Teaching and Teacher Education 28 (2012) 1083–1090

Contents lists available at SciVerse ScienceDirect

Teaching and Teacher Education

journal homepage: www.elsevier.com/locate/tate

Noise, what noise? Raising awareness of auditory health among future primary-school teachers

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HIGHLIGHTS

- Noise-induced hearing loss is becoming a serious health problem in young people.
- Prevention is hampered by the scant awareness concerning the harmful effects.
- Prevention in primary school depends of future school teachers.
- Practical activities in future school teachers raise their degree of awareness.
- Activities similar to those proposed here can prevent noise-induced hearing loss.

ARTICLE INFO

Article history:
Received 14 October 2011
Received in revised form
8 June 2012
Accepted 10 June 2012

Keywords:
Classroom intervention
Health education
Noise
Prevention
University students

ABSTRACT

We study the perception of acoustic contamination and its deleterious effects on students preparing to become school teachers and analyse their acoustic habits, with the aim of raising their awareness concerning this problem. We designed a number of activities, applied during a practical lesson, in which students evaluated some of their perceptions and attitudes towards noise, and recorded their hearing capacity. Students increased their noise awareness after performing the practice. We propose the introduction of activities similar to those proposed here, to prevent hearing loss from exposure to noise and promote such preventive activities among these future school teachers.

1. Introduction

Noise has long been closely linked to human civilization, as evidenced by the existence in ancient Roman Period and during the Middle Ages of laws to reduce noisy activities in the streets (Goines & Hagler, 2007). However, the harmful effects of noise are in general little known. The WHO (2011) reported cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus, and annoyance as effects that noise exerts on health, and estimates that at least one million healthy life years are lost every year from traffic-related noise in the Western Europe (see also Evans, 2006). Research has placed special focus on the negative effects of noise in relation to young people, in particular children and adolescents, since their educational development is negatively affected.

It has been known for decades that noise interferes with the communication between teachers and pupils, hampers short-term memory, reading and linguistic skills, motivation, and reaction time. Bistrup (2003), reviewing research results in primary and secondary schools and day-care centres of Denmark, Germany, Italy, the Netherlands, Sweden, United Kingdom and North America, found that a reduction in noise levels improved speech and word intelligibility, short- and long-term memory, linguistic skills, and scores on annual proficiency exams. However, more than the immediate effects of ambient noise on education, a special relevance is given to losses in auditory capacity due to exposure to noise. These losses are usually undetected in the short-term or are transitory, but their effects can become permanent on the long term. Children with hearing difficulties have trouble learning and show misconduct more frequently than do control children, this situation negatively affecting their education. A pioneer study carried out by Anderson (1967) comparing 120 students with unilateral and bilateral high-frequency losses and 120 in control

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http://dx.doi.org/10.1016/j.tate.2012.06.002

group in Buffalo (USA) reported that the former scored lower on tests for basic skills, exhibited behavioural problems, and had lower self-esteem. More recently, Bess, Dood-Murphy, and Parker (1998) identified the students with minimal sensorineural hearing loss (SNHL) from a sample of 1218 children in grades 3, 6, and 9 from Nashville (USA), and compared them with a control group with normal hearing. All of the participants performed the Comprehensive Test of Basic Skills (CTBS), the Screening Instrument for Targeting Education Risk (SIFTER) and the Revised Behavior Problem Checklist for a subsample of children with SNHL and their counterparts with normal hearing. For an assessment of the relationship between SNHL and functional status, test scores of all children with SNHL and all children with normal hearing in grades 6 and 9 were compared with the COOP Adolescent Chart Method, a screening tool for functional status. They found that SNHL was exhibited by 5.4% of the study sample, while prevalence of all types of hearing impairment was 11.3%. Third-grade children with SNHL had significantly lower scores than did normally hearing controls on a series of subtests of the CTBS/4; however, no differences were noted at the 6th- or 9th-grade levels. The SIFTER results revealed that children with SNHL scored poorer on the communication subtest than did normal-hearing controls. Some 37% of the children with SNHL failed at least one grade. Finally, children with SNHL exhibited significantly greater dysfunction than children with normal hearing on several subtests of the COOP, including behaviour, energy, stress, social support, and self-esteem.

The prevalence of noise-induced hearing loss in young people has been increasing worldwide for decades, and it has been documented that hearing losses related with leisure noise could affect up to 12–15% of all children during their schooling years. Niskar et al. (2001), in a large-scale report from USA, found that 12–15% of school-aged children have some hearing deficits attributable to noise exposure. Axelsson, Jerson, Lindberg, and Lindgren (1981), in a hearing test on 538 teenage boys from Scandinavia, revealed a hearing loss (greater than 15 dB) in 15% of them. Peng, Tao, and Huang (2007), in a Chinese study of 120 young users of 'personal listening devices', found impaired hearing (loss greater than 25 dB) in 14% of subjects. Meyer-Bisch (1996), in a French audiometric survey of 1364 young subjects, found evidence of hearing problems in 12% of the general population, and detected hearing loss in 66% of the subgroup that often attended rock concerts or used 'personal cassette players' for more than 7 h per week. Similar results were found by Metternich and Brusis (1999) in a small group of 24 German teenagers.

