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Who Are My Conversational Partners? A behavioral scoring method using voice activity patterns

→ Introduction

- Group conversations are more complex than dyads, posing greater challenges for people with hearing loss, especially in noisy environments, making conversational partner identification particularly difficult for hearing aid users (HAUs).
- Prior research shows that turn-taking patterns can be used to reliably identify conversation partners beyond dyads [1] but lose reliability in multi-talker settings [2].
- We present a Conversational Alignment Score (CAS) framework that uses voice activity patterns to quantify turn-taking alignment and identify conversational partners in realistic multi-talker settings.

→ Hypothesis

In multi-talker conversations, the HAU's true conversational partners will exhibit stronger turn-taking coordination, characterized by minimal gaps and overlaps. This alignment can be quantified using the CAS values.

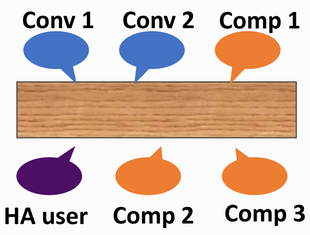
→ Aim

To develop and evaluate a CAS framework that uses only voice activity patterns to:

- **Quantify turn-taking alignment in multi-talker conversations.**
- **Identify the HAU's most likely conversational partners with high Partner Identification Accuracy in realistic and complex settings.**

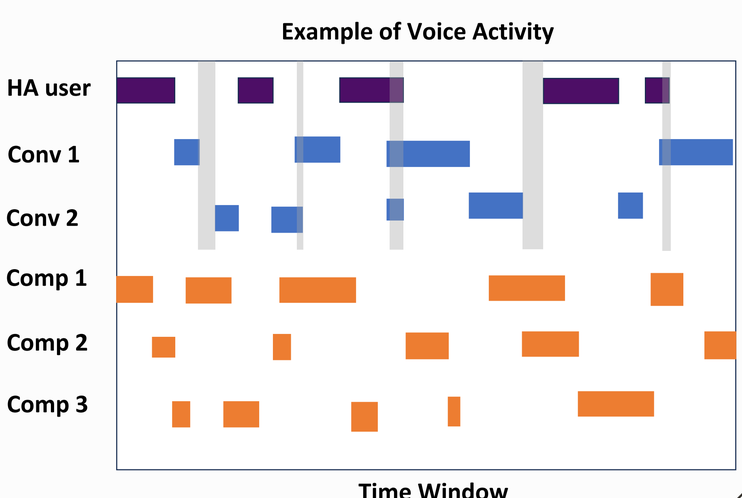
→ Method

Example of CAS calculation for every possible partner group in 3-talker scenario:



➢ Step 1 - Voice Activity Detection (VAD)

VAD traces are extracted from all speakers in a group conversation, with additional competing talkers introduced from a separate conversation.



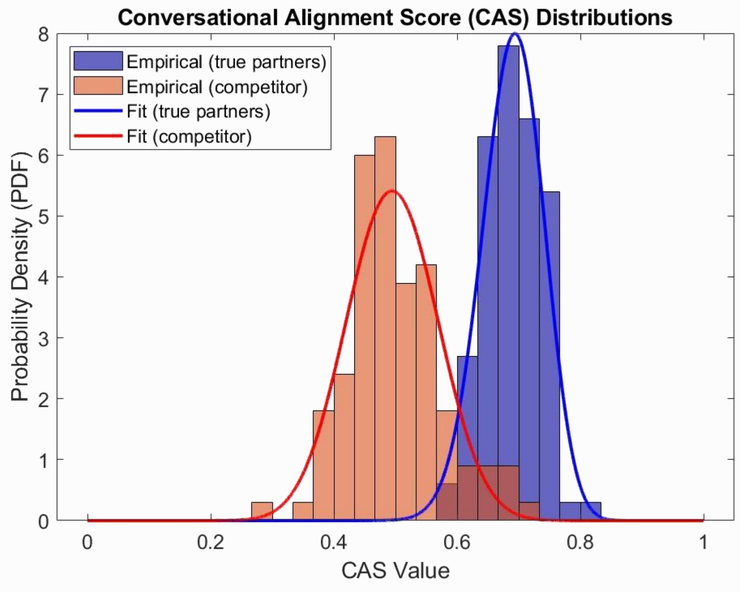
➢ Step 2 - Turn-taking analysis and coordination scoring

