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Bianchi, Federica; Verhulst, Sarah; Dau, Torsten

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Behavioral and objective measures of the precedence effect

Federica Bianchi, Sarah Verhulst, Torsten Dau
Centre for Applied Hearing Research, Technical University of Denmark

Abstract

The precedence effect (PE) refers to the dominance of directional information carried by a direct sound (D) over the spatial information contained in the reverberating sounds (surrounds) in sound localization. Many studies investigated the PE at different stages along the auditory pathway, but it is still unclear whether this perceptual phenomenon originates from peripheral or central processes. The present study aimed at investigating peripheral contributions of the PE, comparing psychoacoustic data to objective measures of lag-suppression.

The psychophysical data showed that the time range in which the PE occurred (precedence window) was between 1 and 5 ms. Click-evoked otoacoustic emissions (CEOAEs) were recorded to investigate monaural lag-suppression at a peripheral stage of the auditory pathway, and showed lag-suppression within the precedence window. Following brainstorm responses (ABRs) were used to investigate both monaural and binaural lag-suppression at the brainstem level. The ABRs to monaural stimulation reflected the peripheral lag-suppression, while the binaural ABRs did not show any additional contribution to binaural processes to the monaural lag-suppression.

The results of this study demonstrate a monaural and peripheral component to lag-suppression, reflecting basilar membrane (BM) lead-lag impulse response interactions, in a time range from 1 to 4 ms.

Introduction

Consider a direct sound (D) with a single reflection (lag). The lead-lag pair is reproduced in the free field by two clicks played over loudspeakers at different locations. The perception of the lead-lag pair depends on the lead-lag delay and varies both in the number of perceived stimuli and in their location.

Psychoacoustical experiments

Aim

- Define the three windows of perception
- Define the lateralization of the lead-lag pair for each window

Stimuli

- Devise with ICIs of 0-8 ms and ITDs of 200 and 900 μs were presented using an interleaved technique. For each ITD and ICI condition, 1800 repetitions of the following three stimuli were presented:
  - Single Click (SC)
  - Double Click (DC)
  - Double Click Inverted (DCI)

Results

- Mean echo-threshold occurs for an ICI of 4.3 ms (stimulation).
- Similar thresholds for monaural and binaural stimuli.
- Fusion mechanism not dependent on binaural processes, in agreement with [2].

Observations:

- Mean echo-threshold occurs for an ICI of 4.3 ms (stimulation).
- Similar thresholds for monaural and binaural stimuli.
- Fusion mechanism not dependent on binaural processes, in agreement with [2].

CEOAEs

Aim

- Investigate monaural monaural and binaural stimulation to investigate whether binaural processes contribute to lag-suppression at brainstem level

Stimuli

- Devise with ICIs of 0-8 ms and ITDs of 200 and 900 μs were presented monaurally and binaurally. The ABRs were recorded using 4 surface electrodes M1, M2, Fz, and Cz (reference).

Results

- These results suggest that the lead-lag interactions on the BM provide a peripheral source of lag-suppression occurring for ICIs within the precedence window.

ABRs

Aim

- Compare ABRs to monaural and binaural stimulation to investigate whether binaural processes contribute to lag-suppression at brainstem level

Stimuli

- Devise with ICIs of 0-8 ms and ITDs of 200 and 900 μs were presented monaurally and binaurally. The ABRs were recorded using 4 surface electrodes M1, M2, Fz, and Cz (reference).

Figure 4 Procedure to derive the suppressed response from the unmasked ITD=300 μs condition. Echo suppressor 

Figure 7 ABRs recorded for subject KE for binaural stimulation (left: ITD=300 μs; right: ITD=600 μs). The waves V elicited by lead and lag are indicated by downward-pointing triangles.

Discussion

Perceived location of a lead-lag pair as a function of the lead-lag delay. The head schematics refers to a free field setup, where the leading click is indicated by a star.

Monaural and binaural ABRs

For 4 out of 6 subjects, the lag-wave reduction obtained for binaural stimulation was not larger than the solution obtained for monaural stimulations. These results suggest that binaural processes did not add any substantial contribution to monaural and peripheral suppression at the brainstem level, in agreement with [4].

Conclusion

The results show that BM lead-lag interactions are the main source of lag-suppression up to the brainstem. This suggests the existence of a peripheral and a binaural component to the linearized PE.

References