Attendance to concerts and discotheques, as well as the use of MP3-players among young people and the scant use of protecting ear devices are the main causes for these data. In USA, Chermak and Peters-McCarthy (1991) found a very low (5.5%) use of earplugs by students attending noisy activities. In Canada, Lees, Roberts, and Wald (1985) found a temporal displacement of hearing threshold of 10–30 dB due to the use of earphones by students. In Sweden, Hellström, Axelsson, and Costa (1998) evidenced a temporary threshold shift of auditory capacity of 33 young females and 30 young males after listening to a portable cassette player for 1 h, despite listening levels of 91–97 dB. In Valencia (Spain) with a small sample of 25 students, Maldonado Román, Ramírez Moreno, and Enríquez Enríquez (2003) reported that 50% listened to music at a very high volume, and 85% acknowledged being more permissive of leisure noise than those from other activities. In Florida (USA), Holmes, Widen, Carver, and White (2007), in a study with 245 young adults age 18–27, 157 participants reportedly used no hearing protection in any noisy activities such as using firearms or attending concerts, clubs, or discos. In Córdoba (Argentina), Serra, Biassoni, Hinalaf, Pavlik, and Pérez Villalobo (2007) studied a group of 181 students aged 14–15 and resampled later at age 17–18, and these researchers found that the going to discos was the most frequent noisy recreational activity and the use of personal music players was the second most frequent experience reported. Also, there was a progressive increase in music-related recreational activities participation over time. In The Netherlands, Vogel, Brug, Van der Ploeg, and Raat (2010a) estimated that around 1.25 h/week in discotheques is enough to diminish hearing capacity, and highlighted the lack of caution against loud music among young people when attending discotheques.

Music is the sparsement noise to which young people are exposed most frequently, as a consequence of digital technology (Morata, 2007), the main source of danger from noise exposure. The long-life batteries and thousands of songs stored allow the use of MP3 devices in noisy environments for substantial durations, as on aeroplanes, trains, or mass transit, and can reach a sound intensity of 120 dB. Considering the hearing-damage risk criterion of 85 dB with an exposure duration of 8 h, the use of MP3-players potentially places the listeners at risk of hearing damage (Fligor & Cox, 2004). However, the use of these devices is common every day and its frequency is increasing among teenagers. Henderson, Testa, and Hartnick (2011) found, from the period 1988–1994 to 2005–2006, an increase from 19.8 to 34.8% of North American teenagers exposed to loud headphone music, and this trend was paralleled by increased hearing loss (although only in female youth). Sales of MP3 devices significantly rose from 2001 to 2007 (SCENIHR, 2008). Since acoustic habits are not so different in teenagers worldwide, increased hearing losses induced by leisure noise are predicted to be widespread (Zhao, French, Manchaiah, Liang, & Price, 2011) highlighting the importance of stopping this progressive rise in incidence.

These predictions underline the value of education to prevent hearing losses and other harmful effects of noise exposure. Gallagher (1989) found that, after informing 1529 students about the dangers of loud music, the proportion of listeners that used protection in concerts increased. Folmer, Griest, and Martin (2002) reviewed different educational prevention programs in USA, and found greater concern for and intention to use protection against noise. Chung, Des Roches, Meunier, and Eavey (2005), in a study on the visitors of the web MTV.com, found that 20% of the visitors were prone to use ear protection against noise, but the proportion jumped to 50% when the information came from professional doctors, and to 60% when informed that the exposure to noise without protection caused permanent hearing losses. Widén, Holmes, and Erlandsson (2006) analysed the use of earplugs in teenagers attending to music events from USA and Sweden, the proportions being 9.5% and 61.2%, respectively, due to informative campaigns in Sweden in which earplugs were offered free of charge at music events. Chen, Huang, and Wei (2008) reported a lack of information as the main reason given by students to ignore protection against noise; these researchers also found, in a sample with 254 young males and 225 young females, a high correlation between the information about protective measures and the intention to adopt them. García Ferrandis, García Ferrandis, and García Gómez (2010), reported that 35.7% of high-school Spanish students acknowledge willingness to change their behaviour and noise-reducing activities after receiving information on the harmful effects of noise contamination. All these studies evidence that providing information is an effective way to promote prevention.

