Psychometric functions of a dual-task paradigms

The effect of SNR presentation order

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INTRODUCTION

- Listening effort is the cognitive resources allocated for understanding speech.
- A dual-task paradigm is used to quantify the listening effort, wherein the listener performs a primary speech recognition task and a secondary task simultaneously.
- Results of our previous study (Wu, Stangl, Zhang, & Perkins, submitted) indicate that the psychometric function of reaction time (RT) was peak shaped, with RT increasing and then decreasing as signal-to-noise ratio (SNR) decreased. We suspect that this peaked shape is due to the fixed presentation of SNR order causing listeners to actively decide to "quit" in their efforts of speech recognition at very poor SNRs.
- Purpose: to determine whether the SNR presentation order (fixed or randomized) will affect the shape of the psychometric function of listening effort.

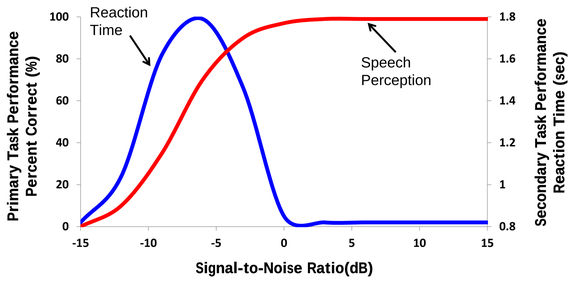


Figure 1. Results from the previous study revealed a peak-shaped psychometric function.

METHODS

Subjects

- 25 adult (12 males, 13 females) ages 19 – 30 (mean = 21.24)
- Native English speakers with normal hearing and normal color vision

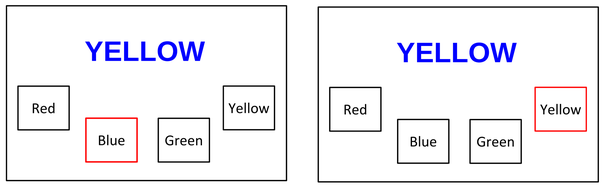
Equipment

- Speech stimulus presented in a sound treated booth through earphones
- Visual stimulus presented on a computer screen
- Participants responded via keyboard

METHODS

Procedure

- Each subject's SNR50 was obtained using the Hearing In Noise Test (HINT)
- Dual-Task Paradigm:
  - Primary task: speech recognition in noise
  - Secondary task: Stroop test, with two conditions
    - **Easy**: respond to stimulus by pressing the space bar
    - **Hard**: respond to stimulus by pressing the button corresponding to the color in which the word is written
- Upon mastery of practice, each subject completed the dual-task paradigm at 11 SNRs ranging in increments of 2dB from -10 dB to +10 dB of their individual SNR50. Twenty sentences were used at each SNR. In total, 220 sentences were used.
- The presentation order of the 220 sentences (and SNRs) were randomized.



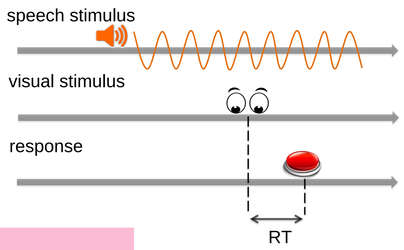


Figure 2. Schematic illustration of the dual-task paradigm.

Measures

- Reaction time to the visual stimulus is measured
- Speech Perception was measured as the amount of correctly repeated words
- Listening Effort was measured as a function of change in reaction times of the simple or hard tasks

RESULTS

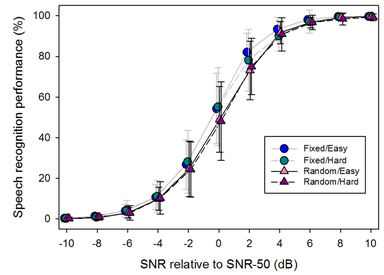


Figure 3. Comparison of SNR relative to SNR50 (dB) in relation to Speech recognition performance (%) between Fixed (Wu, Stangl, Zhang, & Perkins, submitted) and Random conditions (the current study).

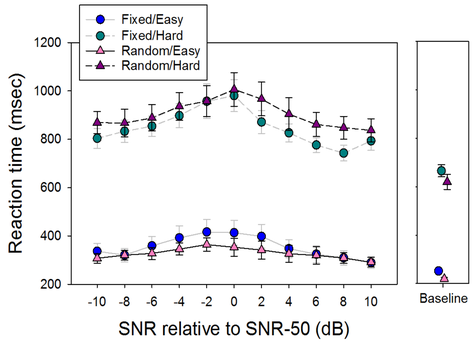


Figure 4. Comparison across results of SNR relative to SNR-50 (dB) and Reaction Time (msec) during Fixed versus Random trials.

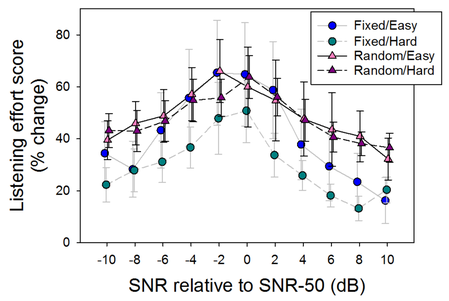


Figure 5. Comparison of SNR relative to SNR50 (dB) in relation to Listening effort score (% change) between Fixed and Random conditions. Here, Listening effort score = 100% x ([dual-task RT – baseline RT]/baseline RT).

RESULTS

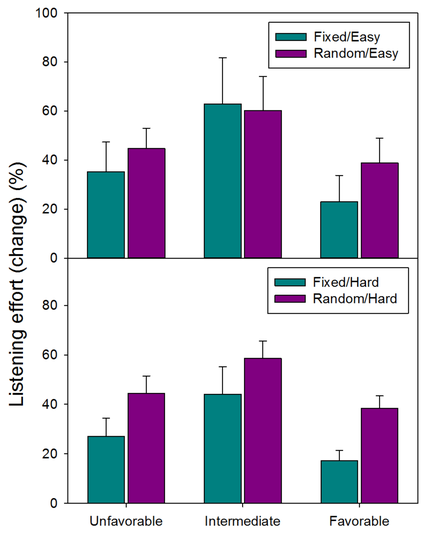


Figure 6. reveals SNR split into 3 categories: Unfavorable (-10, -8, -6 dB), Intermediate (-2, 0, +2 dB) and Favorable (+6, +8, +10 dB) SNR levels.

- In the **easy** condition, the effect of SNR was significant ($p < 0.001$). Effect of Task Order ($p = .658$) was not significant. The interaction between SNR and Task Order was not significant ($p = 0.206$)
- In the **hard** condition, the effect of SNR was significant ($p < 0.001$). The effects of Task Order ($p = .065$) approached, but did not reach the significance level. The interaction between SNR and Task Order was not significant ($p = 0.663$)
- In both **easy** and **hard** conditions, follow-up analysis indicated that the listening effort of intermediate SNR was higher than that of unfavorable and favorable SNR, while the listening effort was essentially the same for unfavorable and favorable SNRs.

CONCLUSION

- Overall, the shape of reaction time in relation to SNR is highly similar in random and fixed order, indicating that the peaked shape of listening effort psychometric function is not due to listeners actively deciding to quit in their efforts of speech recognition at very poor SNRs.

REFERENCES

Wu, Y. H., Stangl, E., Zhang, X., & Perkins (submitted). Psychometric functions of dual-task paradigms for measuring listening effort. *Journal of Speech, Language, and Hearing Research.*

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