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Evaluating the Use of Steering a Hearing Aid in a Dynamic Multi-talker Environment Using Body Signals

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In this study the potential of steering a hearing aid through head pointing or eye gaze was evaluated on hearing-impaired participants when using natural behaviors. “Eye steering” was more effective than “head steering” when following natural movements, especially when the target was positioned to the side of the participant.

Introduction

- The latest hearing aids allow some form of steering audio with the head by using beamformers. However those beamformers remain broad and do not usually offer much help in the **cocktail party problem**.
- It is possible to obtain more **precise beamformers** that can separate distinct voices in a multi-talker situation using multi-microphone arrays [1,2].
- The question this study focuses on is **how to control those accurate beamformers**. Current beamformers are controlled by the head, but studies have shown that eye steering can also be beneficial for users [1, 2, 3].
- In order to investigate which type of steering works better with **natural movements**, an experiment was designed to compare the **speech intelligibility** and the **behavior of participants** in a dynamic multi-talker situation under three different steering conditions, assuming we had access to ideal beamformers.

Methods

Experimental design

Participants: 6 hearing impaired participants who were wearing their own hearing aids.

Setup: Sentences from the DAT speech corpus [4] were presented from three loudspeakers located at -30°, 0° and +30° to the participant (figure 1).

Stimulus:

- DAT sentences are in the form: ”*Asta thought about a shirt and a mouse yesterday*”. The task is to repeat the two target words.
- 9 lists of 20 sentences were presented, 3 lists for each condition.
- All three talkers were speaking at the same time, the target was indicated by an LED which was **activated the moment a new sentence started**.
- Before steering a TMR of 6 dB was applied for the control condition to be comfortable without reaching ceiling performance.

Three steering conditions were investigated:

- No steering
- Head steering
- Eye steering

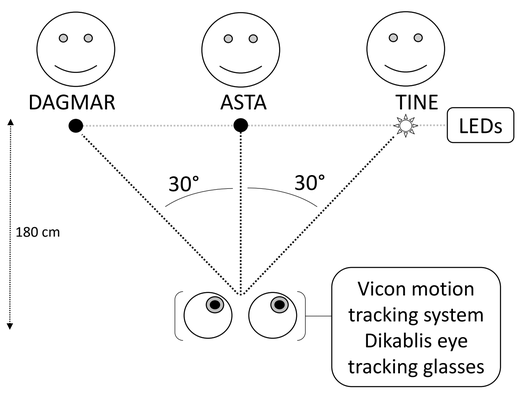

Figure 1: Picture to better represent the setup, with three visual targets, LEDs under them, Vicon system and Dikablis glasses to detect head movement and eye gaze.

Functioning of the system to steer audio

- Angle of head or eyes controls steering (depending on condition) according to figure 2 by modifying the **sound level output by the loudspeakers**.
- Examples of steering:
  - Participant’s eyes are pointing at an angle of -30°
    - Loudspeaker 1: +6 dB
    - Loudspeaker 2: -6 dB
    - Loudspeaker 3: -6 dB
  - Participant’s eyes are pointing at an angle of 15°
    - Loudspeaker 1: -6 dB
    - Loudspeaker 2: -4 dB
    - Loudspeaker 3: -4 dB
- Therefore participants were **penalized** if they were not pointing exactly at the target.
- Instructions: “The system is steered with your head and eyes.”

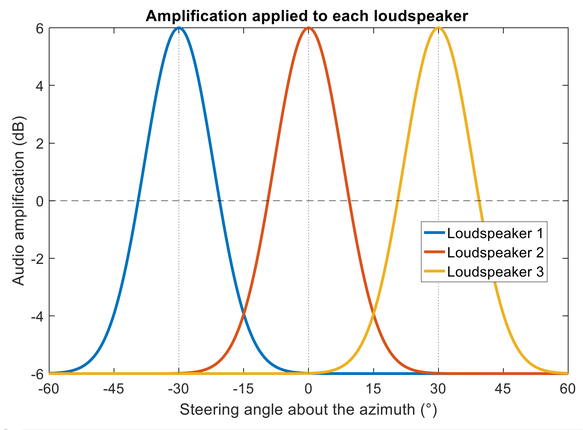

Figure 2: Details of the amplification applied to each loudspeaker depending on the angle of steering.

Results

Speech intelligibility

- The speech intelligibility was evaluated for each sentence and categorised according to the steering condition and the position of the target.
- The “eye steering” condition is **significantly better** than the “no steering” condition.
- **When the target is in the middle**, “head steering” is significantly better than “no steering” and similar to “eye steering”.
- **When the target is on the left or on the rig**ht of the participant the “head steering” does not perform as well and the variance between the text subjects is larger.