The increase in hearing losses by noise exposure in teenagers, the appearance of hearing losses at earlier ages, and the reduction in cognitive ability in school-age children, imply that elementary school and high school are appropriate environments to confront the problem and provide prevention guidelines. However, this idea contrasts with concepts held by teachers concerning noise contamination. A survey on 50 high-school teachers in Spain

(Collado Martínez, 2007) evidenced conceptual mistakes for a better approach to study noise in classroom. Some 76% of teachers scored the work centre as noisy or very noisy, and 80% declared having communication problems due to noise. Asked about the harmful effects of noise, they usually failed to mention health problems or cognitive implications such as lower academic performance, difficulties of concentration, or hampered learning. Finally, 44.4% declared having discussed noise contamination in the classroom, but usually only a theoretical explanation was given without practical activities. This was the prime reason behind our approach, consisting of a series of activities directed at students studying to be primary-school teachers. The approach was based on three points:

- The youth of future teachers: this implies more formative behaviour and thus easier to instil healthy habits.
- The cascade effect of teachers: by raising awareness in the teacher, we can influence generations of future pupils.
- Reaching parents: teacher awareness of the problem can prompt information and prevention programmes of for pupils' parents, thus again multiplying the effects of their activities and more directly influencing the pupils' behaviour.

The period of compulsory education is appropriate to implement health education, because children are still in a formative period in terms of their life habits (Morón Marchena, 1998). During infancy, healthy habits can be fomented more easily than during adolescence, when habits are more established and unhealthy habits are more difficult to discourage. Adolescence is characterised by a strong influence of the peer group, which can exert a stronger influence than do educational programmes. The problem continues during adulthood, when the lifestyle is firmly established and difficult to change through education. Thus, it is advisable to reach children when they are young. However, the educational programmes to prevent unhealthy habits against noise cannot be implemented unless teachers agree with these programs. The perception held by the upcoming generation of primary-school teachers concerning acoustic contamination will determine the way that they treat this subject during their teaching. Thus, the university, the institution that trains these teachers, plays a pivotal role in this sense. If the university students (future teachers) become aware of their own risky attitudes towards noise, they may take more interest when implementing preventive programmes while teaching at the primary educational levels.

In this work, we present the results of a series of activities performed with the students being trained in primary education at the University of Granada (Spain). Our intention is to raise the awareness level in these future teachers, thus promoting their future commitment to implement activities to prevent hearing loss for their pupils. For this, we gathered data on the habits of these students with respect to environmental noise with which they usually live. Then, we used these data to demonstrate to these students the negative implications for their own auditory-health habits.

2. Material and methods

The activities presented in this study were designed as a practical lesson for the school-teaching students of the University of Granada (Spain). A total of 129 students enrolled in this course. Attendance to the practical lessons, although high, was variable, and thus the sample size is detailed in each part of the study.

Before starting the activities, the students were informed about the aims of the research, and were invited to participate. Confidentiality was guaranteed; nevertheless, some students declined to participate and others took part only in some of the activities, thus causing some variations in the sample size, depending of the activity. Furthermore, confidentiality impeded an individualized analysis of the data (Table 1).

2.1. Tests of noise as a contaminant

The perception of noise as a kind of contamination was investigated using two tests. Students took the tests two weeks before as well as four weeks after the practical lesson (see below *Efficiency of the practice*). A total of 90 students took the tests. A subgroup ($n = 55$) was asked to describe the ways in which humans can produce contamination, thus an open question (hereafter "open test"). Another subgroup ($n = 35$) was asked to rank noise as a contaminant in a closed list (hereafter "closed test") among different contaminant activities by humans (see Appendix I). The two types of tests were designed for different objectives. The open test, to cite or fail to cite noise as a possible answer was meant to show to what extent the student was aware of noise as a contaminant. However, the open test did not provide a quantitative assessment of the ranking of noise as a contaminant in relation to other forms of pollution. This appraisal was made in the closed test.

2.2. Acoustic habits

The habits of students in relation to noise (e.g. entertainment, living area) were interviewed by means of a questionnaire of 14 items (see Appendix II), in which students were asked to evaluate several characteristics of their daily environment, places for entertainment (discotheques, pubs, etc.), sensitivity to noise, and concern about noise as a contaminant. Students filled out the questionnaire as a part of the preparatory work for the practice activity.

2.3. Activities of the practice lesson

A total of 129 students took part in the practice activities. Activities were 2-h sessions in which students were confronted with different proposals. First of all, students were provided with the scale used by the WHO to mark the thresholds for damage according to noise intensity. Once the list was discussed and the students were aware of these limits, they were invited to enter the webpage www.dangerousdecibels.org (Griest, Folmer, & Martin, 2007), in which they performed simulations and gathered information on the harmful effects of noise. Then, they read a guide sheet with articles in local newspapers referring to problems of ambient noise in their city. Finally, two activities were performed with the students:

1. Measurement of volume at which students set their earphones. Students were invited to play their earphones with two songs of their own choice played at the usual volume. Each song was played for 1 min, the highest sound volume was registered, and the two highs were averaged.