Calculate CAS, the CAS score **penalizes** gaps and overlaps

States	VAD	Status
S_1	$HAU = 0, CONV_1 = 0, CONV_2 = 0$	All are silent
S_2	$HAU = 1, CONV_1 = 0, CONV_2 = 0$	Only User talks
S_3	$HAU = 0, CONV_1 = 1, CONV_2 = 0$	Only Conv1 talks
S_4	$HAU = 0, CONV_1 = 0, CONV_2 = 1$	Only Conv2 talks
S_5	$HAU = 1, CONV_1 = 1, CONV_2 = 0$	HAU and Conv1 talk
S_6	$HAU = 1, CONV_1 = 0, CONV_2 = 1$	HAU and Conv2 talk
S_7	$HAU = 0, CONV_1 = 1, CONV_2 = 1$	Conv1 and Conv2 talk
S_8	$HAU = 1, CONV_1 = 1, CONV_2 = 1$	All talk

➢ Step 3 - Partner identification

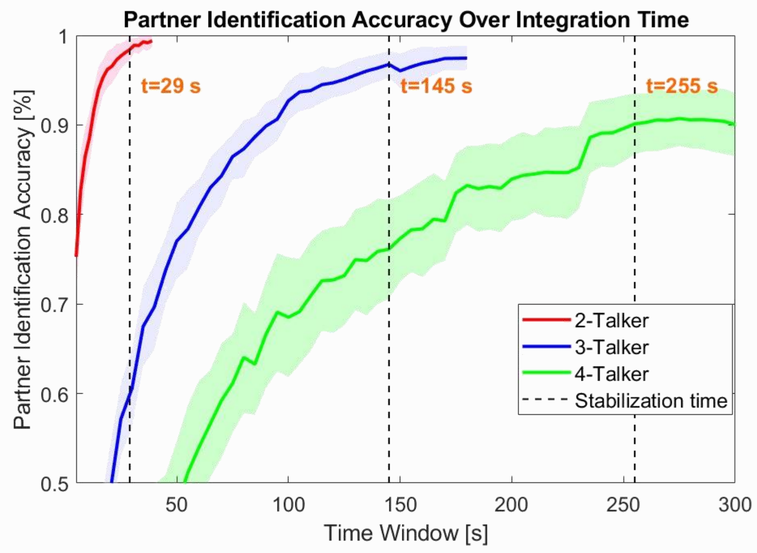
Bayesian modeling separates true partners from competitors based on their CAS distributions, producing a True Partner Probability for each candidate group.

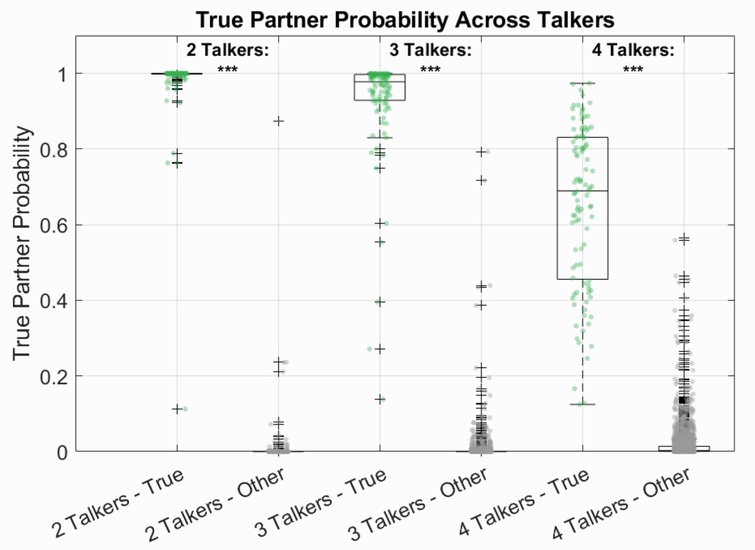


- ❑ The method has been generalized to handle any number of talkers in a group conversation.
- ❑ The method was evaluated on real conversational datasets with:
  - **Group sizes:** 2-talker [3,4], 3-talker [2], and 4-talker [5] conversations
  - **Noise levels:** Low vs. high
  - **Hearing status:** Normal hearing vs. hearing impaired
  - **Hearing aid use:** Aided vs. unaided

