

# VOICES IN NOISE OR NOISY VOICES: EFFECTS ON TASK PERFORMANCE AND APPRECIATION

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## 1 Introduction

Processing information that is presented orally in background noise requires focusing on the target signals while suppressing the irrelevant sounds. Whether this can be done successfully depends on a complex interplay between features of signal and noise tasks at hand, and individual characteristics of the listener [1],[2],[3].

Irrelevant speech is often shown to be particularly disturbing, especially when it is intelligible and meaningful. More generally, phonological similarity between target and masking signal might also increase the influence of the masker [1].

Voice disorders can be regarded as a particular type of noise because the noise is actually part of the target signal. Dysphonia is defined as a speech disorder ‘characterized by the abnormal production and/or absences of vocal quality, pitch, loudness, resonance, and/or duration, which is inappropriate for an individual’s age and/or sex.’ (ASHA). The effect of dysphonia on learning is a very pertinent question, as dysphonia is often reported in teachers.

Dysphonic voices (DV) have been shown to affect information processing and language comprehension in children [4] as well as in adults [5]. This is in line with the generally known effects of irrelevant noise on task performance. It is less clear how important the effects of DV are, compared to other external noise sources.

No relationship has been found between the severity of the dysphonic voice and the degree of decrease in information processing [6]. It remains to be seen whether voice disorders yielding a creaky versus a breathy voice have different effects on information processing.

Finally, it has been little investigated how dysphonic noise and background noise might interact, and what their combined effect on information processing is. Again, this is a pertinent question as dysphonic teachers teaches in some kind of (classroom) background noise.

In this work, the effect on information processing is investigated for (1) DV versus multitalker babble background noise, and versus non-speech background noise with a spectrum similar to dysphonic noise, for (2) voice disorders with different perceptual characteristics, and for (3) the combined effect of DV and multitalker babble. Information processing is studied in two ways, by looking at

the retention of information, measured with an exam, and by looking at subjectively reported ease of processing.

## 2 Method

### 2.1 Participants and protocol

Forty-nine volunteers between 18 and 30 years old (average: 21.1 years) participated. Participants were instructed to listen carefully to 10 different 5 minute lectures on various topics. After each lecture, they had to write down up-to five key elements they had retained from the lecture, as well as answer six true/false questions. After all lectures had been listened to, participants were asked to order them in terms of how easy it was to follow the content of the lecture, with the easiest first and the hardest at the last place.

### 2.2 Listening conditions

All lectures were read by a 40-year female speech therapist. Play-back of the lectures was done with different voice characteristics and different fragments of background noise.

For the voice characteristics, three different DV were simulated using the software TC Helicon VoiceOne. A panel of three voice experts and five non-expert listeners judged the voice quality of the simulations. The selected simulations were judged as clearly dysphonic and could not be distinguished from natural (non-simulated) voices by the non-expert listeners. One healthy voice condition was added to the three simulated DV, so in total four different voice conditions were included.

Background noise conditions also varied. All four voice conditions were presented twice, once without additional background noise and once with unintelligible multitalker babble noise.

Finally, two different background noise conditions were added for the healthy voice only. So-called dysphonic background noise was created from the spectrum of one particular dysphonic voice fragment by randomizing the phase. The dysphonic voice was mixed with the healthy voice with two different angles of incidence. Once the healthy voice was played to the right ear and the dysphonic noise to the left ear, in the second condition both speech and noise were played to both ears.

Participants listened to the lectures through headphones, voices were played at 68 dB calibrated with the Head And Torso Similar (HATS) type 4128C from Brüel & Kjær. Multitalker babble and dysphonic noise were played at 63 dB.

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## 3 Results

### 3.1 Task performance

Participants performed quite well on the information processing task. On average 4.2 key elements (maximal score 5) were correctly reproduced, with an interquartile range spanning from 3.5 (first quartile) to 5 (third quartile). Similar results were found for the true/false questions, on average 3.9 of the six questions were correctly answered, ranging from 3.0 (first quartile) to 5.0 (third quartile).

Mixed linear regression analyses revealed no significant effect of voice condition, background noise, or the interaction of voice and noise on the scores of the open questions and the true/false questions, with all p-values clearly exceeding 0.1.

### 3.2 Subjective rating

Mixed model linear regression showed a clearly significant interaction effect of voice condition and background noise on reported ease to process information ( $p < 0.0001$ ). This result is investigated further by pairwise Tukey post-hoc testing ( $\alpha = 0.05$ ).

The clearest effect is seen for multitalker babble, these conditions are rated significantly worse compared to conditions without additional background noise, for all voice conditions.

Dysphonic noise is rated significantly less positively compared to the healthy voice without additional background noise, regardless of the angle of incidence of the dysphonic noise. Compared to a healthy voice in multitalker babble, especially the condition with dysphonic noise presented to both ears scored significantly less disturbing. When the dysphonic noise was presented to the left ear only, scores are closer to the multitalker babble, the difference being no longer clearly significant ( $0.05 < p < 0.1$ ).

The effect of DV appears to be similar to the dysphonic noise; DV are also rated significantly less favorably compared to the healthy voice without background noise. Compared to the healthy voice in multitalker babble, they are rated significantly easier. No significant differences are seen in-between the different DV, nor between DV and dysphonic noise.

DV presented in multitalker babble do not appear to additionally lower the subjective rating; in multitalker babble no significant difference is found for scores of the healthy voice in multitalker babble compared to the DV.

## 4 Discussion

Task performance appears to be relatively unaffected by the DV and the background noise. For the background noise, this could be partially explained by clearly positive signal-to-noise ratio (5 dB) and the moderate level of the background noise. The dysphonic disorders were not extreme either. In addition, for a complex task such as information processing from a full text, it has been shown that contextual information and higher level of

concentration required might actually be beneficial to deal with background noise [7],[8].

For the subjective rating, both multitalker babble and DV are rated less favorably compared to a healthy voice without additional background noise. Speech sounds (multitalker babble) are known to be likely to draw the listener's attention, whereas the dysphonic sounds might be difficult to separate perceptually from the target signal as it is inherently part of it. In this experiment, the multitalker babble has clearly been recognized more strongly as an interfering noise source. The dysphonic characteristics have also negatively influenced the rating. The fact that they are produced by the speaker, hence inherently connected to the target signal, appears to be less important, as adding dysphonic noise as background noise to a healthy voice leads to similar results.

## 5 Conclusions

The reported difficulty to process orally presented information clearly increased when lectures are presented in multitalker babble. DV have also a negative, albeit less strong, effect. Different DV do not appear to lead to distinguishable effects, and within background noise, DV do not lead to further increase in reported difficulty compared to the healthy voice.

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