Table 1
Activities, participating groups, and sample size at the different stages of the study.

Before	Pre-tests of noise as a contaminant	Acoustic habits	Practice	Post-tests of noise as a contaminant
Group A	Closed (35)	68	86	Closed (26)
Group A	Open (27)			Open (60)
Group C	Open (28)	51	43	Open (43)
Total	90	119	129	129

2. Measurement of student's auditory threshold. In this activity, a known sound was placed at the end of a hall, and students were asked to move away from the sound until it was no longer audible. The auditory threshold was estimated by recording the distance at which students failed to perceive the sound. The test sound played was the alarm of a mobile phone, set at a sound intensity of 57.0 ± 0.6 dB (average of 20 records of 1 min in duration).

After the data were recorded and analysed, the results were discussed with students on the basis of the information gathered. The discussion was directed to compare the volume at which students set their earphones on the WHO scale, and comparing the students' attitudes against noise depending on whether they produced (MP3 devices) or accepted (leisure noise) this noise or whether they were receivers of undesired (traffic, work) ambient noise.

Sound volume was measured with a digital sonometer Roline model RO-1350. All measurements were made in the laboratory and the hall of the Department of Didactics of Experimental Sciences, at the Faculty of Educational Sciences, University of Granada (Spain). Environmental noise was measured in order to control its possible effect on measurements, since auditory capacity varies with the background noise levels. During seven lesson days, environmental noise was measured at three different positions, noting the highest record for 1 min period, once per hour (four in total) during morning and afternoon (7 days × 3 positions × 2 periods of time × 4 records). The environmental noise was higher during the mornings than during the afternoons ($F_{1,162} = 60.05$, $p < 0.0001$), and lower in the laboratory than at the end of the hall, near the main hall of the faculty ($F_{2,162} = 70.20$, $p < 0.0001$; interaction $p = 0.6642$; two-way factorial ANOVA; Table 2).

2.4. Efficiency of the practice

Four weeks after the performing of the practice, students were asked to answer the same tests as before, in order to score whether the students' appreciation of noise as a problem and contaminant had changed. The number of students taking the tests differed before and after the practical lesson, but all the people answering the questionnaire after the practical lesson had performed the practice.

2.5. Statistical analysis

Whenever possible, parametric statistics were used to analyse the results, when looking for differences between records of sound volume for environmental noise in the lab and hall (ANOVA) or between groups in sound volume of earphones (Student's *t*-test), or when correlating the student's age with the sound volume in the earphones and with the auditory threshold (Pearson's correlation). However, most of the variables recorded were either nominal or ordinal. The nominal variables were analysed by frequency-distribution and contingency tests, and ordinal ones by Mann–Whitney *U* tests. Relationships between ordinal or continuous variables were checked by Spearman rank correlations. Due to the different nature and sample sizes for the different variables, whenever a statistical analysis was performed, both the analysis type and sample size was detailed. Means are expressed as mean ± 1 SE.

Table 2
Background noise at the spaces of practices. $N = 28$ in each cell.

dB	Lab	Mid hall	End hall
Morning	49.8 ± 0.7	55.3 ± 1.0	56.9 ± 1.3
Afternoon	44.7 ± 0.4	49.1 ± 0.8	54.9 ± 0.6

3. Results

3.1. Pre-test of noise as a contaminant

In the open test, less than half of students (43.5%, $n = 55$) mentioned noise as a contaminant. The closed test provided similar results, since the average score for noise was 7.2 ± 0.3 ($n = 35$, from 1 the most important contaminant to 9 the least). In general other contaminants, such as industry or traffic, were cited by students as more important contaminant activities.

3.2. Acoustic habits

A total of 119 students answered the questionnaire, although not all the items were filled out by all the students (see sample sizes in Table 3).

All the students considered their home (and their private space at home) as silent or quiet, while in general they scored both their residence area as quiet to moderately noisy (around 80% of the answers). With respect to the noise environment in the usual places for entertainment, most of the students (79%) classified them as noisy or very noisy, although visits were usually restricted to weekends (more than half of the answers).

Most students claimed to set the TV at home at a medium volume, but almost a quarter of them acknowledged a high or very high volume. More than half of students (59%) used earphones only sporadically (half an hour or less per day), but 5% used them three or more hours per day. Some 36% of the earphone users acknowledged that they set the volume high or very high.

Almost 80% of the students identified noise as a high or extreme contaminant (in contrast to the data offered by the pre-test), and around 75% scored their auditory capacity as high or very high; conversely, only 32% of them consider themselves to be sensitive or very sensitive to environmental noise.

