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# PERFORMING MENTAL ARITHMETIC TASKS IN REAL CLASSROOMS: DOES PERFORMANCE DEPEND ON THE TYPE OF BACKGROUND NOISE AND TASK DIFFICULTY?

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## ABSTRACT

Reverberation and background noise are known to impact on student's speech reception and in turn on their academic attainments. In this study, performance in a mental calculation task was explored. Children with normal hearing were presented with mental calculations with two levels of difficulty, in three listening conditions (quiet, traffic noise, classroom noise). A differential negative effect of listening condition on maths performance emerged in relation to task difficulty and children's age. The detrimental effect of classroom noise was most evident for the youngest children, and when the task was moderately difficult.

## 1. INTRODUCTION

Noisy classrooms are generally known to have a negative impact on student's academic attainments [1]. Noise proved detrimental to speech recognition but also to performance in more complex tasks, resembling activities that children engage in during daily lessons (e.g., comprehension, word recall). Whereas a plurality of studies dealt with verbal tasks in the school setting, only a few examined the impact of a realistic sound environment on arithmetic, in spite of its relevance in school education [1, 2]. Moreover, little attention has been paid to verbally-presented math tasks and age-related differences in children's ability to cope with noise when performing such tasks.

This study aims to investigate the effect of noise on mental calculation ability in a school setting. In particular, we were interested in examining whether the effect of realistic background noises was modulated by the children's age and by the task difficulty.

## 2. MATERIAL AND METHODS

### 2.1 Participants

A total of 162 children between the ages of 11 and 13 years participated in the study. They attended nine classes from two middle schools in Ferrara (Italy).

In addition to the maths task, each child was administered a standardized test to assess her/his math fluency [3]. The measure was used for screening purposes, and included in the analysis as a covariate.

### 2.2 Mental calculation task

The mental calculation task, derived from [4], consisted of sets of two-digit additions and subtractions. The difficulty of the problems was manipulated by means of the presence or absence of borrowing and carrying procedures, obtaining two levels of difficulty (low for additions or subtractions without carrying/borrowing, or high for additions or subtractions with carrying/borrowing).

For each question, participants listened to the playback of a problem (e.g., "*Ora risolvi 87-62*" [Now solve 87-62]), then three possible answers appeared on their tablets and they were asked to select the right answer by tapping on the screen. They were given a maximum of 20 s to choose their answer.

### 2.3 Listening conditions

The task was presented in three listening conditions: quiet, traffic noise, classroom noise. In quiet, no background noise was played back and the children performed the task in the actual ambient noise of the classroom. In the traffic noise condition the recording of a road in conditions of busy traffic was played back. The classroom noise consisted of sound events typical of a working classroom (e.g., chairs scraping) digitally mixed with a non-intelligible signal with the long-term average spectrum and the temporal envelope of a speech signal (ICRA noise [5]).

Children participated in the experiment as a whole class and the task was administered collectively to them in a laboratory classroom. The classroom had a  $T_{mid}$  (reverberation time  $T_{20}$  averaged over the 0.5-2 kHz octave bands) in occupied conditions of 0.57 s. In the area of classroom occupied by the students the level of the speech signal was 60 dB(A), and the signal-to-noise ratios (SNRs) were  $> +15$  dB and 0 dB, respectively in quiet and in the traffic/classroom noise conditions.

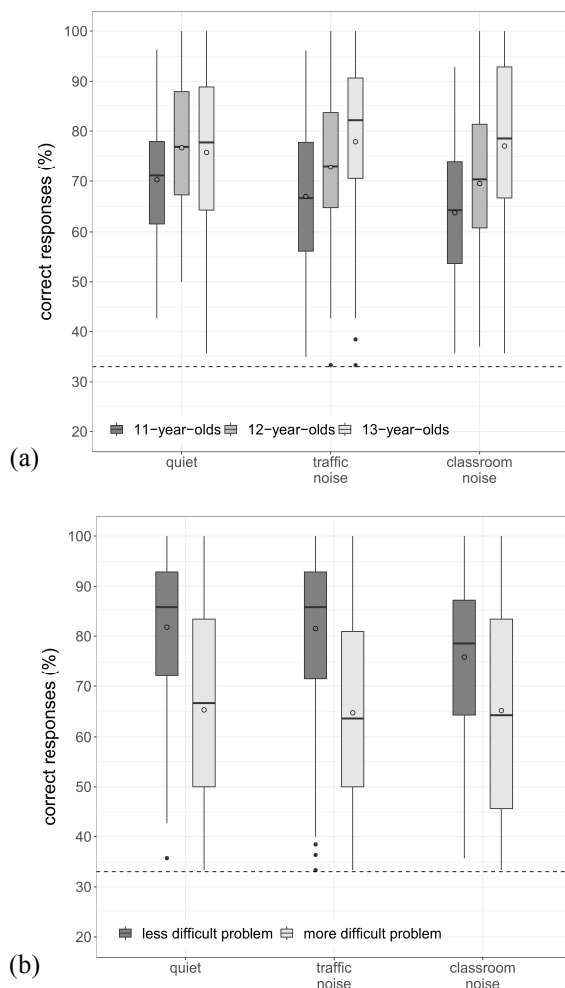
### 2.4 Data analysis

The statistical analysis was conducted using Generalized Linear Mixed-effects Models (GLMMs). In each model the following fixed effects were included: listening condition, task difficulty, age group. Participant, listening

condition and difficulty were also included as random effects.

### 3. RESULTS

The analysis of the accuracy results revealed a significant main effect of all fixed effects (all  $p$ s < 0.003). The interactions between listening condition and age ( $p = 0.002$ ) and between listening condition and difficulty ( $p < 0.001$ ) were also significant.



**Figure 1.** Accuracy in the task by (a) age and listening condition, and (b) difficulty and listening condition

The interaction between listening condition and age (Figure 1a) indicated that 11- and 12-year-olds were significantly more accurate in quiet than in classroom noise ( $p < 0.001$ ), whereas no difference between listening conditions emerged for 13-year-olds.

The interaction between listening condition and level of difficulty (Figure 1b) indicated a better performance in quiet and traffic noise than in classroom noise for the less difficult problems ( $p < 0.001$ ), while there was no difference between listening conditions for the more difficult problems.

### 4. DISCUSSION

Results indicated that the negative effect of classroom noise was modulated by the participants' age. The

younger children were the most affected by the noisy conditions, whereas the influence of the sound environment gradually disappeared in the older children. Literature studies indicate that younger children are more vulnerable to environmental noise than older children and adults, as their cognitive functions are still developing and consequently more prone to disruption. Therefore, we could attribute the better performance of older students in mental calculation to a greater capacity to allocate their cognitive resources or direct attentional control.

As for the effect of noise on tasks with different levels of difficulty, we found that accuracy was negatively affected by classroom noise but only for easier maths problems, whereas this was no longer the case for more difficult problems. A possible explanation for this result lies in that a more complex maths task implicitly encourages children of any age to actively focus their attention on the task in hand. The difficulty of a task, time constraints, motivation and individual capacity all influence how much we concentrate, and higher levels of concentration have been shown to protect against the negative impact of noise on task performance.

Our findings have implications for classroom learning because different types of environmental noise affected children's performance differently at different ages, and depending on the complexity of the task in hand. The finding warrants further investigation to see if the same applies to other areas of learning too.

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