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Effect of passive smoking on auditory temporal resolution in children

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ABSTRACT

Objective: To determine the effect of passive smoking on auditory temporal resolution in primary school children, based on the hypothesis that individuals who are exposed to smoking exhibit impaired performance.
Design: Auditory temporal resolution was evaluated using the Gaps In Noise (GIN) test. Exposure to passive smoking was assessed by measuring nicotine metabolite (cotinine) excreted in the first urine of the day.
Study sample: The study included 90 children with mean age of 10.2 ± 0.1 years old from a public school in São Paulo. Participants were divided into two groups: a study group, comprising 45 children exposed to passive smoking (cotinine > 5 ng/mL); and a control group, constituting 45 children who were not exposed to passive smoking. All participants had normal audiometry and immittance test results.
Results: Statistically significant differences ($p < 0.005$) in performance on the GIN test were found between the two groups, with mean thresholds of 5.3 ms and 68.9% correct responses in the study group versus 4.6 ms and 74.0% in the control group.
Conclusion: The children exposed to passive smoking had poorer performance both in terms of thresholds and correct responses percentage on auditory temporal resolution assessment.

1. Introduction

National antismoking laws cover 16% of the global population. However, significant exposure of many individuals remains. The World Health Organization (WHO) has estimated that around 6 million people die each year from tobacco use including 600,000 who die from exposure to tobacco smoke. The global average of children exposed to passive smoking is estimated to be 41%. The highest level, almost 68%, is found in the Western Pacific Region. In the Americas the exposure is estimated to be about 25% and in Europe about 51%. Exposure to passive smoking can be extremely harmful to health, particularly among children, and is associated with increased rates of lower respiratory tract diseases. These conditions can lead to problems such as asthma, bronchiolitis, pneumonia, bronchitis and also cases of upper respiratory tract infection, increasing the incidence of acute otitis media [1–3].

The vulnerability of the auditory system to tobacco smoke is evident and the exposure to second-hand smoke during childhood has been established as a risk factor for hearing loss [4]. Talaat et al. [5] conducted a study involving 411 children aged between 5 and 11 grouped as follows: 131-no exposure (Group 1), 155-mild exposure (Group 2) and 125-heavy exposure (Group 3) to passive smoking. Comparison of the results for pure tone and speech audiometry, and immittance among the three groups revealed an increasing degree of hearing loss: 3.8% in Group 1; 4.5% in Group 2 and 15% in Group 3. A previous study reported with the same population presented in this study revealed a markedly reduced otoacoustic emissions response level in the exposed children [6], which is consistent with previous reports in neonates [7,8].

Although tobacco smoke exposure still lacks an ideal method of measurement, relying on self-report may lead to inaccurate measures of nicotine exposure, so the use of biomarkers have been suggested with the cotinine being the most used available method [9]. Cotinine is used in research as a reliable marker for determining smoking status, it is the main metabolite of nicotine, shows a high correlation between its concentration on blood and urine and a half time life of approximately 17 h [10].

The impact of the adverse effects of smoking and its consequences for child development in the medium and long terms has

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yet to be established.

Measurements of auditory processing, particularly temporal processing, may be useful for assessing this impact on auditory development. Temporal resolution can be defined as the ability to detect time gaps between sound stimuli or the shortest time gap an individual can discriminate between two audible sound signals [11,12]. Children with impaired temporal resolution have a greater likelihood of having language learning difficulties than children with normal temporal resolution [13] once temporal processing skills are related to phonemic, lexical and prosodic discrimination and underlies most other auditory processes (localization, discrimination, binaural integration and separation). Temporal resolution is typically evaluated through a psychoacoustic measurement known as gap detection in tonal or click stimulus (Random Gap Detection Test, Keith, 2000) [14] or in noise (Gap in noise, Musiek, 2005) [15]. The Gap in noise procedure has been proven to be a clinically feasible and sensitive measure for both adult [15] and pediatric [16] population.

Although several studies have determined normative values for auditory temporal resolution tests in the pediatric population, no studies have closed related second-hand smoke to auditory temporal processing in children [16–18]. Evidence from animal studies revealed that nicotine concentration can affect normal development of gap detection. A high concentration of nicotine (5 mg/kg) was associated with lower detection of gaps and a higher detection threshold, indicating impaired auditory temporal processing [19].

Thus, the objective of the present study is to determine the effect of passive smoking on auditory temporal resolution in primary school children, based on the hypothesis that individuals exposed to nicotine passively exhibit impaired performance.