3.3. Activities of the practice lesson

Students set their earphones at an average of 86.7 ± 0.7 dB ($n = 104$). Sound intensity was not significantly different either between the two groups of students (morning 85.9 ± 1.0 dB, $n = 58$; afternoon 87.7 ± 1.1 dB, $n = 46$; $t = 1.213$, $p = 0.2285$) or between sexes (females 86.5 ± 0.8 dB, $n = 93$, males 88.1 ± 2.25, $n = 11$;

Table 3
Results of the questionnaire about acoustic habits in students. All figures are the percentage of students in each category.

Noise at:	Silent	Almost quiet	Moderately quiet	Noisy	Very noisy
Residence area (118)	5.9	45.0	32.2	12.7	4.2
Inside home (119)	20.2	57.1	14.3	7.6	0.8
Study place (115)	26.1	52.2	14.8	6.9	0
Entertainment places (119)	0.8	4.2	16.0	58.0	21.0
Visit to entertainment places (days/week) (118)	(0) 1.7	(1–2) 35.6	(3) 54.2	(4) 8.5	(≥5) 0
Use of electronic devices	Very low	Low	Medium	High	Very high
TV volume (118)	0	0.8	75.4	23.0	0.8
Earphone volume (111)	1.0	12.6	50.4	28.8	7.2
Earphone use (hours/day) (93)	(<1 h) 58.0	(1 h) 28.0	(2 h) 8.6	(3 h) 2.2	(>3 h) 3.2
Perception of noise	Very low	Low	Medium	High	Very high
Noise as a contaminant (114)	0.8	3.5	16.7	65.0	14.0
Sensitivity to environmental noise (113)	0.8	1.8	65.5	30.1	1.8
Own auditory capacity (113)	0	1.8	31.0	56.6	10.6

$t = 0.9237$, $p = 0.3695$; Student's t-test). In addition, no relationship was found between earphone sound intensity and the student's age ($R^2 = 0.0047$, $p = 0.4965$, $n = 100$; Pearson correlation).

With respect to the student's auditory threshold, again no differences were found between sexes (females 21.3 ± 0.5 m, $n = 100$; males 21.1 ± 1.5, $n = 11$; $t = -0.1446$, $p < 0.8873$), but the two groups differed (morning 18.6 ± 0.5 m, $n = 61$; afternoon 24.5 ± 0.6 m, $n = 50$, $t = 7.8763$, $p < 0.0001$; Student's t-tests) and there was also a positive relation to age ($R^2 = 0.0368$, $n = 107$, $p < 0.0477$, $n = 100$; Pearson correlation).

3.4. Relationships between perception of noise as a contamination and acoustic habits

No relationship was found between the perception of noise as a contaminant or sensitivity to noise with TV volume ($r_s = -0.073$; $n = 113$ and $r_s = -0.074$; $n = 112$), earphone volume ($r_s = 0.041$; $n = 100$ and $r_s = -0.083$; $n = 99$), or noise in entertainment places ($r_s = -0.007$; $n = 114$ and $r_s = -0.008$; $n = 113$ respectively; $p > 0.4$ in all; Spearman rank correlation).

3.5. Relationships between acoustic habits and hearing capacity

Perception threshold of hearing stimulus did not correlate with TV volume ($r_s = -0.146$; $p = 0.1249$; $n = 112$), earphone volume ($r_s = 0.104$; $p = 0.3062$; $n = 99$), or noise in places of entertainment ($r_s = 0.058$; $p = 0.5450$; $n = 104$; Spearman rank correlation).

3.6. Relationships between different acoustic habits

TV volume correlated neither with earphone volume ($r_s = 0.007$; $p = 0.9469$; $n = 103$) nor with noise in places of entertainment ($r_s = 0.102$; $p = 0.2739$; $n = 118$). However, there was a significant correlation between the student's own evaluation of earphone volume and instrumental measurements ($r_s = 0.4416$; $p < 0.0001$; $n = 96$), as well as between earphone volume and noise in places of entertainment ($r_s = 0.283$; $p = 0.0036$; $n = 104$; Spearman rank correlation).

3.7. Effectiveness of the practice

Four weeks after the practice, students were asked to fill out the same questionnaire as before, in order to test whether the students' appreciation of noise as a problem and contaminant had changed.

The group of students who were asked to rank noise as a contaminant in the closed test concerning different contaminating activities by humans showed increased appreciation of noise as a contaminant (Table 4), since the average rank for noise lower to 6.2 ± 0.4 ($n = 26$), although the difference was only marginally significant ($Z_{27,34} = 1{,}92$, $p = 0.0552$, Mann–Whitney U test).

With respect to the students filling out the open test, both groups (morning and afternoon) showed greater appreciation of noise as a contaminant, although the increase was significant only in the morning group ($\chi^2 = 11.48$, df = 1, $p = 0.0007$ vs. $\chi^2 = 1.176$, df = 1, $p = 0.2781$; contingency tests; Fig. 1).

