Effect of face mask and noise on word recognition by children and adults

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Abstract

Previous studies have shown that noise has a detrimental effect on speech intelligibility and language comprehension, more so for children than adults. Furthermore, the mandatory use of face masks due to the COVID-19 pandemic presents an additional communication and learning barrier. The current study investigates the effect of face mask on low frequency word recognition in quiet and noise by adults and, more importantly, by young children who just completed the first grade of primary school. Preliminary results indicate that word identification is significantly compromised when produced with a surgical face mask, with more pronounced negative effects for children listening in noise. Implications on new word recognition and learning by first graders in noisy classrooms with compulsory mask usage are considered.

Keywords: face masks, noise, word recognition, children, adults

Introduction

A lot of research has been conducted on the speech perception abilities of children vs adults in adverse listening conditions (for a review, see Leibold & Buss, 2019), as understanding speech in noise is an everyday challenge for children in school settings and has a negative impact on learning (Erickson & Newman, 2017). There is consensus that children face greater difficulty recognising and understanding speech in background noise relative to adults, with competing speech posing a greater obstacle than white or speech-shaped noise (Corbin et al., 2016). Apart from noise, the use of face masks that has been mandated in educational institutions and other indoor spaces, presents an added barrier to speech recognition and communication (Toscano & Toscano, 2021).

Although the effect of noise and face mask on speech perception has been investigated for adults, to the best of our knowledge, there are no studies regarding children. Thus, the current paper investigates the influence of mask and noise on word recognition in adults and typically developing primary school children with normal hearing. Low frequency words were selected, as later acquired words have been shown to provide greater insight between linguistic knowledge and masked speech recognition (Leibold & Buss, 2019).

Methodology

Twenty six listeners, fourteen adults and twelve children were recruited for the study. Adults were aged 19 to 51 years old and children were aged 6;8 to 7;6 (years;months) and had just completed the first grade of primary school. All participants underwent formal audiological testing to ensure normal hearing, and two adults were excluded due to moderate hearing loss at high frequencies. All subjects had no reported speech, language and learning difficulties. Two adults and two children took part in a pilot experiment so as to choose a suitable SNR (signal-to-noise ratio) level for each type of noise and age group. Ten adults and ten children participated in the main experiment. All testing took place in the sound proof booth of the Speech Signal Processing Laboratory of the Computer Science Department of the University of Crete and was approved by the University Research Ethics Committee.

Listener performance reported in the present paper was based on linguistic material that included 250 low frequency words selected from the lexical database Greeklex 2 (Kyparissiadis et al., 2017) which were expected to be unfamiliar to first graders. The words were embedded in the carrier phrase «Πες τη λέξη …» ("Say the word …"). The material was recorded twice in quiet by a female primary school teacher, once wearing a surgical face mask and once with no mask. Two types of noise were selected, real classroom noise and two-talker noise. Classroom noise (CN) was recorded inside a real classroom of a local primary school. Two-talker noise (TTN) was a mixture of two female speakers, each recorded separately reading a different children's literature excerpt. According to the pilot experiment, children required higher SNR levels to reach adult performance (Leibold & Buss, 2019) and TTN posed a greater obstacle as documented in other studies (Corbin et al., 2016). Based on the pilot results, a single SNR level for each noise condition and age group was selected: 0 dB for adults and 2.5 dB for children for CN, and 5 dB for adults and 7.5 dB for children for TTN. A MATLAB algorithm was created in order to mix clean stimuli with the chosen SNR levels and randomise them for every listener.

For the main experiment, ten adults and ten children, five male and five female in each group, listened to 40 stimuli in each noise type, half produced with mask and half without mask, and afterwards the same words were presented in quiet, in the same mask condition as presented in noise. Thus each listener was tested on 160 words in total in three different sessions: one session in CN, one in TTN and one in quiet. A single loudspeaker was placed in front of the listener, at a radial distance of 0.9 m. Each mixture was presented at approximately 65 dB SPL. Listeners' responses were recorded using Audacity and were rated by the first author. Any response that did not exactly match the original word was marked as incorrect.