2. Method

Approval for the study was granted by the local Research Ethics Committee. After a full explanation about the aims and procedures of this research with children and parents, the free and informed consent was signed by the parents or guardians and all the children signed the Assent Term.

2.1. Casuistic

A team of 4 researchers from the School of Medical Sciences involved in this project selected the nearest public elementary school for the study. Authorizations were obtained to inform and invite children from 4th and 5th years of elementary school to participate in the study ($n = 200$). The public elementary school is located in a central region of São Paulo, the largest city in Latin America. According to the *Socioeconomic Index of Brazilian Basic Education Schools* students at this public school location had a low socio-economic level [20].

Children with similar age and school grade were selected for the two groups from individuals who agreed to participate ($n = 186$). Parents filled out a simple questionnaire with questions about language development, hearing abilities and history of neurological or psychiatric syndromes or disorders. For been included on this research, it was observed that the parents have no appointments about these topics. Parents were also asked about smoke habits.

All children with no history of the syndromes or disorders mentioned above were included. The children were then tested by basic audiological evaluation (including pure tone and speech audiometry, and immittance testing). Audiometrically normal subjects were defined as those with thresholds for air-conducted stimuli ≤15 dB hearing level (HL) at all frequencies 0.25–8 kHz, tympanometry result type A (with compliance peak between −99 and 50 daPa) [21] and acoustic reflex present from 0.5, 1 and 2 kHz.

Individuals with normal results were tested for auditory temporal resolution. The children were classified into the “exposed” and “not exposed” groups based on the cotinine levels measured. Individuals with cotinine concentration <5.0 ng/mL were assigned to the Control group and those with levels >5.0 ng/mL to the Study group. The overall study sample comprised 90 children selected through the inclusion and exclusion criteria and they were divided into the two study groups: Control group ($n = 45$, not exposed) and Study group ($n = 45$, exposed) according to passive smoking exposure. The age range for both groups was 10.2 ± 0.1 years of age, and the gender was also balanced.

2.2. Procedure

Audiologic assessments were carried out at the Clinic of Speech-Language Pathology and Audiology. Urinary cotinine concentration was determined at the Department of Physiological Sciences.

The Gap in Noise (GIN) [11,15] test was applied using a CD recording played on headphones via an Itera model audiometer connected to the CD player, inside a sound-proof booth. The stimulus was applied monaurally at 50 dB SL, based on average hearing thresholds of 500, 1000 and 2000 Hz. Both ears were tested.

In the GIN test, sound stimuli are placed on four test tracks and one training track. The stimuli consist of six-second segments of white noise randomly interspersed with gaps (periods of silence). The gaps are randomized and of different durations (2, 3, 4, 5, 6, 8, 10, 12, 15 and 20 ms). The training track was applied prior to commencing the test, making sure that the child being tested understood the task instructions.

The participants were instructed to press a response button upon hearing the gaps within the noise.

Performance on the GIN test was calculated based on two measurements [11]. The first measurement was approximate gap threshold, defined as the shortest gap duration identified in four out of six trials; while the second measurement was the correct identification of gaps of any length, expressed in a percentage.

2.3. Determination of the nicotine metabolite – cotinine

Cotinine urine concentrations were used as a biomarker for nicotine smoke exposure. The Abnova ELISA kit [22] was used to determine urinary cotinine concentration. The first urine of the day was collected from the children at their homes in an appropriate vessel. The vessels containing the urine samples were brought to school and delivered to the researchers. This collection and delivery procedure took no longer than 2 h. The samples were immediately stored in a freezer at −20 °C for further use in the ELISA assay procedure (1–6 months). A urinary cotinine concentration of 5 ng/mL was adopted as the cut-off point for discriminating between exposure and non-exposure to passive smoking [22,23].

2.4. Learning difficulties – questionnaire completed by teachers

The teachers filled out a questionnaire collecting information about the students considering all of the following aspects: 1) below expected academic performance; 2) reading and writing difficulties; 3) mathematics reasoning difficulties; or 4) school failure. The presence of each aspect was scored with 1 point and absence with 0 points. The scores for all four aspects were summed up to provide an overall level of the learning difficulties of the student, as follows: a) zero: No difficulty; b) 1: minimum difficulty; c) 2: little difficulty; c) 3: medium difficulty and d) 4: maximum difficulty. The teacher was not aware if the students belonged to the study group or the control group.