Table 4
The percentage of students scoring noise as a contaminant activity from a given list (Appendix I; 1 means maximum importance, 9 minimum), before and after the practice activities.

Score	1	2	3	4	5	6	7	8	9	n
Pre-test	0.0	2.9	5.7	2.9	0.0	17.1	17.1	25.7	28.6	35
Post-test	3.9	3.9	7.7	3.9	11.5	15.4	19.2	30.8	3.9	26

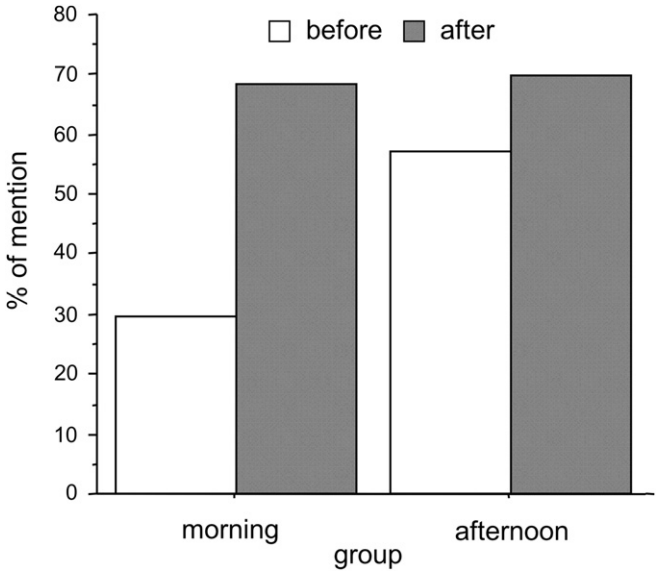

Fig. 1. Percentage of students citing noise as a contaminant activity in the open test, before and after the practice activities.

4. Discussion

4.1. Initial noise perception by students

The first barrier to overcome in preventing damage associated with acoustic contamination is the lack of public perception of the hearing problems due to excessive noise exposure (Holmes et al., 2007). The results of the pre-tests (Table 4, Fig. 1) confirm this lack of perception by university students, since most did not mention noise as a contaminant and those who did scored its importance as low. These results agree with previous studies, not only with Spanish students (García Ferrandis et al., 2010), but also in other countries, such as Australia (Fleer, 2002), Malaysia (Said, Yahaya, & Ahmadun, 2007), South Korea (Kim, 2011), and Turkey (Onur, Sanir, & Tekkaya, 2012).

4.2. Features of the noise in students' environments

Environmental noise linked to the place of residence or study cannot in general be controlled by the student, and is greatly determined by the availability in the residence as well as the economic possibilities of the students when choosing an environment. Notably, some students consider their residence as noisy or very noisy, while this appreciation is lower for their home and place of study. The aim of characterizing the environment in which students perform their daily activity is based not only on the direct impact regarding health, but also on the influence in other acoustic habits. That is, some students stated that they played their music systems at a higher level when they were in noisy places, in order to block out environmental noise. This would mean that people living daily in noisy environments would set their personal devices such as earphones at higher sound levels, thus incurring a higher risk of acoustic damage.

While it is hard for students to choose the characteristics of the residence and workplace, an entertainment establishment can be selected. However, this choice is strongly determined by social pressure, places of entertainment with high levels of noise being common for young people worldwide (Griest et al., 2007; Vogel, Brug, Van der Ploeg, & Raat, 2010b). This habit, which increases with age during adolescence (Serra et al., 2007), can trigger

temporary changes in the hearing level and can cause tinnitus (Chung et al., 2005; Martínez-Wbaldo et al., 2009; Smith, Davis, Ferguson, & Lutman, 2000). Nevertheless, it is difficult to reduce the number of young people who visit these noisy entertainment places because of the strong peer pressure and because young people are stimulated by this kind of entertainment (Hellström et al., 1998). Those who seek such entertainment seem to be satisfied with the kind of sparsement received, and they do not adequately weigh the future harm to health (Vogel et al., 2010a). Our questionnaire does not specify the kind of place visited by young people (either discotheques, bars, pubs, or other) although all these establishments may have high levels of environmental noise and thus represent a high risk level that unwary students confront.

A high proportion of students admitted to immoderate use of earphones, in terms of both time of use and volume, a habit that can be injurious. Earphone use is widespread in society, being ubiquitous among the young people in the streets and public transport listening to music or the radio with these devices. The use of these personal audio systems is, together with visits to discotheques and other noisy places of entertainment, one of the sources of social noise experienced by teenagers and young people (Griest et al., 2007; Holmes et al., 2007; Vogel, Brug, Hosli, Van der Ploeg, & Raat, 2008). The average sound level that students habitually use in their earphones is dangerously high, 86.7 $\pm$ 0.7 dB (the maximum records surpass 100 dB). In addition, it should be taken into account that these measurements were recorded in a relatively quiet environment, with a low level of background noise (see Table 2). However, students acknowledged that they often set a higher volume in their earphones when confronted with high environmental noise (see above). Thus, it is advisable that in many daily situations of higher noise levels (e.g. streets with traffic, public transports) students may set their earphones even higher than recorded during our trials, thus suffering a higher risk of auditory damage (Lees et al., 1985). The effects of the environmental noise can also be appreciated regarding the differences in hearing thresholds between morning and afternoon. The difference can presumably be explained by the different level of background noise at different times of the day, background noise being around 2–6 dB on average higher in the morning (see Table 2).

