Noise level assessments:

Subjective vs objective measures

Elizabeth Beach (1), Warwick Williams (1,2) and Megan Gilliver (1,2)

(1) National Acoustic Laboratories, Australia
(2) Hearing Co-operative Research Centre, Sydney, Australia

ABSTRACT

The aim of the study was to establish the accuracy with which individuals can estimate the noise level of everyday events to which they are exposed. A group of 45 volunteer participants was recruited to wear personal noise exposure meters for periods of up to five days. The volunteers kept diaries of their daily events and were requested to estimate the noise level of all events on a 1 to 10 Likert scale. The results showed that participants could successfully estimate the noise level of daily events, suggesting that individuals are able to make reasonable estimates of the noise level of events they experience. This result is of potential significance for those interested in producing effective hearing health awareness programs in that individuals may be able to assess their own degree of hazard exposure.

INTRODUCTION

The question of whether or not individuals can accurately perceive the noise level of everyday events and activities is important because it could play a role in the prevention of noise-induced hearing loss (NIHL). If individuals can accurately estimate the noise level of particular events or activities, they will be well-placed to decide whether or not to avoid such events or minimise their exposure to them.

To date, there appears to be few studies examining the subjective assessment of noise levels of daily activities. Perception of the noise level of work-related events has been studied by Neitzel et al. (2009) who found that workers can differentiate between relative noise levels and degrees of noise variability during work shifts. Two other studies have examined the perception of noise level of non-occupational (or leisure) events. In an unpublished Master's thesis, Madetoja (1998) derived a regression equation to describe the relationship between the subjective assessment of noise on a scale of 1 ('quiet') to 5 ('very loud') during specific leisure events and measured noise levels for those same events. The result provided a surprisingly good linear relationship between subjective and objective noise level assessment. A similar survey, although smaller in terms of the number of people involved, was undertaken by Choi (2008). This was also an unpublished Master's project, and found a linear relationship between measured noise levels and subjective assessments on both 5- and 10-point scales.

The primary aim of the current work was to determine whether a group of young adults was capable of accurately and consistently estimating the noise level of events experienced during both occupational and leisure time.

METHOD

Noise measurements were gathered from personal noise exposure meter or dosimeter readings. The dosimeters used were CEL-350 dBadge Personal Sound Exposure meters marketed by Casella-CEL (Bedford, UK), calibrated using a CEL-110 Acoustic Calibrator. Dosimeters were worn by participants who volunteered to wear the devices every day for a four-or five-day period. The measurement periods were chosen to represent noise exposures that individuals receive during a typical week from work and non-work (leisure) activities. The test days included Friday evening, and Saturday through to Sunday evening in order to maximise the number of leisure activities experienced during the test period. Dosimeters were worn for all waking hours, except for water and body contact sports, during which they were placed as close as possible to the activity area. During sleep periods, recordings were not carried out because the devices were attached to a battery charger for recharging overnight, and pilot tests had shown that noise levels during sleep were negligible.

Participants were also requested to complete a diary record of activities and events experienced during each day. For each event, participants noted the duration and location and completed a subjective assessment of noise level using a rating scale of 1 (very quiet) to 10 (very loud). The descriptions attached to the points on the scale are shown in Table 1.

Table 1. Noise level rating scale: item descriptions

1-2	Someone could comfortably hear you use a whisper / very quiet voice from 1 metre away (e.g. library)
3-4	You could easily hold a conversation with someone 1 metre away from you without raising your voice
5-6	Conversation is possible with someone 1 metre away, but requires you to raise your voice (e.g., noisy cafe)
7-8	You need to shout to be heard by someone 1 metre away. Difficult to hold a conversation
9-10	Cannot be heard by someone 1 metre away, even when shouting. Volume level may be uncomfortable after a short time

Participants

Participants were volunteers who indicated they were prepared to wear a dosimeter for the required period and keep a notated diary of activities and events. These participants were recruited through social-network internet sites, individuals known to researchers, and work colleagues using a 'snowball' recruitment method. Ethics approval was obtained through the Australian Hearing Human Research Ethics Committee. In total there were 45 participants aged between 18 and 35 years. Forty-two participants supplied appropriate data for the noise level ratings of events (22 males, 20 females, mean age: 26.8). All participants received a department store gift voucher valued at $100 for their participation.

