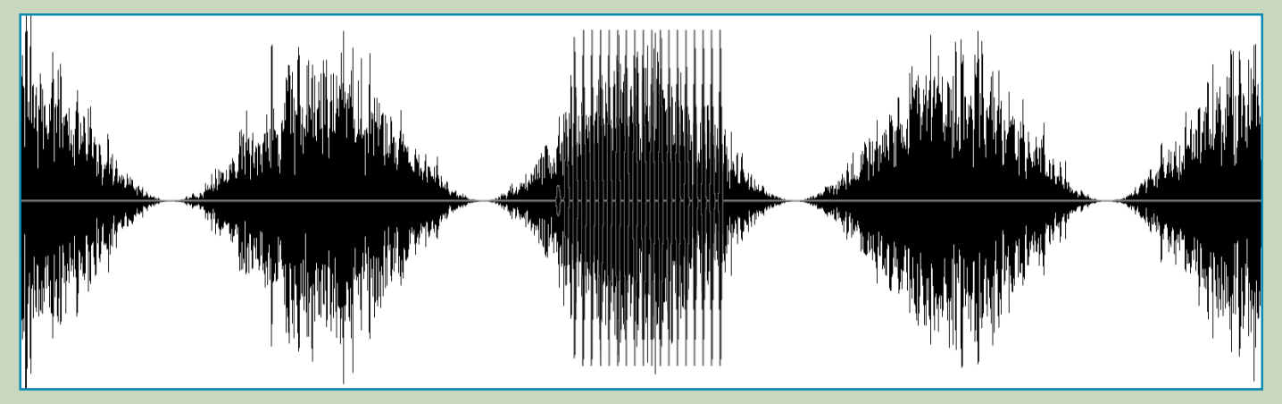
H. cinerea call in the peak



H. chrysoscelis call in the dip



H. chrysoscelis call in the peak



Analysis

- Count impulses in response to or in absence of call
- Determine d', the measures of signal detectability
- Calculate threshold difference from FLAT noise using d'=1.5 for each masker
- Perform 3-way ANOVA with species, maskers, and modulation rates