4.3. Effects of practice in noise perception by students

Practice activities heightened the perception of noise as a contaminant, with a noteworthy increase of answers in the post-test, in which students gave a high ranking to noise as a contaminant or mentioned it in the open test (Table 4, Fig. 1). In this sense, the activities performed succeeded in raising student awareness concerning health problems associated with environmental noise. However, the statements and scoring of students regarding noise as a contaminant in the questionnaire of acoustic habits prior to the practice activities seem contradictory with results found in the pre-test, in which 80% of answers scored contamination by noise as high or extreme (see *Noise as a contaminant* in Table 3). These answers may have been anticipatory, since the questionnaire was filled out just before the practice about noise, and the students previously knew the subject of the practice. This prior knowledge could have predisposed the students to describe noise as a problem at a level higher than their habitual opinion, despite that the questionnaires were completely anonymous. Such an interpretation would at least partially explain the lack of correlations between certain variables that were subjectively appreciated by students regarding their own habits with respect to noise, as for instance considering noise as a contaminant. In any case, the true success of these programmes and activities needs to be evaluated over the long term (Folmer et al., 2002). Our intention was to test the effectiveness of the activities one year after performing the practice, but we were unable to contact a significant number of students involved, since many had already graduated, and could not be located.

The key role that music plays in entertainment for young people explains the close correlation between visits to noisy places for entertainment (discotheques and pubs, usually with loud surrounding music) and the volume measured in their earphones. These results agree with those of Vogel, Verschuure, Van der Ploeg, Brug, and Raat (2010) on Dutch students; that is, the frequent use of MP3-players usually coincides with frequent prevalence of other harmful behaviour. This is a noteworthy point, since our results suggest that most students are unaware of the risks of many of their activities (Vogel et al., 2008). They recognize they set their earphone volume high, as evidenced by the close correlation between their subjective perception and the instrumental setting. However, people tend to justify noise as being unimportant or weak when they themselves produce it (Sánchez, 2001). Raising awareness in the population concerning their own physical and emotional states, as well as habits that affect wellbeing, is one of the objectives of health education (Busquets & Leal, 1993). Thus, the first step to change habits among people is to raise their awareness of those habits.

The students interviewed by García Ferrandis et al. (2010) stated that better knowledge of the damage associated with acoustic contamination would promote some changes in their behaviour. Our results suggest that this is a promising path to explore in order to raise awareness among young people about the risks of exposure to noise: the perception of noise as a contaminant and the appreciation of its danger increased in our students after the performing of the practice, a preliminary and necessary step for prevention. Hopefully, this knowledge will continue to influence their future behaviour. Moreover, an important factor to consider is that in the near future these students will be the teachers of young children (our students are trained to teach children of 3–6 years old). Thus, these future teachers will be prepared to promote healthy habits with respect to environmental noise in children, and will perhaps be more receptive to prevention programmes than their colleagues who lack this perception of noise as a serious health problem. Children in the early stages of education are more receptive to proposals of healthy habits, since their social behaviour remains to be completely established and is less conditioned by peers.

5. Conclusions

Many different studies worldwide have firmly connected noise exposure to learning and health problems, demonstrating that a greater prevalence of noise induces hearing loss in children and adolescents. Awareness of the problem has promoted educational programs for prevention (see Folmer et al., 2002; for a review). The question, then, is why they are not put in practice more frequently. We offer several answers to this question:

1) Low social awareness concerning acoustic pollution is evidenced by prior research on environmental education, and specific studies on this issue are scarce.
2) Ear health and protection against noise is poorly covered in textbooks and school curricula (Chen et al., 2008). For instance, in Spain and the UK, this question is scarcely presented and is usually treated tangentially to other scientific issues (Perales, 2003; Zhao et al., 2011).
3) The already tested programmes are hardly publicized in the right forums (Blair, Hardegree, & Benson, 1996; Folmer et al., 2002; Griest et al., 2007; Holmes et al., 2007). The

noteworthy point is that these programmes are not usually published in educational journals, but in medical ones such as *International Journal of Audiology*, *Noise and Health*, *American Journal of Audiology*, which are usually not consulted by teachers and educational researchers.

