O Ruído e sua interferência sobre estudantes em uma sala de aula: revisão de literatura***

Noise and its interference over students in a classroom environment: literature review

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Abstract

Background: influence of the acoustic environment on learning. Aim: to analyze the possible alterations students of schools found under the impact of internal or external noises may present. Method: literature review on the following subjects: auditory processing, speech perception, acoustics of classrooms and basic notions about noise. Conclusion: schools are under the impact of varied noises that can become invisible opponents to the learning process, especially in a place where the listening situation must be privileged. Audiologists can be part of a multidisciplinary team, helping to monitor these areas and helping to implement hearing conservation programs.

Key-Words: Noise; Speech Perception; School.

Resumo

Tema: a influência do ambiente acústico na aprendizagem. Objetivo: analisar alterações que podem ocorrer aos estudantes de uma escola que se encontre sob impacto de ruídos internos ou externos às suas instalações. Para isso, foi realizada uma revisão da literatura sobre temas: processamento auditivo, percepção de fala, acústica em sala de aula, noções básicas de ruído. Conclusão: a escola se encontra sob forte impacto de ruídos diversos, que se tornam opositores invisíveis à aprendizagem, em um local onde a situação de escuta deveria ser muito privilegiada, e que os Fonoaudiólogos podem auxiliar uma equipe multidisciplinar no monitoramento destas áreas e na implantação de programas de conservação auditiva.

Palavras-Chave: Ruído; Percepção da Fala; Escola.

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Introduction

A lot has been spoken about noise, sound pollution, psycho-physic alterations in the human being due to the noise and, therefore, a lot of school professionals have been asking about the noise impact over the day-by-day educational activities developed in the school.

Several mass communication means, such as newspaper, magazines, have published in their articles discussions and approaches about the disorders provoked by the noise on people who are daily in contact with noise. Most interestingly is that we don't even notice that we live with moderate noise daily and that it becomes our body's enemy. We can realize that even during pleasure activities we are exposed to strong intensities of noise and that people assume a passive posture, seeming not to be aware of its harmful effects and to avoid it (Celani & Costa Filho, 1991).

The aim of this article is to analyze the alterations that may occur in school students exposed to the influence of noise in their scholar environment, generated inside or outside the school, that is, the classroom, the patio, the library, the meeting or assembly room. We would like to be able to help the speech and hearing therapist in the hard task of monitoring these areas that become the natural learning barn of a youth that may be having its intellectual development altered by the negative influences of the environment.

Basic notions about noise

Many authors, worried about this topic, raised some definitions of noise that are necessary to enable us to understand the basic definition of sound.

Gerges (1991) affirmed that sound and noise are the same physic phenomenon, although they are not synonyms. A noise is just a type of sound, but a sound is not necessarily a noise. Under the psycho-acoustic point of view, a noise would be an unpleasant sensation triggered by the reception of acoustic energy.

Sound, music or noise trigger pleasant or unpleasant sensations in an individual and, therefore, some researchers interested in the psycho-physic aspects developed studies to evaluate the existing correlation between noise, mood and irritability (Lundquist et al., 2003).

If the adequate notion of a problem's definition already took us to its solutions, we believe that the effective noise control inside a school would be totally outlined. Nevertheless, what differs these positions is the individuality of each human being when facing a learning process in an unfavorable listening situation. Despite knowing that noise is part of our everyday lives, not only for those people who live in great urban centers and that are becoming more and more patient with the sounds (desirable or not) that might be music, honks, bird, sirens, etc.; we must focus how we deal with these sounds when they occur together with learning situations, where all subject's energy should be directed to his studies, during the hard task of listening, saving and learning regardless of the noise.

We can realize that each human being refers differently to the same competitive noise. While one person doesn't even notice that a car with loud-speakers is passing by during his class, another one may feel the necessity of sitting forward, another may be disinterested of the subject since he is not being able to follow what the teacher is saying, another one may start feeling some physic annoyance, such as headache, tiredness, muscle pains, etc.

According to Bentler (2000), what interferes the most in a classroom is the signal-to-noise ratio (SNR). The more positive it is, the better the listening situation offered to the students will be. The closer to zero or negative it is, the worse will be the situation for the students to understand the teacher's speech.

The elucidation of this relation is important. Lets consider a classroom. The teacher's voice will be called signal (S) and the noise to which the classroom is exposed, from the outside or the inside of the school, will be called noise (N). When we use a sound pressure level meter we will find a voice intensity used by this teacher (for example, 70 dB) and a noise intensity (for example, 80 dB). In this example, the classroom would be with a SNR of -10 dB!

The students always report that they listen what the teacher says, even in the back of the classroom. This statement is correct! Although, what they can not notice is that the speech misses its intelligibility, once it wastes its energy from the front to the back of the class.

