

Speech Perception Challenges: The Role of Second Language Experience Across Masker Types in native Malayalam speakers for Low-frequency Phonetically balanced words

Pradeep Kumar Mahapatra¹, Dhananjay Rachana^{1*}, Ritwik Prakash¹, Ashish Bisht¹

Nitte Institute of Speech and Hearing, Nitte (Deemed to be University), Mangalore, India

PRADEEP KUMAR MAHAPATRA¹

<https://orcid.org/0009-0000-2669-7473>

DHANANJAY RACHANA¹ (Corresponding Author)

<https://orcid.org/0000-0003-3321-7225>

RITWIK PRAKASH¹

<https://orcid.org/0009-0002-9912-323X>

ASHISH BISHT¹

<https://orcid.org/0009-0009-8595-8296>

HIGHLIGHTS

- Examined the effect of language exposure on speech perception using SNR-50 and MR
- New language exposure showed no significant influence on perception or MR
- Masker complexity and language influenced speech perception outcomes

ABSTRACT

Background and Aim: Speech perception in noise is influenced by factors like masker type, language familiarity, and the listener's linguistic experience. In multilingual contexts like India, understanding how second language learning affects native language speech processing is crucial and remains relatively underexplored. The study aimed to examine the effect of learning a new language on speech perception of low-frequency, phonetically balanced (PB) native Malayalam words in the presence of different masker conditions.

Methods: A cross-sectional study included 54 native Malayalam-speaking participants (18-25 years) in two groups: Experienced (n=27; >4 years of Kannada exposure) and non-experienced (n=27; no Kannada exposure). Signal-to-noise ratio for 50% correct recognition (SNR-50) and masking release were assessed using the Malayalam low-frequency phonetically balanced (PB) words in the presence of 2-talker (2TB) and 4-talker babble (4TB) in Malayalam, Kannada, and speech-shaped noise (SSN).

Results: In both experienced and non-experienced participants, SNR-50 performance followed 2TB > SSN > 4TB. Both groups performed better with native (Malayalam) than non-native (Kannada) maskers. However, no significant differences were observed between the groups. Interestingly, for masking release, the non-experienced group showed slightly more with 2 TB and the non-native (Kannada) masker ($p > 0.05$).

Conclusion: Findings indicated that exposure to Kannada did not produce a significant advantage in perceiving Malayalam low-frequency PB words in different noise conditions. Future studies with larger samples and different levels of proficiency may further clarify the role of language exposure in speech perception in noise.

Keywords: Speech perception in noise, masking release, Malayalam, multi-talker babble, language exposure.

INTRODUCTION

Speech perception in noise depends on both acoustic factors and linguistic properties of competing speech, including familiarity with phonetic patterns, noise type, and speaker-listener language, making comprehension harder than in quiet [1]. Interference from background sounds—termed masking—occurs as either energetic masking, where maskers overlap the target signal peripherally, or informational masking, where listeners struggle centrally to separate similar-sounding target and background speech despite audibility [2]. Listeners can partly counter this through masking release: perceptual gains that occur during brief dips in babble noise, allowing target speech to peek through [3]. This release is enhanced further when additional cues, such as spatial separation or distinct voice characteristics, aid target-speech focus [4].

Language familiarity modulates speech-on-speech masking, with recognition differing for native versus non-native competing speech [5, 6]. Native-language maskers may increase informational masking through lexical competition, while unfamiliar maskers can reduce interference due to inaccessible linguistic content [7, 8], suggesting masking effects depend on listener experience and linguistic similarity. Most research focuses on pairings like English-Mandarin or English-Dutch [5, 6], with fewer studies addressing multilingual contexts like India, where exposure to related languages is common. Malayalam and Kannada, both Dravidian languages, share phonological/prosodic features; native Malayalam listeners show differing recognition of Malayalam versus Kannada babble [7], though effects of extended Kannada exposure remain unclear.

Low-frequency PB word lists were used to ensure speech perception scores reflected genuine auditory processing rather than lexical familiarity or contextual prediction, minimizing top-down compensatory strategies. Their reduced familiarity reveals subtle perceptual difficulties often missed by high-frequency words [8] and requires reliance on acoustic cues rather than guesswork [9], better capturing listeners' ability to segment speech in complex listening conditions.