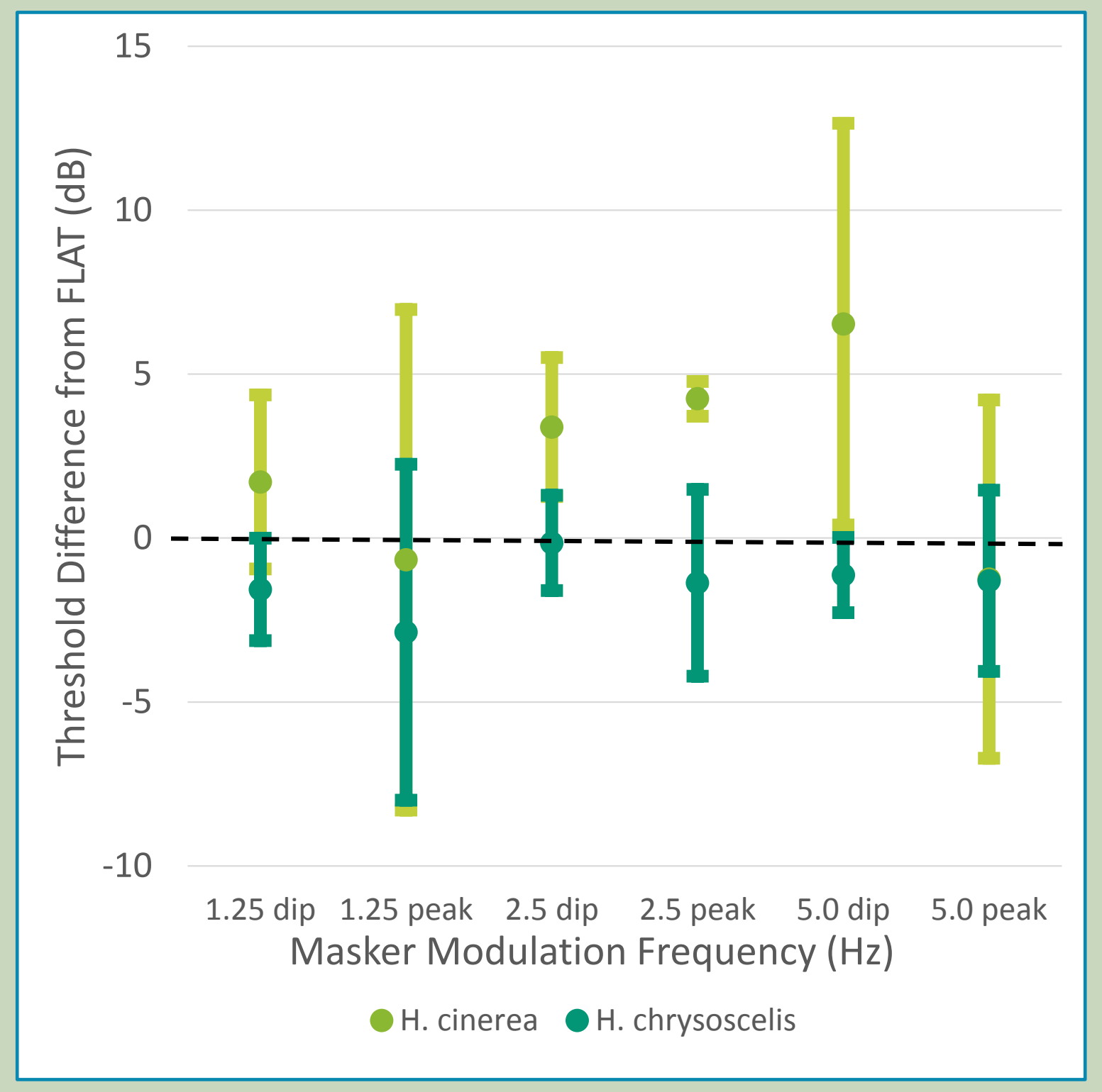
Results

- On average, females of *H. chrysoscelis* detected calls at significantly lower thresholds than females of *H. cinerea* (A, D).
- Females of *H. chrysoscelis* experienced lower thresholds for calls presented with SAM maskers compared to those presented with unmodulated FLAT noise (A, C).
- For most call and SAM masker combinations, females of *H. cinerea* experienced higher thresholds than for calls played in unmodulated FLAT noise (A, B).
- The modulation rate of SAM maskers significantly affected the amount of masking release observed in the frogs (D). Calls coupled with maskers of lower modulation rates tended to be detected at lower thresholds than those paired with higher frequency maskers (A, B, C).
- The threshold differences between calls placed in the peak or the dip of SAM maskers was not significant (D).

