Capturing the impacts of poor classroom acoustics in high school pupils

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Summary

There is increasing evidence that noise levels in schools impact on pupils' learning and attainment. However, the extent to which noise levels impact on performance once contextual factors such as pupils' age, school and learning needs are taken into account has not been addressed. In this study we examine the impact of realistic classroom noise at two different levels on the performance of high school pupils in reading comprehension tasks, numeracy, mathematical reasoning and speed of processing tasks. School factors and within pupil differences are controlled for in the analyses. Six hundred and sixty-nine pupils, aged 11- to 16-years, completed bespoke tasks measuring reading comprehension, arithmetic, mathematical reasoning, and information processing. Classroom noise was presented in two conditions reflecting the maximum (70 dB L_{Aeq}) and minimum (50 dB L_{Aeq}) levels of classroom noise observed during lessons in an extensive noise survey of secondary school classrooms. Using linear regression analyses we explored the ways in which noise levels impact on the high school students' accuracy and latency to respond to the tasks. Once school and within pupil factors were controlled no added variance was accounted for by exposure level on the reading tasks and the speed of processing task. By contrast, for accuracy in the numeracy and mathematical reasoning tasks noise exposure contributed significantly to the models. It is argued that numeracy and mathematical reasoning tasks are particularly vulnerable to the effect of classroom noise for older pupils due to the demands these tasks place on information processing resources. The importance of considering both pupil and school factors on experimental studies aiming to elucidate the impact is emphasized.

PACS no. 43.50Qp

1. Introduction

The detrimental effects on pupils of noise and poor acoustic design in schools have been of concern for many years [1]. Noise negatively impacts on children's academic attainment and ability to process information quickly and efficiently. In investigating the effects of noise on children a wide range of attainments and performance factors have been considered. These include reading, attention, mathematics, and memory. Tasks that involve language, such as reading, and those that have high cognitive processing demands involving attention, problem solving and memory appear to be those most affected by exposure to noise [1]. However, such effects are not always evident, comparisons across measures are rarely reported and confounding variables often not sufficiently controlled [2]. For example, both class and school membership affects academic performance and such factors need to be controlled when interpreting the results of experimental studies [3]. The impact of noise on children's performance is also affected both by child factors such as age and learning difficulties [4, 5]. Many of the studies examining the effects of chronic [6, 7] and acute noise exposure [5] have focussed on children in elementary school years. Much less is known about the type of noise that is most detrimental to performance for high school pupils, the levels at which these disruptive effects become apparent and whether the effect is moderated by pupils' age. In the current study we compare high school students' performance on literacy, numeracy and a speed of processing task, measuring sustained attention and visual attention, to examine the impact of noise levels on accuracy and latency of responses. We then consider whether within child factors (age and reported learning difficulties) and school factors moderate the impact of the noise exposure.

2. Description of the study

As part of a wider study on the impact of noise on performance in secondary schools, pupils aged between 11and 16 from eight schools (N = 669) were assessed on their accuracy and speed of performance on measures of literacy, word learning, numeracy and speed of processing. One group of pupils completed the tasks during exposure to classroom noise at 50 dB L_{Aeq} and the second in classroom noise at a level of 70 dB L_{Aeq}. Pupils were matched for school year group and testing occurred at the same points in the year for both groups

3. Methods

Test sessions took place in participating pupils' usual science room under the supervision of a teacher and two experimenters. Tests were completed on laptops provided for the participants. An experimenter gave verbal introductions about the task and then instructed participants to enter their names and ages onto the laptops. Responses were anonymised. Before starting the task, participants completed an animated tutorial installed on the laptop, which demonstrated the procedure and were given an opportunity to ask any questions about the procedure before the task began.

4. Experimental tasks

The test signal was constructed from samples of a real recording, from a classroom, of pupils engaged in 'Individual Work'. The recordings consist of a background of irrelevant unidentifiable speech (babble) with irrelevant identifiable speech (teacher comments, pupil discussions) and sound events (chair scrapes, pencil drops, occupant movement) present. It was replayed over headphones (mono) at levels representative of the upper and lower range of noise levels measured during lessons as part of an extensive survey of secondary schools (50 dB L_{Aeq} quiet and 70 dB L_{Aeq} loud) [8].

Pupils completed a reading task that assessed speed of reading and reading comprehension. Children were presented with 160-word science texts. Reading level was controlled to ensure that the youngest pupils could read and understand the text. Texts were presented in a fixed order starting with the easiest (average reading age 11) and progressing to the most difficult (average reading age 12). Two sets of materials were developed, consisting of four texts, each on a different theme related to scientific research. Each set of texts was matched for word length and number of multi-syllable words. All texts were presented in three sections. A title page featuring a multi-syllable word describing the subject matter of the text and an explanation of its meaning preceded the text. Five questions accompanied each text, including a measure of word learning. Participants completed tests of arithmetical computation and mathematical reasoning. These materials were adapted from the (US) Institute of Education Sciences' National Centre for Education Statistics TIMMS mathematics items (Trends in International Science Studies) which are freely available from the NCES's website.. There were 30 items in the test set. In addition, participants completed a speed of information processing task based on the British Abilities Scale [9] where they were required to scan a series of rows in a matrix and identify the circle having the most squares in each row. Each row of stimuli was presented individually following a press on the space bar. There were 30 trials with, which progressed through arrays of 3-, 4- and 5-circles. Speed of responding was recorded for all tasks.