Despite growing research on speech-in-noise perception, few studies examine how second-language exposure affects native-language speech perception in multilingual populations like India's. This study investigated Kannada exposure's effect on perceiving Malayalam PB words, since Kannada is commonly acquired by Malayalam speakers migrating to Karnataka for education/employment, providing sustained naturalistic exposure. We examined masker type (two-talker babble, four-talker babble, speech-shaped noise), masker language (Malayalam, Kannada), and Kannada experience on speech reception thresholds in native Malayalam listeners. Participants formed two groups: non-experienced (no Kannada exposure) and experienced (≥ 4 years

exposure), the latter threshold reflecting sufficient duration for functional second-language acquisition per prior bilingual studies [10, 11].

It was hypothesized that the speech reception thresholds would worsen as masker complexity increased, with four-talker babble producing poorer performance than two-talker babble and speech-shaped noise, consistent with previous findings [12, 13]. Masker language would influence performance, with differences between native (Malayalam) and non-native (Kannada) competing speech [5, 7]. Finally, if second-language exposure influences speech segregation, listeners with Kannada experience should be expected to demonstrate different speech reception thresholds compared to non-experienced listeners.

METHODS

The study included two groups of normal-hearing adults, all native Malayalam speakers, aged 18 to 25 years, recruited through convenience sampling. Power analysis was conducted for sample size estimation using G*Power software version 3.1 with an assumed moderate effect size (Cohen's $d = 0.5$ to 0.6), with power set at 0.8 and alpha at 0.05 , resulting in a sample size of 27 in each group. A mixed-design study was conducted with masker condition as the within-subject factor and language exposure as the between-subject factor. Masker conditions included two-talker babble and four-talker babble presented in Malayalam and Kannada, and speech-shaped noise. Participants underwent audiological, cognitive, and language screening. Normal hearing was confirmed via Pure tone average ≤ 15 dB HL (no group differences, $p > 0.05$, Mann-Whitney U), Type A tympanograms with acoustic reflexes, and bilateral Transient-evoked otoacoustic emission (> 6 dB SNR). Cognitive status was screened using the Malayalam-Mini-Mental State Examination (score > 25), and Kannada exposure was assessed via the Language Experience and Proficiency Questionnaire (LEAP-Q). Participants with otological/neurological disorders or occupational noise exposure were excluded. Written informed consent was obtained, following the Declaration of Helsinki.

Participants

For the purpose of this study, participants were operationally classified into two language-experience groups based on their Kannada exposure. The experienced group consisted of participants with at least four years of Kannada language exposure, whereas the non-experienced group consisted of participants with no prior Kannada language exposure before recruitment.

The non-experienced group comprised 27 native Malayalam-speaking participants (14 male, 13 female) ($M = 19.4$ years, $SD = 1.62$) with no prior exposure to Kannada. They were first-year undergraduate students at a university in Karnataka, and at the time of recruitment, it was ensured that these students had just arrived in Karnataka for their studies. They were recruited within the first month of their program and had not yet been exposed to the Kannada language, either socially or academically. The experienced group comprised 27

participants (14 males, 13 females; $M = 22.8$ years, $SD = 0.96$) with at least four years of exposure to Kannada. They were fourth-year students from the same university. They had consistent exposure to Kannada through academic activities and everyday social interactions during their residence in Karnataka. Their proficiency in Kannada was assessed using the LEAP-Q [14]. Participants were considered proficient if their LEAP-Q score was greater than 7. The mean LEAP-Q score was 7.8, indicating a functional level of Kannada proficiency. Although the experienced group had a slightly higher mean age than the non-experienced group, all participants were within the young adult age range, minimizing the influence of age-related auditory differences.

Stimuli

The target stimuli consisted of five equally balanced lists of low-frequency, phonetically balanced (PB) Malayalam words. The use of low-frequency words was intended to minimize lexical familiarity effects and provide a more sensitive assessment of speech perception under challenging listening conditions. The word lists were obtained from the list prepared by Prabhu and used in previous research by Bisht et al. [15]. The recordings were conducted in a sound-treated room that had the ambient background noise was less than 25 dBA. The microphone was positioned 30 cm from the speaker's mouth on an adjustable stand to capture sound appropriately and achieve adequate recording quality. All recordings were carried out with Adobe Audition® software (version 2.0.5) at a sampling rate of 44.1 kHz and 24-bit resolution. For the recordings, hiss reduction and denoising were performed in Adobe Audition® (v. 3.0) to improve recording quality. Every word was exported as an individual .wav file and normalized to -3dB for root mean square (RMS) amplitude.

