Speech Predictability Can Hinder Sentence Recognition in Difficult Listening Conditions

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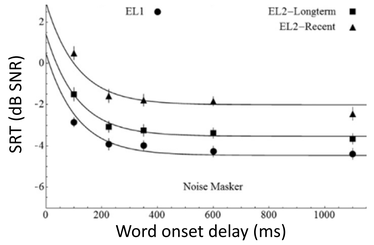
Motivation

At least two factors may potentially facilitate the recognition of words along a sentence in hard listening situations:

1. Noise adaptation [1,2]: Normal-hearing listeners show better speech reception thresholds (the signal-to-noise ratio giving 50% of word recognition) when isolated words are delayed from the noise onset.

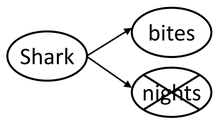


Ben-David et al. (2016) Hear Res

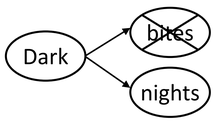
2. Predictability [3]: The perception of word #1 may bias the perception of word #2. That is, for a constant SNR, the probability of recognizing word #2 (P_2) can be greater when the preceding word (P_1) is correctly recognized than when the same word #2 is presented in isolation (or it can be smaller when the preceding word is missed or misunderstood).

When the sentence is : **The shark bites…**

Recognizing word 1 facilitates the recognition of word 2



Misunderstanding word 1 hinders recognition of word 2



Hypothesis

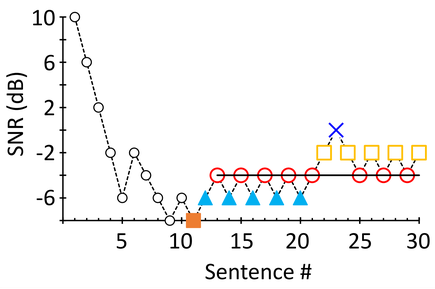
For congruent sentences, word recognition improves gradually as a sentence unfolds.

Approach

(1) Measure speech reception thresholds (SRTs). (2) Calculate the proportion of recognized words at different levels (re the participant SRT), ranging from easier to harder listening conditions.

Methods: SRT measurement

- 1-down, 1-up. 50 % correct. Tracked variable: noise level or speech level (in quiet). 30 sentences presented.
- From the final 20 sentences, only those presented at the desired level were chosen.



Different levels (re SRT) were analyzed:

SRT
Conditioning
+4
+2
0
-2
-4
-6

Methods

SRTs were measured for sentences from two corpora with different syntactic structures to investigate if the word position effect depended on the type of presented word:

Spanish HINT corpus

- 90 participants. Age 30.4 years (±12.5). AT ≤ 25 dB HL
- Different number of key words across sentences

The first four words (regardless of whether these were key words or not) were analyzed.

- *Conditions*: Quiet and masked [International female fluctuating masker (IFFM); double IFFM (2IFFM); speech shaped noise (SSN)].
- Presented via the HD580 headphones.

Spanish Sharvard corpus

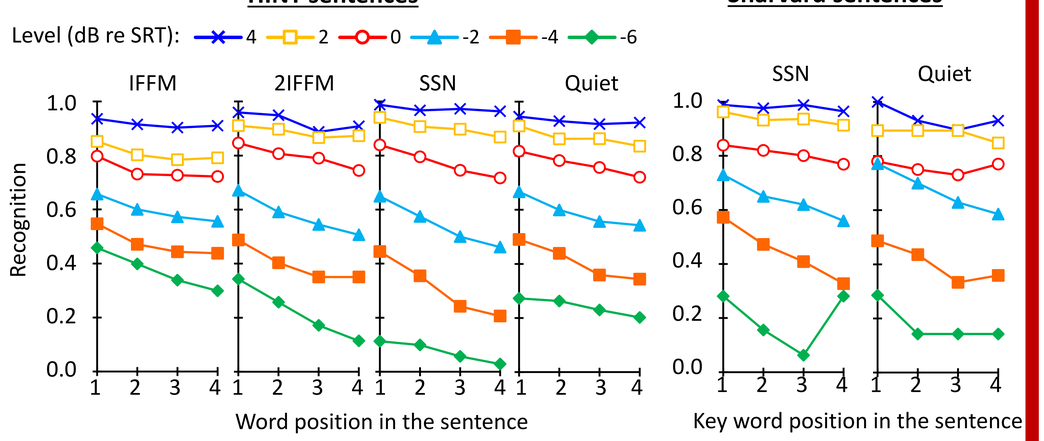
- 16 participants. 26.6 years (±5.7) AT ≤ 25 dB HL
- Five key words in all sentences

The first four key words analyzed (the fifth key word had a lower RMS level)

