Real-life Listening in the Lab: Does Wearing Hearing Aids Affect the Dynamics of a Group Conversation?

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Abstract

Hearing science traditionally focuses on testing listening in isolation. Here we explore the effect of providing hearing aids to listeners with hearing impairment by analyzing the dynamics of a group conversation. First, a pilot study was conducted to identify suitable conversational starters. Using these starters, preliminary results from an experiment involving two normal-hearing and one hearing-impaired interlocutor are presented. The results show that when providing hearing-aid amplification to the hearing-impaired talker in close-to-quiet situations (noise at 50 dB SPL) and applying directional signal processing when conversing in noise (75 dB SPL), all talkers reduce their speech level. This effect could stem from the normal-hearing interlocutors no longer having to compensate for the communication difficulty experienced by the hearing-impaired interlocutor.

1 Introduction

When evaluating the detrimental effects of being hearing impaired (HI), hearing science has traditionally one-sidedly focused on the ability to listen. Some of these detriments can be, partly, compensated for by presenting amplified and processed sounds through hearing aids (HAs).

Recently, the hearing science community has requested more emphasis on '*encompassing the interactive nature of everyday communication*' (Keidser et al., 2020) into experimental designs. So far, a few studies have focused on exploring the communication between a HI and a normal-hearing (NH) interlocutor, showing the NH alters the spectral content of his/her speech (Beechey et al., 2020b; Hazan et al., 2019) and increases speech levels (Sørensen et al., 2021) when having a conversation with a HI interlocutor. Providing HI interlocutors with HA amplification caused the HI to initiate turn-taking faster (FTO floor-transfer offset), increase the articulation rate, and reduce the speech level. In response, the NH interlocutors also reduce the speech level when their HI conversational partner was wearing a HA as opposed to unaided listening (Beechey et al., 2020a; Petersen et al., 2022).

We are currently exploring whether similar effects of HA signal processing can be seen in a group conversation between a HI person and two NH persons. This includes identifying a suitable conversational task when increasing the group size from two persons to three.

2 Identifying Suitable Conversational Tasks

Studies within hearing science often evaluate within-subject changes e.g., of providing HA amplification or speech-enhancing HA processing strategies. As such, the study design must meet these demands: **1)** conversations must be replicable and natural. **2)** No learning/ training effect of the conversation task to avoid alterations in the conversational dynamics over time. **3)** The above should be realized for previously unacquainted interlocutors. Additionally, **4)** the task should not require visual acuity or physical activity.

As none of the existing methods for starting a conversation met the above criteria, we conducted a pilot study exploring three conversational starters prior to the actual experiment: **A) Consensus** questions where participants were to agree upon a common answer. **B) Picture cards** with keywords encouraging a conversation based on a theme. **C)** Four historical events to be put in chronological order in a **timeline**.

The goal of the study was to investigate whether the starter affected the conversational dynamics. A total of 10 examples of each starter were generated and tested in four groups of three NH interlocutors.

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The timeline task showed significantly altered dynamics compared to the consensus and picture-card tasks: **i)** The turn-taking timing (median FTO) was significantly higher (33 ms longer, $p < 0.001$), **ii)** there were fewer floor-transfers (2.6 turns/min less, $p < 0.001$), **iii)** the speaking times between talkers were less balanced (difference between talkers was 9.75% higher, $p = 0.03$), and **iv)** more silence was present within the 5-minute conversations (24.9 s of additional silence, $p < 0.001$). None of these measures showed any training/learning effects over time.

These results indicate that the timeline task was less interactive. One participant noted to another "*you are thinking inside your head, you have to say it out loud*". And difference in speaking times was likely due to a difference in background knowledge between participants.

The timeline task was discarded, and for the experiment investigating the effects of HA processing, the picture cards and consensus questions were used to start the conversations.

3 Effect of Hearing Aid Processing on Group Conversational Dynamics

Using the two tasks described above to initiate conversations between a HI and two NH persons (one <35 years and one >50 years), we investigated how providing HA processing to the HI talker affected the group conversation. The effect of HA amplification was investigated in low 50 dB SPL background noise (unaided vs aided), while the effect of providing directional microphone sound-processing[1] was examined in high 75 dB SPL background noise (omni-directional vs directional).

Preliminary analysis of the first 10 triads shows that providing HA amplification to the HI interlocutor reduced the speech levels of all three talkers in low background noise (unaided vs aided: -1.2 dB, $p = 0.002$, **Figure 1A**). Similarly, in high levels of noise, improving the listening situation of the the HI interlocutor by providing directional signal-processing caused all three talkers to reduce their speech levels (omni vs dir: -0.7 dB, $p = 0.04$, **Figure 1A**). As might be expected, this change was most evident for the HI talker (omni vs dir: -2.0 dB, $p = 0.001$, **Figure 1B**).

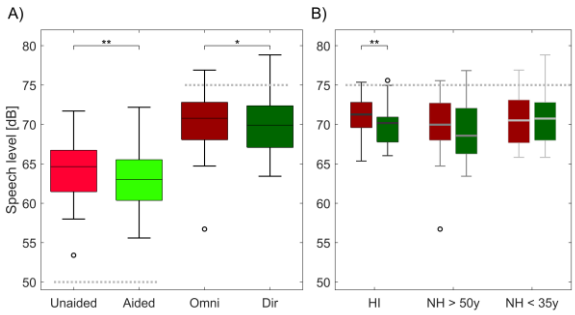

Figure 1: A) Effect of providing hearing aid amplification (unaided vs aided) at a low background noise level and of directional signal-processing (omni vs dir) in a high level of noise. The noise levels are indicated by dotted grey lines (50 dB and 75 dB respectively). **B)** The interaction between talker and effect of directional processing (omni vs dir) showing how the HI talkers are most affected by the alteration in hearing aid signal processing.

While conversing at a very positive SNR in the low level of noise (13.6 dB), the conversation in noise is conducted at low SNR (-4.9 dB). In a standardized speech-in-noise test using every-day sentences, an SNR of -2.5 dB corresponds to an intelligibility of around 50% for younger NH listeners (Nielsen & Dau, 2009). As all interlocutors in the current experiment were able to conduct a conversation at -4.9 dB SNR, the speech intelligibility seems to be much higher for real-life communication, than in the standardized laboratory tests of speech understanding in noise. This illustrates how the traditional single-sided focus on listening result in test scenarios which far from resemble every-day listening.

This is the first known attempt to investigate the effect of HI and HA signal processing on the dynamics of a group conversation. Preliminary results show that, despite only affecting the listening condition of the HI talker, HA processing causes all talkers to adjust their speech levels. Although the effect in noise is largest for the HI talker, it also affects the two NH talkers, potentially due to the NH talkers no longer having to make up for the communication difficulty experienced by the HI listener when providing adequate HA processing, improving audibility.

[1] Omni-directional processing preserve the auditory input, while directional processing combines the HA microphone inputs to emphasize sounds from the front, while attenuating noise from the back.

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