The study utilized three masker conditions: 2TB, 4TB, each presented in both Malayalam and Kannada, and SSN. To ensure linguistic relevance and consistency, speakers were assigned different sets of sentences drawn from standardized Kannada and Malayalam story passages. To reduce masker-gender effects, both male and female voices were used to create the multi-talker babble. All recordings were evaluated by trained raters for naturalness, clarity, and overall speech quality. The 2TB condition was created by mixing the speech stimuli of two speakers (one male and one female), while the 4TB condition combined recordings from all four selected speakers (two male and two female). This ensured that the masker stimuli were linguistically and acoustically balanced across both languages. For the masker, the average pitch was 139 Hz for 2TB_Mal, 131 Hz for 2TB_Kan, 135 Hz for 4TB_Mal, and 128 Hz for 4TB_Kan.

For the speech-shaped noise (SSN) condition, representative Malayalam and Kannada speech samples were recorded, concatenated, and processed using a custom MATLAB script [16] to generate noise matching the original speech's long-term average spectrum. Multi-talker babble maskers incorporated both male and female speakers to enhance ecological validity and maximize informational masking, introducing greater pitch and voice-characteristic variability representative of natural speech.

Three audiologists with over five years of experience rated the samples on the basis of fluency, clarity, and pronunciation using a 4-point Likert scale (0-3). Attributes like Rate of Speech Duration, Distortion, and

Naturalness were scored from Not Appropriate (0) to Totally Appropriate (3). Ratings were collected via a Google Form, and the highest-rated sample was selected as the target stimulus. All the maskers had approximately the same energy level across the spectrum, with the overlapping long-term average spectrum of 2TB and SSN depicted in Figure 1.

Procedure

The experiment was conducted in an acoustically treated, double-room setup with ambient noise levels below 25 dBA. Using the Smriti Shravan software [17] participants were tasked with a low-frequency Malayalam PB words identification test under various masking conditions. Both the target stimuli (Malayalam words) and the different maskers (2TB, 4TB, SSN) were uploaded into the software to measure the SNR-50, the signal-to-noise ratio needed for 50% accurate word recognition. The stimuli were delivered bilaterally through a personal computer routed via an audiometer, presented at 0 dB SNR and 60 dB SPL, using Sennheiser HDA 200 headphones. The participants listened to the target word with background noise, and a closed-set response was given by the participants by selecting the perceived word on the computer screen. An adaptive procedure was used to adjust the SNR in 2-dB step sizes. A three-down and one-up rule was applied, meaning the SNR was decreased after three correct responses and increased after one incorrect response. A total of eight reversals were conducted for each condition, and the midpoint of the last four reversals was used to calculate the SNR-50 for each masking condition.

Analysis

SNR-50 values were obtained across masker conditions with randomized stimulus presentation. SSN SNR-50 quantified energetic masking, while babble SNR-50 reflected total masking (energetic plus informational). Masking release (MR) was calculated as the difference between SSN and multi-talker babble SNR-50 scores, with larger values indicating greater benefit. This measure reflects reduced informational masking and improved target-masker segregation during speech perception amid competing speech backgrounds [18].

Statistical analysis

Statistical analyses used SPSS v29.0. Descriptive statistics were computed, and normality was checked via the Shapiro-Wilk test. Baseline PTA equivalence between experienced and non-experienced groups was assessed using Mann-Whitney U tests. Separate three-way mixed ANOVAs examined effects of language experience (between-subjects), masker noise type, and masker language (within-subjects) on SNR-50 (noise type: 2TB, 4TB, SSN) and masking release (noise type: 2TB, 4TB), both crossed with masker language (Malayalam, Kannada). Main effects and interactions were evaluated via the General Linear Model, with significant effects followed by Bonferroni-corrected post-hoc comparisons. Significance was set at $p < 0.05$ throughout.