We shall stress that there is a recommendation that the mean noise level inside a classroom should be between 35 to 45 dB (Table 1), once levels between 50-65dB (although acceptable) provoke a mild stress initiating the hearing discomfort, vigilance and agitation (Thiery e Meyer, 1988).

TABLE 1. Noise levels (in dBA) indicated for acoustic comfort in several surroundings (Gerges, 2000).

Locais		Nível Recomendado
hospitais	apartamentos, enfermarias	30-40
	laboratórios, áreas públicas	35-45
	serviços	40-50
escolas	bibliotecas	30-40
	salas de aula	35-45
	circulação	40-50
hotéis	apartamentos	30-40
	restaurantes	35-45
	portaria, recepção	40-50
residências	dormitórios	30-40
	sala de estar	35-45
auditórios	salas de concerto	25-30
	salas de conferências	30-35
	restaurantes	35-45
escritórios	salas de reunião	25-35
	administração	30-40
igrejas		35-45
locais para esporte		40-55

For a speech and hearing pathologist to be aware of the signal-to-noise ratio established inside a classroom of a certain school, it is necessary that a sound pressure level meter is used in order to enable the professional to measure the noise of a certain place in different times of the day. This way, he will be able to outline a profile of the mean noise of this classroom, as well as to map the occasions where there are higher intensities of competitive noise.

Speech perception

Scientific researches on speech perception started since 1950 (Jusczyk & Luce, 2002) and became a very motivating and productive study field.

In our scholar context, the speech is the great transmitter of knowledge, information and learning, since it is through this tool that the teacher communicates in classroom, passing all the necessary knowledge to the students. This way, the speech becomes the main focus of our attention, as if it is distorted or with an adverse sign by external interferences, it may hinder the understanding of the students, the attention time, their behavior and learning.

We must understand that during the learning situation in a classroom, the student is submitted to two different types of stimuli: the main one that is the teacher's voice and that is the one the student must direct all his attention to; and the secondary one that is the competitive noise and that the student must be able to neglect it in order to allow the main message not to be distorted.

It is important for the speech and hearing pathologist inserted in this situation to establish some important points for the improvement of the listening situation:

· the type of predominant noise in this classroom;
· the characteristics of the teacher's voice;
· the distance between the teacher and the students;
· the kind of desk distribution inside the classroom;
· aspects of the classroom (floor, walls, ventilation, etc.).

The characterization of the type of noise that occurs inside the classroom is important so that we can have a notion of the spectrum of this noise, thus we will know whether it is a high, a low, a constant, an intermittent noise, etc. This will lead us to understand which speech sounds would be more damaged in its presence.

The type of the teacher's voice is also of great value, since we can observe the voice's extent inside the classroom space. As we already know, the male voice has a lower span and the female voice has a higher span; Hodgson (2002) found in his work that the speech perception varies according to the voice level used by the teacher (Table 2).

A fact that can not be disregarded nor forgotten to be mentioned is the reverberation that occurs inside a closed space, such as a classroom. Reverberation and noise control the speech intelligibility in a classroom (Bistafa & Bradley, 2000; Pittman & Wiley, 2001; Pearson et al., 2001; Van Wijngaarden et al., 2002; Bradley at al., 2003; Yon et al., 2003). Several studies are already searching the improvement of listening situations (Johnson, 2000; Da Costa, 2001; Picard and Bradley, 2001; Hodgson and Nosal, 2002; Abdou, 2003; Skarlatos and Manatakis, 2003).

According to Russo (1999), the reverberation is a type of reflected wave and it occurs when the wave returns to the sound source in a time interval

shorter than 1/10 of a second , or when the obstacle is less than 17 meters of the source.

The speech and hearing pathologist is not able to perform this measure that must be done by a technician. Nevertheless, he can not neglect this information, as the reflected waves inside the classroom obstruct the speech understanding.

The speech perception study is important in order to allow us to identify the acoustic cues that are not used by the listener to take phonetic decisions. For example, what makes the listener able to discriminate these two words in a dictation (*Bula – mula*)? A possible cue to be used may be based on the existing difference in the average energy necessary to produce each phoneme (Table 3).

Cunningham et al. (2001) as well as Bradlow et al. (2003) stated that speech perception difficulties might contribute to learning problems in some children, who present difficulties to discriminate two acoustically similar sounds.

The speech acoustic analysis almost never takes into account the context, that is, the combined production of sound to form syllables, words and sentences. The speech usually involves sound sequences that occur quickly. In this moment, the co-articulation occurs, where the sounds miss their own characteristics. This fact may be explained by the example: in the word "*campo*", the /a/ becomes nasal by the anticipation of the nasalization of the /m/. In the word "*sul*", the /s/ is pronounced with rounded lips by the anticipation of the /u/, this does not occur in "*sapo*", where the /s/ is pronounced with opened lips due to the following /a/.