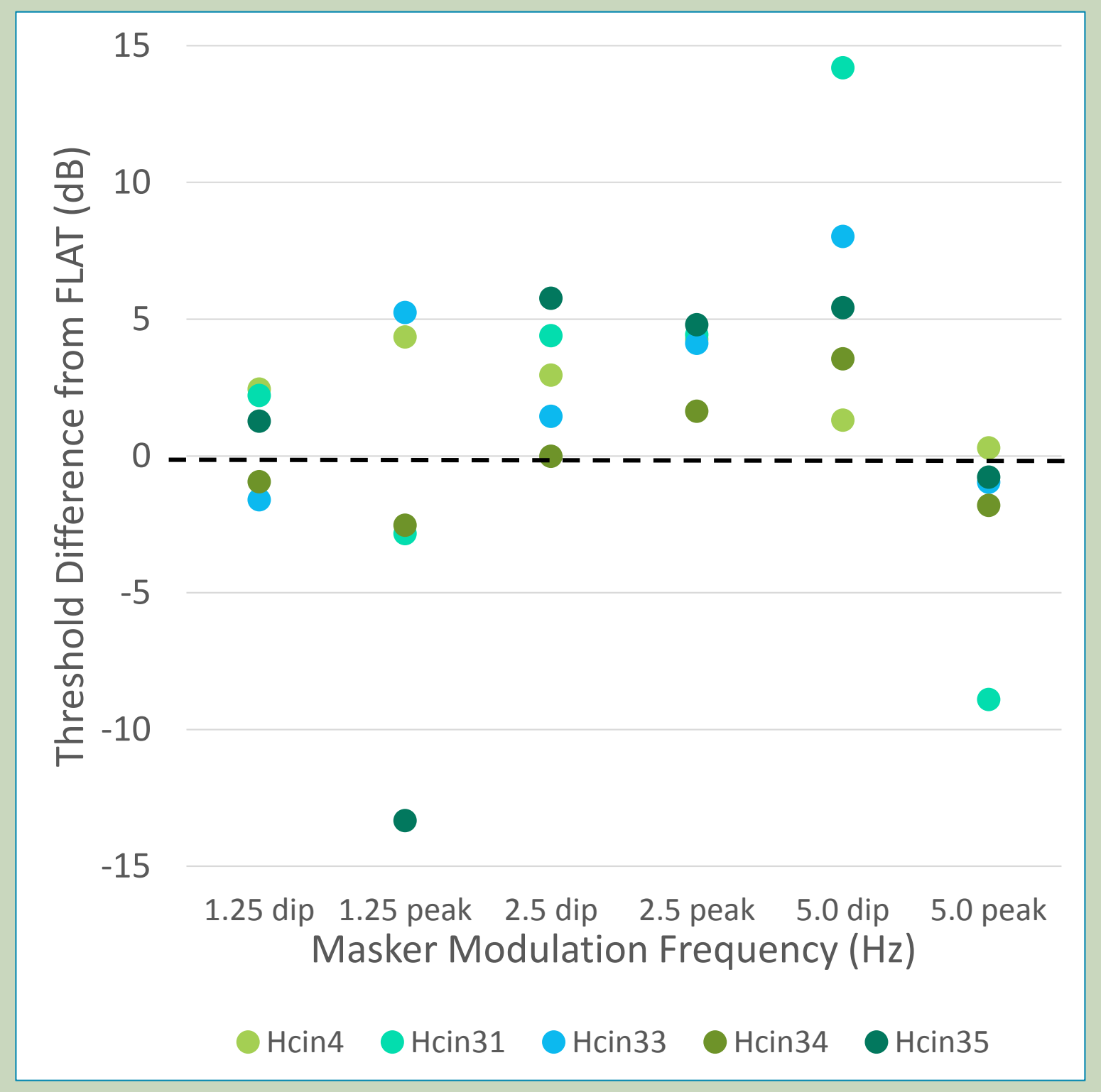
D

Effect	*df*	*F*	*P*	*Partial η^2*
modulation rate	**2**	**5.8**	**0.031**	**0.39**
modulation rate x species	2, 9	1.2	0.309	0.12
call placement	1	4.6	0.060	0.34
call placement x species	1, 9	1.6	0.234	0.15
modulation rate x call placement	2, 1	2.4	0.127	0.21
modulation rate x call placement x species	**2, 9**	**3.8**	**0.050**	**0.30**