RESULTS

This study aimed to investigate the influence of new language experience on speech perception across different masker conditions (2TB_Mal, 2TB_Kan, 4TB_Mal, 4TB_Kan, and SSN) in two groups (Experienced and Non-experienced). The Mann-Whitney U test indicated no significant difference in PTA values between the groups ($p > 0.05$), suggesting comparable hearing abilities. Descriptive statistics for SNR-50 (in dB) across masker type and language are presented in Table 1.

Signal-to-noise ratio for 50% correct recognition

A three-way mixed ANOVA for the SNR-50 results revealed no significant interaction among noise type, masker language, and listener experience [$F(2, 51) = 1.082, p = 0.343, \eta^2 = 0.020$], suggesting that the combined influence of these variables did not differentially affect speech perception. However, significant main effects were found in both masker language and noise type. Specifically, the language of the competing speech significantly influenced speech perception [$F(1, 52) = 20.587, p < 0.001, \eta^2 = 0.284$], indicating that participants' performance was affected depending on the competing speech. In contrast, listener experience did not show a significant main effect [$F(1, 52) = 1.396, p = 0.243, \eta^2 = 0.026$], suggesting that prior experience did not significantly impact speech perception. Further two-way interactions were examined; results stated that the interaction involving experience with noise type [$F(2, 51) = 1.234, p = 0.295, \eta^2 = 0.023$] and language [$F(1, 52) = 2.413, p = 0.126, \eta^2 = 0.044$] was not significant. Post-hoc pairwise comparisons with Bonferroni correction were conducted to further examine the significant main effects.

Pairwise comparisons revealed significantly better SNR-50 performance in the Malayalam masker condition than in the Kannada masker condition (mean difference = 0.816 dB, 95% Confidence interval (CI) [0.455, 1.177], $p < 0.001$). Significant differences were also observed across noise types. Performance was significantly better in the 2TB condition than in the 4TB condition (mean difference = 2.109 dB, 95% CI [1.574, 2.644], $p < 0.001$) and in the SSN condition than in the 4TB condition (mean difference = 1.347 dB, 95% CI [0.765, 1.929], $p < 0.001$). A smaller but statistically significant difference was also observed between the 2TB and SSN conditions (mean difference = 0.762 dB, 95% CI [0.260, 1.263], $p = 0.001$).

Pairwise comparisons revealed no significant difference in SNR-50 between the experienced and non-experienced groups across all noise types (Figure 2; $p > 0.05$).

Pairwise comparisons indicated no significant difference in SNR-50 between the experienced and non-experienced groups across masker languages (Figure 3; $p > 0.05$).

Masking Release Descriptive statistics were computed for MR results (in dB) to compare performance across masker type and language (Table 2).

A three-way mixed ANOVA for masking release revealed no significant interaction among noise type, masker language, and language experience [$F(1,52) = 0.018$, $p = 0.892$, $\eta^2 = 0.000$], indicating that the combined effect did not influence outcomes. Significant main effects were observed for masker language [$F(1,52) = 95.192$, $p < 0.001$, $\eta^2 = 0.647$], with a difference in masking release between the non-native masker and native masker language, and also for noise type [$F(1,52) = 20.587$, $p < 0.001$, $\eta^2 = 0.284$], indicating a difference in masking release across the noise types. However, language experience did not yield a significant main effect [$F(1,52) = 0.236$, $p = 0.629$, $\eta^2 = 0.005$], indicating that exposure to Kannada did not significantly influence masking release across conditions. No significant two-way interaction was found between experience and noise type [$F(1,52) = 2.273$, $p = 0.318$, $\eta^2 = 0.042$], suggesting that the noise complexity was not modulated by language experience. Similarly, the interaction between experience and masker language was insignificant [$F(1,52) = 2.413$, $p = 0.126$, $\eta^2 = 0.044$], indicating that Kannada exposure did not significantly alter the effect of masker language. Post-hoc pairwise comparisons with Bonferroni correction revealed a significant effect of masker language, with greater masking release observed for Kannada than Malayalam (mean difference = 1.225 dB, 95% CI [0.683, 1.766], $p < 0.001$). Significant differences were also observed across noise types, with masking release being greater for the 4TB condition than the 2TB condition (mean difference = 2.109 dB, 95% CI [1.675, 2.543], $p < 0.001$).

