Behavioral and objective measures of the precedence effect

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The precedence effect (PE) refers to the dominance of directional information carried by a direct sound (in the spatial information referred to as the lead-ear) over sounds 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 correlates of the PE, comparing psychoacoustical data to objective measures of lag-suppression.

The psychoacoustical data showed that the time range in which the PE operated (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 how lag-suppression within the precedence window. Behavioral 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 of binaural processes to the monaural lag-suppression.

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

Introduction

Consider a direct sound (lead) with a single reflection (lag). The lead sound is reproduced in the free field by two clicks played over the 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
- Three perceptual phenomena occur within the precedence window:
  - Fusional
  - Lead-lag-dominance
  - Induction

RESULTS
- Mean echo-threshold occurs for an ICI of 4.3 ms (binaural stimulation).
- Similar thresholds for monaural and binaural stimulations
- Fusion mechanism NIT dependent on binaural processes, in agreement with [5, 6]

CEOAes

AIM
- Investigate monaural lag-suppression at a peripheral stage of auditory processing

STIMULI
- Five different ICIs of 0-5 ms and ITDs of 300 and 900 μs were presented using an interleaved technique.

RESULTS
- Lag-suppression in ear closer to lead side

ABRs

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

STIMULI
- Monaural ABRs and CEOAE results: 5 ICIs of 0-5 ms and ITDs of 300 and 900 μs were presented monaurally and binaurally. The ABRs were recorded using 4 surface electrodes M1, M2, Fpz (ground), Cz (reference).

RESULTS
- Lag-suppression in the ABR results might be due to the higher components present in the ABR. Thus, the shorter time range of lag-suppression obtained in the ABR results might be due to the higher frequency content.

Discussion

Monaural and binaural ABRs
- For 4 out of 6 subjects, the lag-wave/s reduction obtained for binaural stimulation was not larger than the solution obtained for monaural stimulations.

Conclusions

The results show that BM lead-lag interactions represent the main source of lag-suppression up to the brainstem. This suggests the existence of a monaural and peripheral component to the binaurally processed PE.