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## Key Words

Listening effort  
Dual task  
Signal to noise ratio  
Children  
Cognitive resources  
Top down processing  
Multitasking

## Abbreviations

AB words: Arthur Boothroyd words  
dB: Decibels  
RT: Reaction time  
SNR: Signal-to-noise ratio  
WM: Working memory

# Listening effort at signal-to-noise ratios that are typical of the school classroom

## Abstract

The aim of the study was to measure listening effort at typical classroom signal-to-noise ratios (SNRs). Listening effort was measured using a dual task paradigm. Participants repeated monosyllabic words presented in a background of children's chatter (primary task) at SNRs that are considered typical of the school classroom environment (quiet, +4, 0, -4 dB) while simultaneously rehearsing sets of five digits for recall (secondary task). High listening effort requires greater cognitive resources and is associated with reduced performance on the secondary task. The study sample consisted of 31 normal-hearing children (9–12 years). Performance was generally maintained on the listening task when multitasking; however, performance decreased on the secondary recall task, especially at the more negative SNRs. This demonstrates that considerable listening effort is required when listening at SNRs that are typical of the school classroom.

## Sumario

El propósito de este estudio fue medir el esfuerzo para escuchar en un salón de clases con un nivel señal/ruido típico. Se midió el esfuerzo para escuchar utilizando un paradigma de doble tarea. Los participantes repitieron palabras monosilábicas presentadas sobre un ruido de fondo de niños hablando (tarea primaria) con una tasa señal/ruido considerada como típica del ambiente en un salón de clases (silencio, +4, 0, -4 dB) mientras que simultáneamente se ejercitaba la memorización de grupos de cinco dígitos (tarea secundaria). El esfuerzo elevado requiere grandes habilidades cognitivas y se asocia con un desempeño pobre en la tarea secundaria. Treinta y un niños normoyentes (9 a 12 años de edad). El desempeño generalmente se mantuvo en la tarea de escuchar durante la realización de varias tareas; sin embargo, el desempeño disminuyó en la tarea de recordar, especialmente en el extremo negativo de SNR. Esto demuestra que se requiere un esfuerzo considerable para escuchar cuando hay un SNR típico del salón de clases.

In everyday life, we are frequently required to divide our attention across several tasks. The ability to multitask depends on the nature and the difficulty of the tasks. Research on divided attention typically involves a dual-task paradigm in which performance on a single task is compared with performance on the same task when it is performed in combination with a second task. According to the model of limited cognitive capacity proposed by Kahneman (1973), if the primary task becomes more demanding and requires more effort, performance on the secondary task (or both tasks) will deteriorate.

In the educational environment, children are often expected to multitask. For example, they may be required to listen to the teacher while taking notes, consolidating the taught information, or using the internet. In addition, the educational environment is not always optimal for listening: classrooms are frequently noisy environments and it is generally accepted that noise has a detrimental effect upon learning and educational attainment of school children (for review see Shield & Dockrell, 2003). Classroom signal-to-noise ratios (SNRs) have typically been reported to be in the range, -7 dB to +5 dB (Arnold & Canning, 1999; Crandell & Smaldino, 1995, 2000) and are often close to 0 dB (Arnold & Canning, 1999). Multitasking may be challenging in such noisy environments because greater listening effort is required. Listening effort refers to the cognitive effort exerted by the listener to understand the speech signal. In ideal conditions, where the speech signal is clearly audible, listening is relatively effortless for normal-hearing adults. When conditions become non-optimal, the listener needs to exert an

increased effort to understand the signal. While ease of listening can be measured using self-report ratings, listening effort in children has generally been measured using a dual-task paradigm.

Hicks and Tharpe (2002) and McFadden and Pittman (2008) used dual-task paradigms to investigate the effect of SNR on listening effort in children. Hicks and Tharpe (2002) compared a group of 5–11 year old children having a mild hearing impairment with a group of children having normal hearing. The primary task was word recognition presented at 70 dB(A) in quiet and in babble at a SNR of +10, +15, and +20 dB. The secondary task was reaction time (RT) to a light presented randomly in time. In the dual-task condition, RT was longer in the children with hearing impairment and this is consistent with the notion that children with hearing impairment expend more effort in listening than normal-hearing children. However the increased RT was similar across the different SNRs suggesting that there was no effect of SNR on listening effort. McFadden and Pittman (2008) compared a group of 8–12 year old children with a mild hearing impairment and a group of children with normal hearing. The primary task was to categorize words as animal, food, or people. The words were presented at 65 dB SPL in quiet and in noise at a SNR of 0 and +6 dB. The secondary task measured the completion rate of a dot-to-dot puzzle. Performance on the secondary task fell when performing both tasks and this was similar for both groups. Mean performance was similar for the two SNRs again suggesting that there was no effect of SNR on listening effort.