5. Results

Data were analysed for correct responses across the literacy, numeracy tasks and for speed of processing. Mean time to respond (latency) was computed for all tasks. Figure 1 presents the average performance (SDs) for pupils in the two noise conditions. As Figure 1 shows participants were more accurate in their responses in the 50 dB L_{Aeq} condition than in the 70 dB L_{Aeq} condition. All comparisons were statistically significant (Reading t (621) = 2.17, p = .007; Word learning t (620) = 2.09, p = .04; Arithmetic t (620) = 5.12, p < .001; Mathematical reasoning t (620) = 5.92, p < .001; Speed of information processing t (620) = 2.22, p =.03).

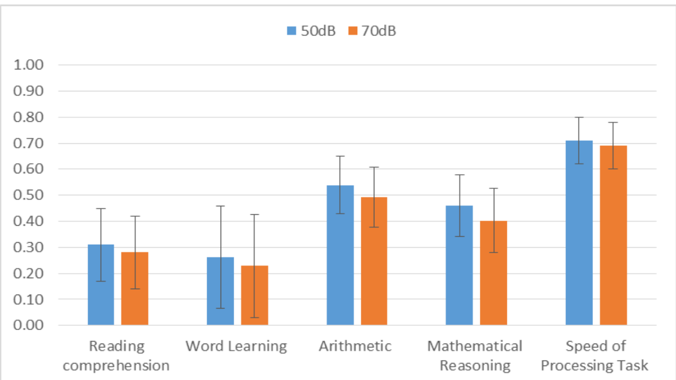

Figure 1. Mean proportion of correct responses (SD) for tasks in 50dB and 70dB noise conditions

Latency to respond was also faster for the arithmetic questions in the 50 dB L_{Aeq} condition (t (620) = 2.60, p = .01) but there were no noise condition differences in response latencies for reading comprehension, word learning, mathematical reasoning or speed of processing. Table I presents the effect sizes for the significant group differences. As the table shows effect sizes were moderate for Arithmetic and Mathematical reasoning and small for the other differences.

Table I. Cohen's D effect sizes for significant differences between 50 dB L_{Aeq} and 70 dB L_{Aeq}

Task	Cohen's D
Reading comprehension	.22
Word learning	.17
Arithmetic	.41
Mathematical reasoning	.48
Speed of Processing	.24
Latency to respond to arithmetic questions	.21

To examine the effects of noise on performance once child factors (age and reported learning difficulty) and school were accounted for a series of stepwise linear multiple regressions were computed on the proportion of correct responses and latency to respond for each of the tasks. The regression model for reading accuracy score was significant F (3, 478) = 25.37, p <.001 and accounted for 34% of the variance. Both child (p <.001) and school (p < .001) were significant but not noise condition (p. = .46)

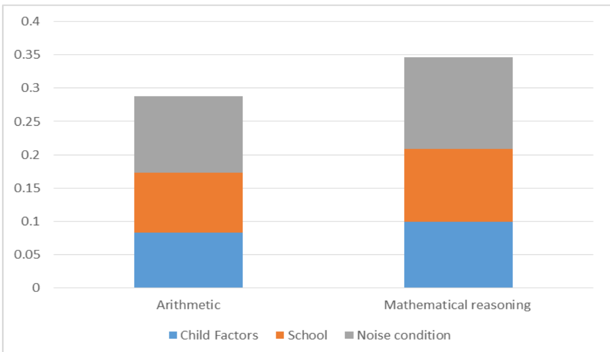

Figure 2. Variance accounted by child, school and noise condition in Arithmetic and Mathematical reasoning accuracy.

Similarly for word learning (F (3, 477) = 14.39, p <.001) and information processing (F (3, 477) =

25.26, p <.001) noise condition was not significant (Word learning p = .31; processing speed p =. 97). By contrast, for both Arithmetic (F (4, 478) = 15.40, p <.001) and Mathematical reasoning (F (4, 478) = 18.78, p <.001), as shown in Figure 2, noise condition contributed significantly to the model (noise condition Arithmetic p < .001; noise condition Mathematical reasoning p < .001).

For latency measures where there were significant models in all cases within child factors (age and learning support) were significant in the regressions but there were no significant effects of school or noise condition.

6. Conclusions

Previous work had demonstrated the general effects of noise exposure on primary school children in terms of sustained attention and visual attention, poorer reading ability and school performance on national standardised tests. The current study demonstrates that acute noise exposure influences adolescents' performance on literacy, numeracy and information processing tasks in terms of both their accuracy and speed of response. However, when confounding child and school variables are controlled significant variance is added only to performance in numeracy and mathematical reasoning. Numeracy and mathematical reasoning tasks draw on domain specific competencies such as number facts but also, importantly are underpinned by a range of other cognitive resources including working memory and executive functioning [10] which affect performance into adolescence and adulthood. Working memory has been shown to be correlated with the ability to resist interference from irrelevant sounds and speech generally [11, 12]. Irrelevant sounds capture attention when respondents are involved in complex tasks, such as mathematical computations, and marked difficulties in accurate responding are evident. By contrast, our data suggest that for the older pupils in this study the reading tasks did not involve complex processing, possibly as a result of the reading level of the texts, and as such irrelevant noise was less problematic. The results highlight the importance of examining performance of adolescents in noise conditions when complex tasks are completed but in addition, controlling for child and school factors.

Acknowledgement

This project was funded by the UK Engineering and Physical Sciences Research Council. The authors would like to thank the schools, pupils and teachers who took part in the study.

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