Pairwise comparisons revealed no significant difference in masking release between the experienced and non-experienced groups in either the 2TB or 4TB conditions (Figure 4; $p > 0.05$).

Post-hoc analysis revealed no significant difference in masking release between the experienced and non-experienced groups for either the Malayalam or Kannada masker conditions (Figure 5; $p > 0.05$).

DISCUSSION

This study examined speech perception and masking release for low-frequency Malayalam PB words with/without Kannada exposure in young adults. Performance varied significantly across noise types, with greatest difficulty in 4TB, followed by SSN, and least in 2TB. Perception was better in Malayalam than in Kannada maskers. Although experienced participants showed slightly higher mean scores, group differences were not statistically significant, indicating Kannada exposure did not significantly influence performance.

Across groups, SNR-50 performance for low-frequency PB words differed significantly by noise type, with the 2TB condition yielding the best performance, followed by SSN, and the 4TB condition producing the greatest masking effect. Superior performance in 2TB likely reflects enhanced auditory stream segregation and beneficial temporal/spectral dips [19], as fewer competing talkers reduce overlap masking the target signal [12,18,20,21]. Conversely, 4TB imposed greater interference than SSN due to heightened phonological demands, increasing both energetic and informational masking [23]. Better performance in SSN than 4TB reflects SSN's predominantly energetic masking, lacking the phonological interference characteristic of fluctuating multi-talker

babble [23]. Comparison of the experienced and non-experienced groups across the three noise conditions showed no statistically significant difference in SNR-50, indicating that Kannada experience did not significantly influence speech perception across noise types.

Participants showed better SNR-50 scores with native-language (Malayalam) than non-native (Kannada) maskers, likely reflecting linguistic familiarity's role in noise. This aligns with first-language advantages from stronger phonetic categorization and lexical access [24,25], enabling more efficient target-speech processing and segregation from competing signals. Performance was also compared between the experienced and non-experienced groups based on masker language. The experienced group showed slightly higher mean scores in both the Kannada and Malayalam masker conditions. However, these differences were not statistically significant.

However, these differences were not statistically significant. Previous studies have explored the influence of bilingual experience on speech perception in noisy environments, suggesting that exposure to multiple languages facilitates improved executive functioning [26] and may interact with cognitive and auditory processing mechanisms involved in managing competing speech signals[27,28]. Nevertheless, the findings of the present study do not provide statistical evidence supporting a significant influence of language exposure on speech perception performance under the tested conditions.

Masking release did not differ significantly between the experienced and non-experienced groups for either the 2TB or 4TB condition. Although small numerical differences were observed, these descriptive variations are not interpreted further because they were not supported statistically. More broadly, masking release may be influenced by characteristics of the competing masker, including the number of competing talkers and the relative contributions of energetic and informational masking. Previous research has also associated speech perception in multitalker babble with attentional processes involved in segregating the target speech from competing signals [29]. However, under the conditions tested in the present study, the findings do not provide statistical evidence that Kannada language exposure significantly influenced masking release

Masking release by masker language did not differ significantly between the experienced and non-experienced groups. The observed numerical differences were small and are reported only as descriptive findings; therefore, they should not be interpreted as evidence of a reliable effect of masker-language familiarity. Previous research has proposed that unfamiliar or non-native competing speech may produce less informational masking because its linguistic content is less likely to be processed. However, findings in this area have been variable [6]. Accordingly, the present results neither confirm nor refute the linguistic familiarity hypothesis. Any apparent group- or language-related pattern should therefore be considered preliminary and interpreted cautiously. Further research with larger samples and more detailed measures of language exposure and proficiency is needed to evaluate this possibility.

The present study also highlighted the impact of using low-frequency phonetically balanced (PB) words, which are inherently more challenging to recognize. Their limited lexical familiarity and lower occurrence in everyday language may make them more susceptible to background noise. This can pose a greater challenge for listeners and may provide a more sensitive measure of auditory processing abilities. Results showed better performance in the 2TB condition, followed by SSN, and lowest in the 4TB condition, consistent with the previous study [30], which also reported higher scores for SSN than for 4TB in the Kannada sentence identification test [31]. However, our findings contrast with those of a study involving participants of a similar age [32]. That study reported greater masking in 2TB than in 4TB for linguistic maskers using the same Kannada sentence identification test. The use of low-frequency word lists in the study likely increased speech perception difficulty, especially under complex masker conditions, underscoring the critical role of word frequency in speech perception research.