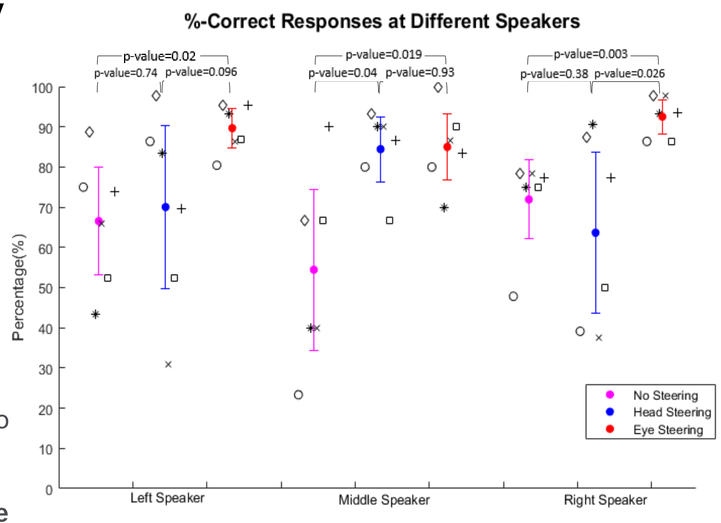

Figure 3: Scatter plot showing the percentage of correct responses at each speaker, for each condition, with 95% confidence intervals and p-values.

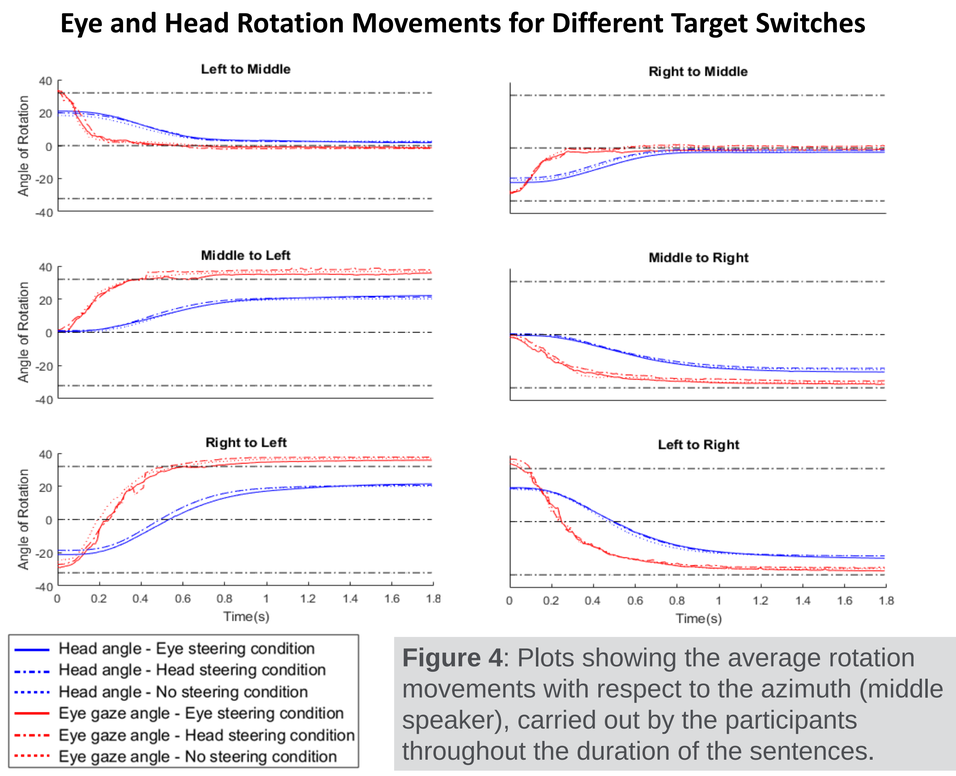

Figure 4: Plots showing the average rotation movements with respect to the azimuth (middle speaker), carried out by the participants throughout the duration of the sentences.

Head and eye gaze movements

- The movement remained similar between conditions.
- The eye gaze usually points closely to the target.
- The head angle is accurate when the target is in the middle, but it doesn’t move the whole way when the target is to the side.
- The eye movement is faster than the head movement.

Discussions & Conclusions

- The speech intelligibility results for the “head steering” condition are explained when taking into account the typical head movement and the functioning of the steering system. It would have been unnatural for the participants to point their head exactly at the targets on the sides.
- A different set of instructions detailing the steering mechanism would have likely lead to better results in the “head steering” condition, but it would not have resulted in natural behavior.
- A very precise beamforming system like this would need to be controlled by eye gaze or would require training to follow unnatural movements.
- It is important to note that this setup was not realistic. Further studies on the head and eye behavior of people in real conversations would be needed to validate these findings.

Information

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