The teacher's voice is another point of real interest when we think about speech perception, as the great task of knowledge transmission depends on it, and it must be clear, harmonious, intelligible and beyond all and any competitive noise, otherwise the students will not follow the teaching.

However, in a noisy classroom, the teacher usually has to overcome the competitive noise to be understood and, therefore he overcharges his phonoarticulatory tract, demanding a stronger voice for a long period of time, that may, many times, provoke vocal chords alterations (edemas, nodules, etc.).

This characterizes the Lombard Effect, that is, the tendency of the speaker to maintain a constant relation between his speech level and the competitive noise.

TABLE 2. Minimum intelligibility levels in relation to the distance (in meters) and the necessary voice level (in dB) according to Georges (2000).

Distância	Normal	Alto	Muito Alto	Grito
0,3	65	71	77	83
0,6	59	65	71	77
0,9	55	61	67	73
1,2	53	59	65	71
1,5	51	57	63	69
3,6	43	49	55	61

TABLE 3. Phoneme's average energy, according to Russo & Behlau (1993).

Fonemas	Média de Energia
/t/ e /d/	em torno de 4000Hz;
/p/ e /b/	entre 500Hz à 1500Hz
/k/ e /g/	entre 1500Hz à 4000Hz;
/m/ e /n/	em torno de 300Hz
/f/ e /v/	entre 1200 a 7000Hz
/s/ e /z/	acima de 4500Hz (até 8000Hz)
/ʃ/ e /ʒ/	2500Hz a 6000Hz;
/l/	350Hz
/r/	500Hz;
/R/	1000 1000 e 2000Hz

De Lucca & Dragone (2003) believe that the teacher belongs to a group that uses the voice professionally and that needs to have special care including the attainment of educational programmes focusing the prevention of vocal problems (Russel et al., 1998), as well as the use of several resources (Jonsdottir et al., 2001; Mendel et al., 2003).

Mattiske et al. (1998) associated several studies concerning the teacher's voice and noted that:

1. The teacher's voice disorders can reduce speech intelligibility and become esthetically unacceptable, bringing social, personal and economic harm.
2. Teachers are high risk professionals for vocal problems.
3. The impact of vocal disorders is immense among teachers.
4. Teachers who remain teaching in the presence of a vocal disorder are forced to change their teaching

style and to reduce their vocal demands, the teachers have trouble establishing or controlling the class.
5. A vocal dysfunction may lead to an early career end.

The literature usually informs us that teachers state that the noise: bothers when they are teaching, demands increase of speech intensity bringing voice problems, several students have trouble understanding their voice and notice great dispersion of the students, damaging their health, learning and well being.

Auditory processing

Auditory processing (AP) is the decoding and the interpretation of the sound waves, from the external ear to the auditory cortex. In short, it is what we do with what we hear (Katz et al., 1992). And this study becomes important when we analyze how the student receives the information in the classroom.

According to several authors, this process occurs in the peripheral auditory system (external, middle and inner ears and VIII cranial nerve), in the central auditory system (brain stem, sub cortical pathways, auditory cortex) and also in the non-auditory central areas (frontal lobe, temporal-parietal connection, occipital lobe).

Through the external, middle and inner ears, the sound energy is translated into mechanic, hydraulic, chemical and electric energy. In the central auditory pathways, the electric sign will be analyzed and distributed in order to favor the messages comprehension. In some transmission stations of the auditory pathway, the fibers cross and other ones stimulate the brain hemisphere correspondent to the stimulated ear. The auditory information will be interpreted, decoded and processed in the brain.

The AP requires that some auditory abilities are intact, as well as the abilities linguistically dependent on the auditory perception: memory, synthesis, closure, attention, association and cognition.

The reduction of the intrinsic and extrinsic redundancies cause uncertainty in the listener, according to Musiek & Rintelmann (2001), while a speech perception in adequate conditions becomes rewarding and encourages the child to develop his perceptual abilities.

Among the factors that help the speech perception there is the knowledge of the topic, the familiarity with the vocabulary used, the knowledge of the phonetic aspects of the speech and the familiarity with the idiom rules.

According to Lasky (1983), the auditory stimuli that occur in the classroom include those presented by the teacher and those presented by the students. The first ones are the relevant stimuli and the other ones are not relevant for the learning. The child focuses on the selected stimulus and refuses the competitive stimulus through his perceptual concentration and his attention direction. In order to learn, the child must keep his attention tuned with the relevant stimulus and ignore the competitive one.