The experienced group did not show a statistically significant advantage in perceiving low-frequency Malayalam PB words. This may be attributed to the linguistic and phonological similarities between Malayalam and Kannada, both Dravidian languages, which may make it difficult for listeners to fully segregate the two languages even with the extended exposure. Shared phonetic/prosodic features between Malayalam and Kannada likely hindered speech segregation, consistent with prior research [7,33], echoing findings that second-language acquisition minimally affects auditory processing [34]. The challenging 0 dB SNR may have masked subtle exposure-related benefits. Lexical frequency effects were not examined here. Overall, Kannada exposure did not significantly affect Malayalam PB word recognition in multi-talker babble. Future studies with larger samples, varied SNRs, proficiency levels, and stimuli types could further clarify language exposure's role in adverse-condition lexical processing. Understanding how language exposure influences speech perception in noise may have implications for audiological assessment and rehabilitation in multilingual populations.

CONCLUSION

This study examined how language exposure affects perception of Malayalam phonetically balanced words under different noise conditions and masker languages. No statistically significant differences emerged between experienced and non-experienced listeners in speech perception performance or masking release, suggesting that prior Kannada exposure did not meaningfully influence Malayalam speech-in-noise perception among normal-hearing young adults. Minor descriptive differences across noise types and masker languages were not significant. Findings were limited to young, normal-hearing adults, restricting generalizability. Future studies with larger samples, varied proficiency levels, and diverse lexical materials could better clarify how language exposure and cross-linguistic similarity shape speech perception in multilingual, noisy environments.

ETHICAL CONSIDERATIONS

Ethical approval

The study was conducted in compliance with the ethical guidelines and adhered to the ethical standards of Helsinki. Ethical approval for this study was granted by the Institutional Ethical Committee of K.S. Hegde

Medical Academy (EC/NEW/INST/2022/KA/0174). Written informed consent was obtained from all participants before their involvement in the study.

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Authors' contribution

PKM: Concept, Study design, acquisition of data, interpretation of the results, drafting the manuscript and statistical analysis; DR: Concept, Study design, statistical analysis, supervision, critical revision of the manuscript; A.B., R.P.: Acquisition of data, drafting the manuscript, Literature search.

Conflict of interest statement

The authors declare no conflicts of interest

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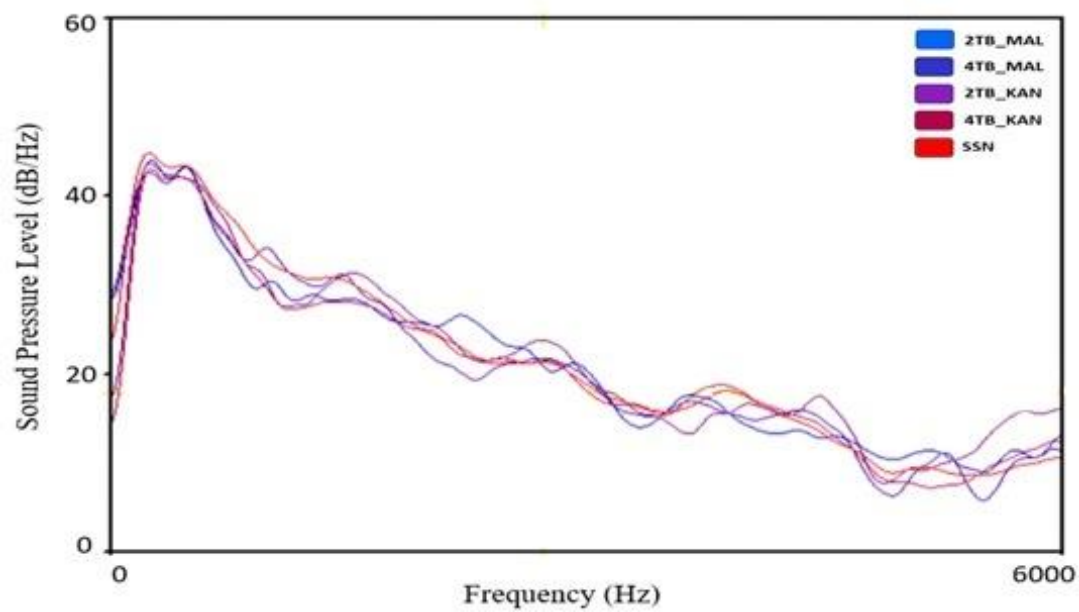