Results

Mixed Analysis of Variance (ANOVA) was used for the statistical treatment of the data. Participant score was analysed vs age group, gender, noise type and mask. All factors except gender were found statistically significant (age group: df=1, F=7.059, p=0.009; gender: df=1, F=0.163, p=0.687; noise type: df=2, F=325.8, p<0.001; mask: df=1, F=4.077, p=0.0463).

Both children and adults showed significantly better performance in the no mask (children: mean: 57.67%, SD: 24.89%, adults: mean: 60.67%, SD: 28.00%) than in the mask condition (children: mean: 51.50%, SD: 29.02%, adults: mean: 58.92%, SD: 27.65%). Also, children performed significantly worse than adults. Although the mask seems to impede children's performance more than that of adults (score reduction: 6.17% for children vs 1.75% for adults), the mask*age group interaction did not reach stat. significance (df=1, F=1.269, p=0.2628).

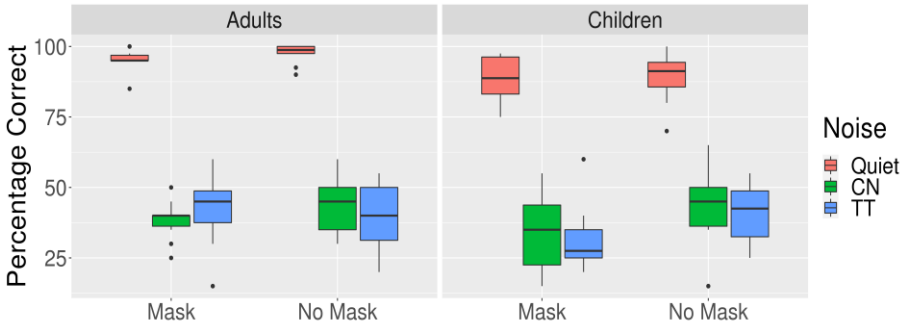

Figure 1. Percentage of correct responses for adults (left) and children (right) in the mask vs no mask condition and in quiet vs two noise types.

Among the three conditions, according to Tukey post-hoc tests, performance in quiet was significantly higher than in the two noise types (quiet vs. CN, p<0.001, quiet vs. TTN, p<0.001). No sig. differences were located between the two noise types (CN vs TTN, p = 0.862) which was expected due to the +5 SNR advantage in the TTN condition. A trend for worse performance by children than adults in the mask condition, and especially in TTN noise (children: mean: 31.50%, SD: 12.03%, adults: mean: 43.00%, SD: 13.58%), was manifested, although the interaction age group*mask*noise did not reach statistical significance (df=2, F=1.161, p=0.318).

Discussion

The pilot study confirms that children require higher SNR levels to reach adult performance (Leibold & Buss, 2019). Even with a +2.5 dB advantage, children still perform significantly worse than adults in the main experiment. TTN has been documented as a greater obstacle in relation to steady-state noise maskers

(Corbin et al., 2016); the pilot study exhibits that the same applies to TTN vs classroom noise (CN). The results of the main experiment demonstrate that recognition of low frequency words produced with a surgical mask is significantly lower for both children and adults in quiet and noise. This is an interesting finding as surgical masks have been reported to cause the least acoustic attenuation in comparison with other types of masks (Bottalico et al., 2020; Toscano & Toscano, 2021). The investigation of this matter, especially for children, is of great importance as auditory word recognition has an impact on language processing, the acquisition of new vocabulary and the development of the reading skill (Snowling et al., 1986). The choice of linguistic material (e.g. frequency of selected words or use of sentences vs individual words), as well as type of face mask are two significant factors in masked speech recognition (Vos et al., 2021). Thus, the trend for children's lower performance in the mask condition manifested in the present study should be investigated further, taking into account the aforementioned factors and including more child participants as well as participants with hearing or language impairments.

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