These auditory abilities are crucial in the normal hearing, specially in the school environment, where there frequently are situations that demand the listener to ignore linguistic information from one source in order to concentrate the attention in a main message. However, the necessity to be attached to one stimulus despite the noise is tiring and shattering and the student may not maintain his attention during the school period of 4 hours. This exhaustion becomes apparent via lack of attention, parallel talks, pains and learning failure.

Dreossi & Momensohn-Santos (2003) performed a research aiming at analyzing the speech perception with competitive noise of 4th grade students. The results were surprising, as the students presented great difficulty to repeat sentences and words recorded in a CD with competitive noise of the Babble kind. Behavioral alterations of the students were observed when they performed the test with the noise, once they felt disturbed, assumed a tightened, compressed body posture, tightened eyebrows, tried to place one ear in a more favorable listening situation, searched to bend the body forward. And when they listened to the list of words or sentences without noise, they sat back comfortably, relaxed, softened the tone of voice, presented a better and slower articulation. Many of them commented about the difficulty and the disturbance when performing the task under the competitive noise and how much easier it was to listen without noise.

Acoustics in the classroom

Knecht et al. (2002) affirmed that the learning and hearing abilities may be damaged by the acoustics of a classroom (noise and reverberation) and that this damage may affect hearing and deaf children. According to Eniza & Garavelia (2003), children beginning literacy are more harmed by the

external noise than older children, once they present a reduced vocabulary.

The Acoustical Society of America (2000) published a study warning the professionals who work with education to the fact that noise, although invisible, brings great implications to the learning and that its control may be easy and economic.

This way, we conclude that there is no architectural nor acoustic planning for the implementation of schools in several places. Therefore, they may be under the impact of noise generated: in the school, in the classroom and outside it.

The noise originated inside the school may be: the cafeteria, the patio, the play area noise, etc. As the noise originated inside the classroom we have the feet and desk crawling, the teacher and students voices, the air conditioning, ventilator, etc. The outside noises include honks, car engines, planes, churches, etc.

The noises generated inside the classroom could be minimized with some basic adequacies of the space. If the school presents cold floor (such as ceramic, tiles, etc.) that is highly reverberant, it would be recommended its covering with a absorbent material (carpets, rugs, rubber, etc.) The classrooms must always be separated by walls that will absorb the energy between the classes. If, even though, the sound of one class is interfering in the other ones, it would be indicated its covering with some kind of material (such as cork, panels, furniture, etc.). The windows without sound proof treatment, must have curtains to minimize the impact of the noise coming from outside. If these classrooms are equipped with ventilators and/or air conditioners, the noise generated by these equipments must also be monitored. Noise of desk crawling is intense inside the schools and it could be controlled by carpeting or even by putting perforated tennis balls under the desks feet.

The noise generated inside the school must be analyzed case by case, so that children during play or interval time don't influence the students that are still in the classrooms; or that the voices from the sport gymnasium don't interfere with the classes. Many times, only the alteration of the entrance doors positioning is enough to reduce the noise between them, so that they are not positioned one in front of the other, or one beside the other.

The lack of resources (Seep et al., 2002) does not justify the noise control failure in the classroom, once the necessary investment is not high. What actually impede this control is the lack of perception about the problem and its probable solutions.

Thus, we can systematize that there are 4 great points to be analyzed in this situation: to reduce, somehow, the noise that arrives in the classroom, to increase the teacher's voice in the classroom using modulated frequency (MF), to improve the classroom's acoustics (Bistafa & Bradley, 2001; Bradley, 2002; Koszarny &Chyla, 2003), and to perform a preventive work of awareness of the sound pollution.

Systematized works for the valuing of the hearing as well as hearing conservation (Bennet & English, 1999; Folmer et al., 2002) done with school children should be implemented in order for them to recognize harmful habits and behaviors for the hearing and to change attitudes, including those related to pleasure habits (Wazen & Russo, 2004).

Conclusion

According to what it was exposed in this article, we can conclude that there are many variables that can interfere with the speech perception inside a classroom and, consequently with the student's learning.

This way, the speech and hearing pathologist who works in this field could not only contribute with his knowledge in acoustics, voice, auditory processing, etc, but also could develop hearing conservation programmes in schools, aiming at the children's awareness so that they can value their hearing, changing behaviors and habits that might harm it, and grow protecting their hearing (using hearing protectors, not being exposed to noisy places, using safety belts, helmets when riding a bike, etc.).

We believe that more researches in this area are needed using the Brazilian Portuguese indicating, this way, the interference that our language suffers with the impact of the competitive noise in the classroom and over the learning.

The speech and hearing pathologists involved with schools may help in the education of these children, no more just indicating children with disorders, and empower themselves in this new segment of preventive action, that is, spreading together with directors, counselors, pedagogues, coordinators, and teachers the bad effects of this listening situation, so that gradually the classrooms may be adapted and rethought in order to favor the intelligibility of speech.

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