Figure 1: Long-term average spectrum of the two-talker babble, four-talker babble, and speech-shaped noise maskers. MAL; Malayalam, KAN; Kannada, SSN; speech-shaped noise

Table 1. Signal-to-noise ratio for 50% correct recognition (in dB): mean (SD) scores and of both experienced and non-experienced groups across the masker conditions.

Groups	Non-experienced		Experienced	
	Mean	SD	Mean	SD
2TB_Mal	-10.34	2.43	-10.79	1.96
2TB_Kan	-10.38	2.51	-9.95	2.21
4TB_Mal	-8.75	2.03	-9.81	1.47
4TB_Kan	-7.10	1.67	-7.36	1.47
SSN	-8.76	1.47	-9.28	1.40

2TB_Mal; 2-talker Malayalam babble, 2TB_Kan; 2-talker Kannada babble, 4TB_Mal; 4-talker Malayalam babble, 4TB_Kan; 4-talker Kannada babble, SSN; speech-shaped noise

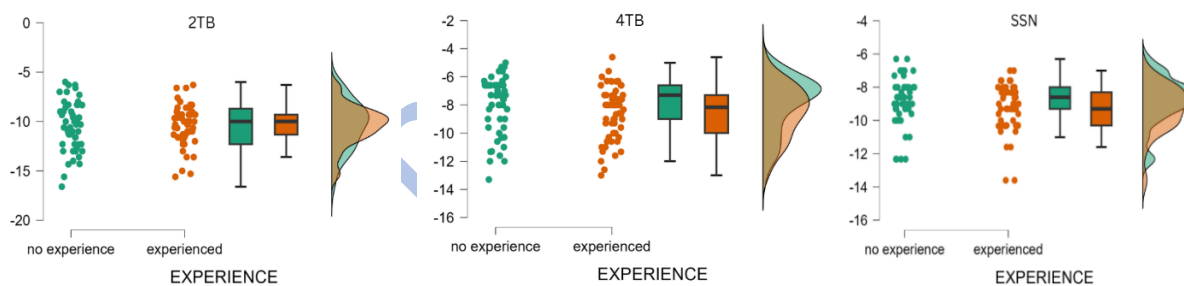


Figure 2. Mean (SD) signal-to-noise ratio for 50% correct recognition score for experienced and non-experienced groups across noise types. Green indicates non-experienced group; orange indicates experienced group. 2TB; 2-talker babble, 4TB; 4-talker babble, SSN; speech-shaped noise

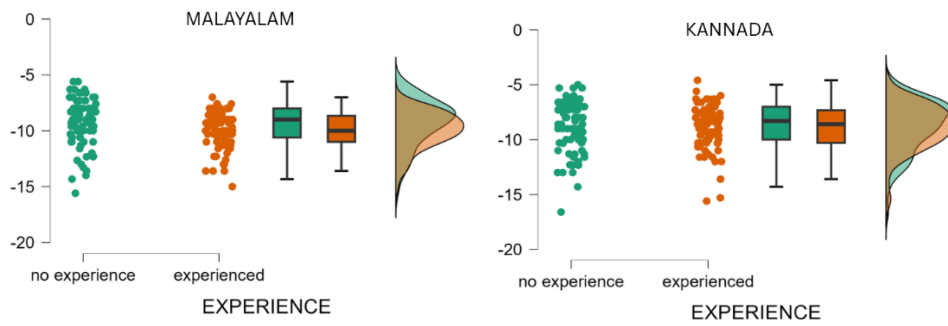


Figure 3. Mean (SD) signal-to-noise ratio for 50% correct recognition score for experienced and non-experienced groups across masker languages. Green indicates the non-experienced group; orange indicates the experienced group

Table 2. Masking release mean (SD) scores (in dB) and of both experienced and non-experienced groups across the masker conditions.