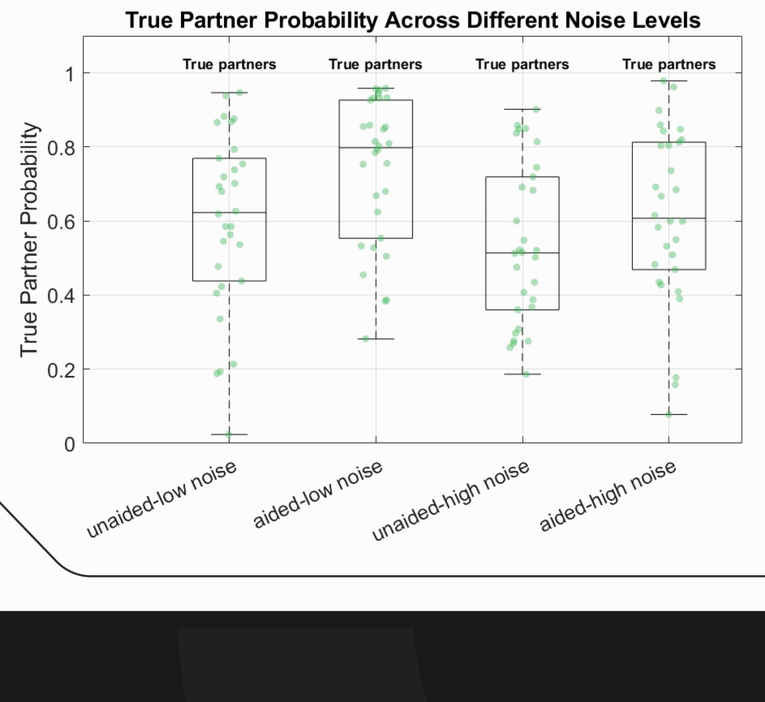
→ Results

- Comparison of partner identification accuracy and CAS values across 2-, 3-, and 4-talker datasets, for time windows where the accuracy becomes stable





- Evaluation of turn-taking behavior across noise levels and hearing aid use for 4-talker data



→ Conclusion

The CAS provides a scalable, voice-activity-based framework for reliably identifying conversation partners in multi-talker, noisy, and complex environments.

Increasing the number of conversational partners requires longer time windows to achieve high partner identification accuracy. Although identification accuracy stabilizes across conditions, true partner probability decreases with more talkers. In the 4-talker dataset, true partner probability is influenced by background noise and hearing aid signal processing.

This work is a step towards integrating turn-taking-based speech enhancement into hearing aid signal processing, with the potential to improve real-world communication for people with hearing loss.

[1]. Hoang, P., Tan, Z.H., De Haan, J.M. and Jensen, J., 2022. The minimum overlap-gap algorithm for speech enhancement. *IEEE Access*, *10*, pp.14698-14716.
[2]. Petersen, E.B., 2024. Investigating conversational dynamics in triads: Effects of noise, hearing impairment, and hearing aids. *Frontiers in Psychology*, *15*, p.1289637.
[3]. Sørensen, AJ., 2021. PDF and PSD files of DiapixDK picture materials-adapted Danish version [Data set]. Zenodo. https:// doi.org/10.5281/zenodo.4638693
[4]. Petersen, E.B., MacDonald, E.N. and Sørensen, A.J., 2022. The effects of hearing-aid amplification and noise on conversational dynamics between normal-hearing and hearing-impaired talkers. *Trends in Hearing*, *26*, p.23312165221103340.
[5]. Nicoras, R., Buck, B., Fischer, R.L., Godfrey, M., Hadley, L.V., Smeds, K. and Naylor, G., 2025. Effective Design for Experiments on Small-Group Conversation: Insights From an Example Study. *American Journal of Audiology*, *34*(2), pp.305-320.

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