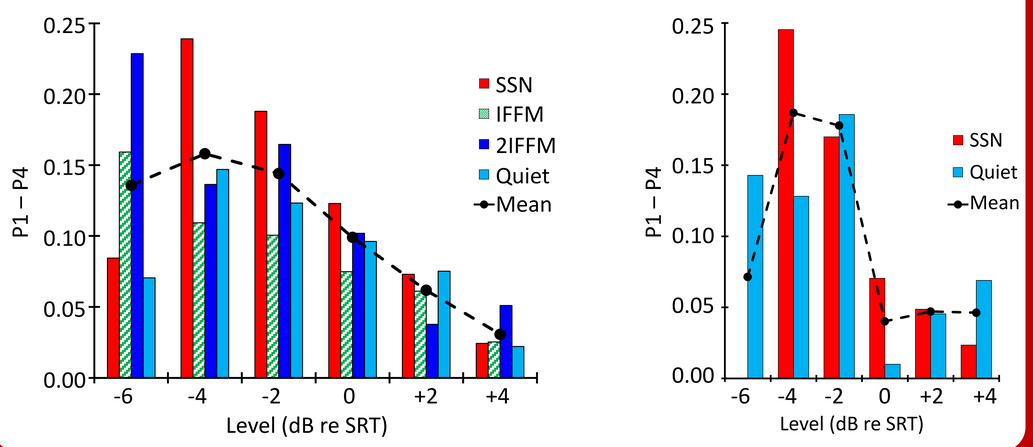
- *Conditions*: Quiet and masked (SSN)
- Presented via the ER-2 Earphones
- HRFT filtered

Results

Word recognition decreases along a sentence in hard listening conditions



Decrease in recognition from word #1 to word #4



Discussion

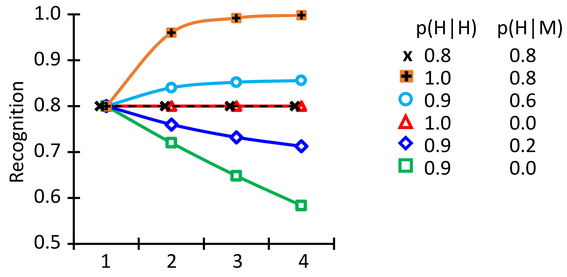
1. The word position effect is not due to different levels across words: words RMS levels were similar from words #2 to #4.

2. Results can be predicted by a conditional probability model

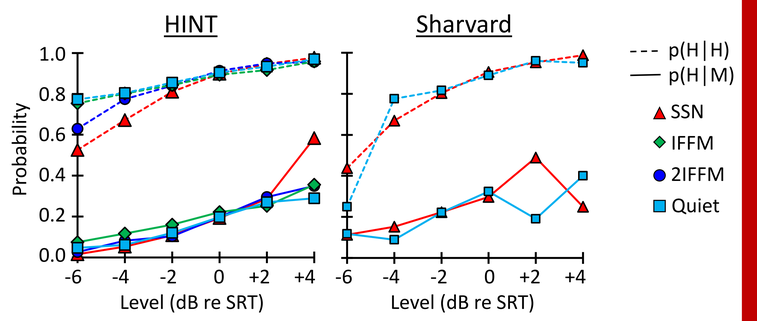
- Probability of recognizing word #1 (P_1): unbiased.
- Probability of recognizing word #2, #3 or #4: *conditioned* by the previous word:

$$P_k = P_{k-1} \times p(H|H) + (1-P_{k-1}) \times p(H|M)$$

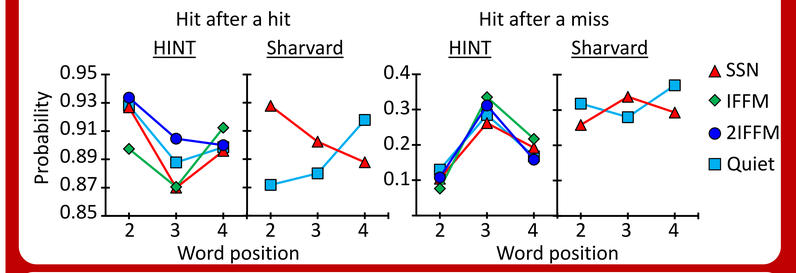
- If predictability exists: $p(H|H) > P_1 > p(H|M)$
- Speech **predictability can facilitate, hinder or not affect** the recognition of words along a sentence depending on the values of p(H|H), p(H|M), and P_1.



3. Data supports model predictions. The experimental probability of a hit after a hit was greater than the probability of a hit after a miss.



4. The probability of recognizing a word after a hit or a miss did not increase gradually from words #2 to #4. Hence, noise adaptation benefits are overruled when words are presented in sentences.



Conclusions

1. Although speech predictability can facilitate sentence recognition, it can also result in declines in word recognition as the sentence unfolds, perhaps because of inaccuracies in predictions.
2. The effect of predictions overruled the potential benefits from noise adaptation.

Acknowledgements
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References

1. Cervera and Ainsworth (2005) AAUA 91:132-144
2. Ben-David BM et al. (2016) Hear Res 341:9-18
3. Altmann GTM, Kamide Y (1999). Cognition 73:247-264.