Groups	Masking release (in dB)			
	Non-experienced		Experienced	
	Mean	SD	Mean	SD
MR_2TB_Mal	-1.50	2.51	-1.51	1.68
MR_2TB_Kan	-1.62	2.20	-0.67	2.16
MR_4TB_Mal	-8.75	2.31	-0.53	1.58
MR_4TB_Kan	-7.10	1.95	1.91	1.24

MR_2TB_Mal; masking release for 2-talker Malayalam babble, MR_2TB_Kan; masking release for 2-talker Kannada babble, MR_4TB_Mal; masking release for 4-talker Malayalam babble, MR_4TB_Kan; masking release for 4-talker Kannada babble

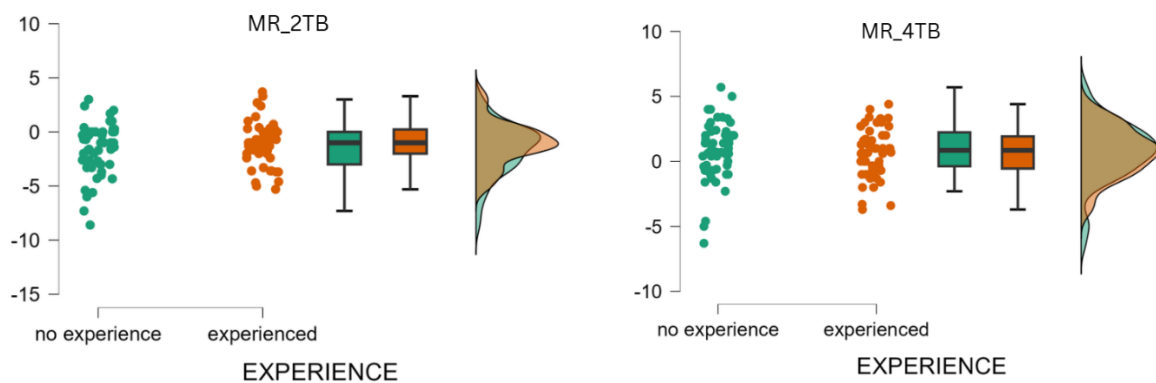


Figure 4. Mean and standard deviation masking release for the experienced and non-experienced groups across different noise types. Green indicates non-experienced group; orange indicates experienced group. MR_2TB; masking release for 2-talker babble, MR_4TB; masking release for 4-talker babble

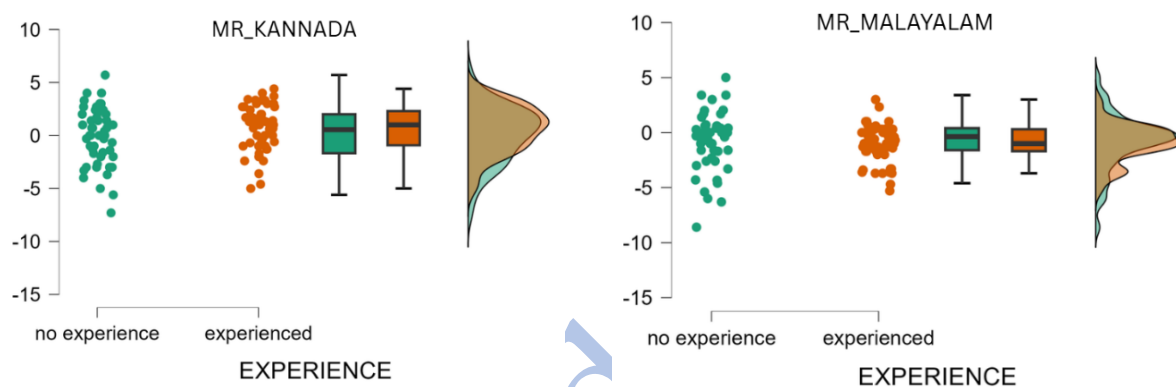


Figure 5. Mean and standard deviation masking release for the experienced and non-experienced groups across masker languages. Green indicates non-experienced group; orange indicates experienced group