Neural correlates of the precedence effect and echo threshold in the inferior colliculus of the behaving cat

Daniel J. Tollin, Luis C. Populin, and Tom C. Y. Yin
University of Wisconsin-Madison, Madison, Wis. U.S.A.

1. INTRODUCTION

The perception of transient sounds delivered from two different spatial locations is experienced by a shift in delay. This delay is due to the properties of the arriving sound and the trajectories of the delay (Bastiaanssen et al., 1988). While the delay is between 10-15 ms, observers perceive a single phantom sound at a location determined by the two loudspeakers. This is known as the precedence effect (PE). For delays greater than 20 ms, two independent sounds are perceived. The presence of the lagging stimuli has virtually no effect on localization performance. The precocity of the PE is a significant departure from how we perceive sounds in the absence of cross-modal integration. The PE is one of the most perplexing auditory phenomena, and the question of whether or not it is dependent on the presence of cross-modal integration remains unanswered. The psychophysical data support this interpretation.

2 METHODS

Three adult cats were used in these experiments. A head holder, eye coil, and recording preparations, were all designed for cats. The cats were tested at an age of 12-18 months. The cat vision was not affected by the recording procedures. The cats were trained to fixate an LED at the midline (0o,0o) and then to make saccadic eye movements to the position of sound sources.

3 PSYCHOPHYSICAL DATA

3.1 Cats understand the target in single-source sound localization

Consistent with the results of earlier studies, the cats were trained to fixate an LED at the midline (0o,0o) and then to make saccadic eye movements to the position of sound sources. The cats were trained to localize the sound source accurately to within ±2 SD of the mean velocity during each trial. Localization performance is virtually unaffected by the lagging stimulus. The presence of the lagging stimuli has virtually no effect on localization performance. The precocity of the PE is a significant departure from how we perceive sounds in the absence of cross-modal integration. The PE is one of the most perplexing auditory phenomena, and the question of whether or not it is dependent on the presence of cross-modal integration remains unanswered. The psychophysical data support this interpretation.

3.2 Cats experience summing localization and the precedence effect

Consistent with the results of earlier studies, the cats were trained to fixate an LED at the midline (0o,0o) and then to make saccadic eye movements to the position of sound sources. The cats were trained to localize the sound source accurately to within ±2 SD of the mean velocity during each trial. Localization performance is virtually unaffected by the lagging stimulus. The presence of the lagging stimuli has virtually no effect on localization performance. The precocity of the PE is a significant departure from how we perceive sounds in the absence of cross-modal integration. The PE is one of the most perplexing auditory phenomena, and the question of whether or not it is dependent on the presence of cross-modal integration remains unanswered. The psychophysical data support this interpretation.

3.3 Echo threshold occurs at longer delays

At echo threshold, response to lag is nearly fully recovered.

4 PHYSIOLOGICAL DATA

4.1 Data analysis

4.2 Responses to single sources

4.3 Responses to precedence effect stimuli

4.4 Responses to the lag recoveries with increasing ICD

5 POPULATION DATA

5.1 Responses to lag recoveries earlier in behaving cats than in unanesthetized cats

5.2 Population recovery function: At echo threshold, response to lag is nearly fully recovered.

6 SUMMARY

1. When tested in a sound localization task, cats experience the precedence effect for delays between 10-15 ms. When tested in the absence of cross-modal integration, they experience two independent sounds for delays greater than 20 ms.

2. Cats experience the precedence effect. For ICDs greater than 13 ms, cats often localize the lagging sound suggesting that they perceive the lagging sound as a separate independent sound source. However, for ICDs between 1-15 ms, cats often localize the paired sounds to the location of the leading sound. There are some indications that the responses of the units were affected by the auditory stimulus.

3. In the inferior colliculus of the behaving cat, the single and transient responses to the lagging sound were suppressed over the range of ICDs for which the PE is maximal (10-15 ms). For ICDs greater than 20 ms, the responses to the lagging sound were not suppressed. The responses to the leading sound were not suppressed for ICDs greater than 20 ms. The responses to the lagging sound were not suppressed for ICDs greater than 20 ms.

4. For ICDs of greater than 13 ms, the response to the lagging sound was nearly fully recovered. The response to the lagging sound was nearly fully recovered. The response to the lagging sound was nearly fully recovered.

5. Single-unit responses to the lagging sound in unanesthetized cats resulted in larger half-max ICDs than in behaving cats.