

# Effect of background noise on listening effort in normal hearing 9-11 year olds

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## Introduction

Listening conditions can be made difficult due to a poor signal to noise ratio (SNR), increased distance between the speaker and listener, and the effects of reverberation. Considerable effort is required to follow speech in difficult listening situations, especially for the hearing-impaired listener. Listening effort refers to the cognitive effort exerted by the listener to understand the speech signal.

Listening effort can be recorded subjectively through a listener's personal rating and also objectively by using a dual task situation. A dual task paradigm involves performing two tasks simultaneously. There is a primary task, to which participants are expected to direct their attention and this is presumed to use the majority of the mental capacity. There is also a secondary task that will compete for cognitive resources and use any spare capacity.

It is predicted that if the primary task becomes more demanding and requires more effort, performance on the secondary task (or both tasks) will deteriorate (Kahneman, 1973). The literature frequently shows a decrease in secondary task performance in difficult listening conditions in adults (e.g. Downs & Crum, 1978; Whearty, 1993). However, there are mixed findings with regards to children's performance in a dual task situation, perhaps because the listening conditions were not sufficiently difficult to require a significant increase in listening effort.

## Aims

- To provide an objective measure of listening effort in children.
- To assess the effect of increased background noise on listening effort as measured by performance on a secondary task. It was hypothesised that as the level of background noise increased performance on the secondary task would decrease.

## Methods

Participants were 31 normal hearing children (aged 9-11 years).

The children's baseline performance on two single tasks was assessed:

### Speech perception

This involved listening to and recalling AB (short, monosyllabic) words at four signal to noise (SNR) ratios (quiet, +4, 0, -4 dB), and

### Digit Recall

This involved rehearsal of five digits over 20s for later recall.

Digit recall and speech perception were combined to create a dual task situation. After presentation of the digits, a set of five words was presented and the children repeated each word as in the single task of speech perception. After the five words, participants were asked to recall the rehearsed digits.

The children were informed that their primary task was to repeat the words correctly and that there would be a prize at the end for the greatest number of words correctly recalled.

## Results

Performance on the tasks are summarised in Figure 1.

In the single task, the scores in the speech perception test decreased as the SNR decreased: as expected, there was little effect of SNR on digit recall.

In the dual task conditions, scores for speech perception decrease as in the single task. Digit recall scores for the dual task condition are lower than those for the single task condition and decrease with decreasing SNR.

There was a statistically significant reduction in mean performance on the secondary digit recall task as the background noise level increased. Scores for digit recall were affected more by SNR in the dual task condition than they were in the single task condition. At the lowest SNR, percent correct on the dual-task digit recall condition was less than half that for the single-task condition.

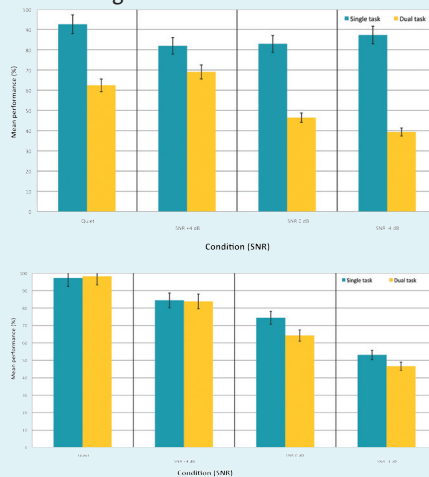


Figure 1. Performance on the digit recall (top panel) and speech perception (bottom panel) tasks

## Discussion

As expected, performance on the speech perception task deteriorated as background noise increased.

In order to maintain performance in the dual task paradigm, the increased listening effort is reflected by reduction in performance on digit recall, especially at the more adverse SNR.

The SNRs used in this study are similar to those reported for typical primary school classrooms e.g., Arnold & Canning, 1999; Crandell & Smaldino, 1995; Crandell & Smaldino, 2000.

Previous dual task studies have produced inconclusive findings in children e.g., Stelmachowicz et al., 2007; McFadden & Pittman, 2008. This may be because the listening conditions were not sufficiently difficult to require a significant increase in

listening effort. The present study used more adverse SNRs than the previous studies and this may explain the difference in findings.

The results have implications regarding acceptable classroom noise levels. If there is increased listening effort in poor listening conditions, this suggests that there will be less available resources for other tasks (such as general comprehension and understanding, note taking, answering questions, following instructions etc) and this could compromise development and educational attainment. The need to improve the SNR and reduce listening effort is likely to be even greater for children who are hearing-impaired or have learning difficulties.

## Conclusion

This study has provided an objective measure of listening effort in children.

Although the children were able to perform two tasks simultaneously, greater effort was required as the background noise increased and this is reflected in poorer performance on the secondary digit recall task.

The SNRs used in this study are comparable to the listening environments in typical primary school classrooms.

The dual task paradigm used in this study has the potential to demonstrate reduced listening effort in listeners after being fitted with hearing aids and/or FM systems.

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