4) Teachers largely disregard the effects of noise in cognitive processes and health (Chen et al., 2008; Collado Martínez, 2007), and there are other misconceptions about sound and noise (Collado Martínez, 2007).
5) Limited importance is given to health problems associated with noise in comparison to others, and therefore the awareness of the general population is rather low, not only in educational institutions, but also medical ones. Consequently, auditory health receives little attention in comparison to depression, drugs, tobacco, alcohol or ETS (Chung et al., 2005), and therefore is of secondary interest in school curricula and prevention programmes (e.g. MSC & MEPSYD, 2008; Zhao et al., 2011).

To overcome these handicaps, we suggest the following specific goals:

1) Awareness needs to be raised among future teachers and education professionals in relation to hearing health problems. University teachers play a pivotal role in this sense, since their activities have an expansive effect: by training future teachers, they can reach a much broader potential target population. Under the supervision of professionals in higher education, the activities presented here have been directed during four years to students intending to become primary-school teachers.
2) An effort was made to train and raise the awareness of teachers already working. This training took two forms: the most usual involved recycling courses, but publication in educational journals is also crucial. The prevention programmes and the research concerning the harmful effects of noise on health are available, but they are presented outside the usual channels known by teachers, such as educational journals, and are far more usual in medical journals, thus reaching doctors and medical workers but not to education professionals.
3) A multidisciplinary approach is needed to sound, noise, and environmental and health problems, giving meaning to some aspects that might otherwise be unattractive to students. This approach could remedy the deficiencies of school curricula and textbooks.
4) The role of teachers goes beyond training and raising student awareness, insomuch as it needs also to reach the students' parents. The involvement of parents in classroom activities would improve the efficiency of such activities by reinforcing the effect in students and broaden outreach in society. Furthermore, parents who become aware constitute pressure to establish these prevention programs as part of the school curriculum.

Society generates a certain level of noise that cannot be avoided, but this is not true for leisure activities associated with loud levels of music. In these cases, the people themselves must control the situation. For future generations, better auditory health requires the cooperation of parents and teachers; raising awareness is a difficult task in comparison to the easy decision of reducing loud MP3 volume or using earplugs in noisy environments.

Acknowledgements

We appreciate the help and suggestions of Dr F. Javier Perales in validating the questionnaires. Four anonymous referees provided many helpful suggestions that improved an earlier version of this manuscript. David Nesbitt kindly corrected the English.

Appendix I. Relevance of contaminant activities

Open test

Enumerate nine contaminant activities and rank them from 1 to 9 according to the degree of the negative effects that, in your opinion, are caused in the environment. 1 means the most contaminant, 9 the least.

Closed test

Rank from 1 to 9 the following list of contaminant activities according to the degree of the negative effects that, in your opinion, are caused in our environment. 1 means the most contaminant, 9 the least.

- Emissions into the atmosphere by industry.
- Emissions into the atmosphere by cars.
- Waste dumped into bodies of water (rivers, lakes, sea) from industry and ships.
- Waste to dumped into bodies of water (rivers, lakes, sea) from houses or recreation activities (beach).
- Noise.
- Light.
- Excessive energy consumption.
- Unnecessary consumption.
- Non-selective discarding of domestic waste.

Appendix II. Interview of acoustic habits

1. Sex:
   a) male, b) female
2. Age:
3. According to the environmental noise, the vicinity of your home can be scored as:
   a) silent, b) almost quiet, c) moderately quiet, d) noisy, e) very noisy.
4. According to the environmental noise, your home can be scored as:
   a) silent, b) almost quiet, c) moderately quiet, d) noisy, e) very noisy.
5. According to the environmental noise, your place of study can be scored as:
   a) silent, b) almost quiet, c) moderately quiet, d) noisy, e) very noisy.
6. According to the environmental noise, your usual places of entertainment can be scored as:
   a) silent, b) almost quiet, c) moderately quiet, d) noisy, e) very noisy.
7. Your usual attendance to noisy entertainment places is about:
   a) daily, b) 4 days/week, c) weekends (2–3 days/week), d) 1–2 days/week, e) rarely or never.
8. The volume you set TV is:
   a) very low, b) low, c) medium, d) high, e) very high
9. Usually you employ earphone devices for listening to music or radio:
   a) yes, b) no.
10. Your daily use of earphones is around:
    a) half an hour/day, b) 1 h/day, c) 2 h/day, d) 3 h/day, e) more than hours/day
11. The volume you set earphones is:
    a) very low, b) low, c) medium, d) high, e) very high
12. In your opinion, ambient noise can be considered as:
    a) extremely contaminant, b) very contaminant, c) moderately contaminant, d) slightly contaminant, e) not contaminant at all.

13. How do you score your own sensitivity to environmental noise?
    a) very low, b) low, c) medium, d) high, e) extreme.
14. How do you score your auditory capacity?
    a) very low, b) low, c) medium, d) high, e) very high.

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