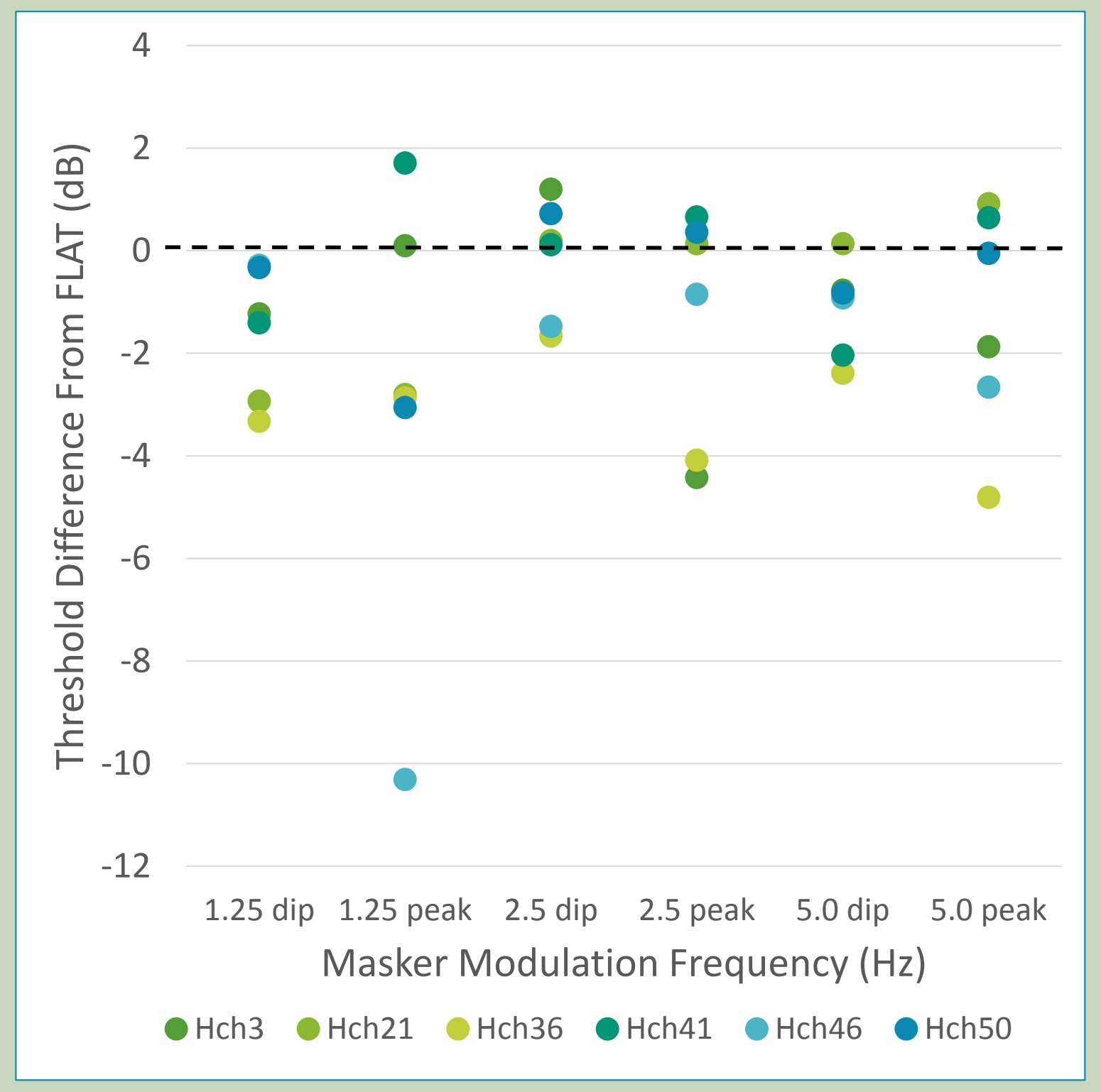
A



B



C



Conclusions

- As in previous dip listening studies, our results suggest a significant difference in detection thresholds between females of *H. chrysoscelis* and females of *H. cinerea.*[13, 14, 15]
- Modulation rates of maskers appear to play a significant role in the amount of masking release experienced by female treefrogs.
- Contrary to the dip listening hypothesis, the placement of the calls in dips or peaks of the SAM maskers did not significantly affect the ability of either species to detect signals.
- Discrepancies between our results and those of past studies may be due to effects of seasonal plasticity.