Data analysis

At the conclusion of the four or five days of recordings (93% of participants recorded noise for five days), dosimeter results were downloaded using supplied software with International Organization for Standardization (ISO) protocols and definitions. The results were discussed with the participants individually to ensure correct and consistent data interpretation. An example of an individual output is presented in Figure 1 which shows the A–weighted equivalent continuous sound pressure level (L_{Aeq}) for a 20-hour period from 8:41am until 4:04am the next day.

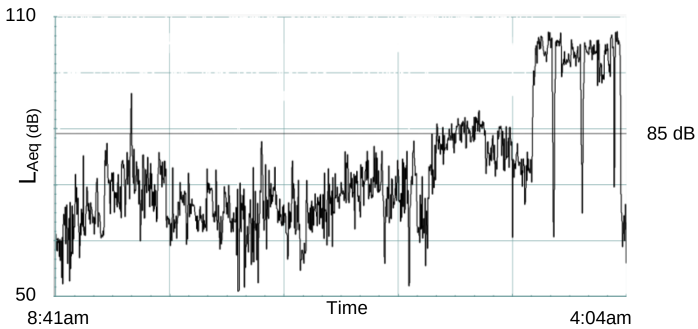

Figure 1. Typical dosimeter output plotting one minute L_{Aeq} (dB). Of particular note is the event at the end of the day: a 3-hour stint at a nightclub where the L_{Aeq} was 102.6 dB.

For each participant, overall noise exposure was calculated for each day and the day of greatest exposure was selected for further analysis[1]. Diary records and noise results on the day of highest exposure were examined, and all events that lasted for a period of 45 minutes or greater were identified. This was considered to be a period of sufficient length to ensure that when a daily diary entry was being made the event would be relatively significant in recent memory and a reasonable judgement could be offered as to its noise level. If an individual had only one or two such events on their day of highest exposure, then their day of second highest exposure was also included in the analysis.

The A–weighted equivalent continuous sound pressure level (or L_{Aeq}) of each identified event and the associated subjective noise level assessment was recorded. A total of 242 events were extracted and each participant yielded at least three usable events (with a mean of 5.9 usable events per participant). Fifty-nine events (24%) were work or study related, and the remaining 76% were leisure events and activities.

[1] Noise exposure is measured in Pa^2h (ISO 1999; AS/NZS 1269.1) and is a particularly useful method of quantifying noise exposure because an exposure of 85 dB over 8 hours (i.e., the legislated workplace limit) is equivalent to 1.01 Pa^2h. Thus, any day which has a noise exposure greater than 1.01 Pa^2h can be deemed a day of excessive noise exposure.

RESULTS

Firstly, the relationship between the subjective assessments and the objective L_{Aeq} measurements was examined by calculating Pearson's correlation coefficients between the two data sets. For all participants combined, the correlation coefficient between the objective and subjective data sets was $r = 0.78$, $p < 0.001$. When correlation coefficients were calculated for individual participants, they ranged from –0.75 to 0.99. Thirty-eight of the 42 participants' subjective assessments were positively correlated with the objective noise measurements and for 24 of these, the correlation was significant (alpha set at 0.05).

Secondly, the linear regression between all L_{Aeq}s and subjective assessments was calculated, and found to be highly significant, $R^2 = 0.61$, $df = 240$, $p < 0.0001$. Thus both methods of analysis indicate a strong, positive linear relationship between the objective and subjective assessments of noise level.

Figure 2 shows a simplified picture of the relationship between the objective and subjective assessment of the noise levels. To minimise the number of data points, the mean L_{Aeq} with respect to each point on the subjective rating scale has been calculated. In those cases where participants nominated a value that lay between points on the rating scale, e.g., 6.5, this figure was rounded to the nearest whole number on the rating scale. For some points on the subjective rating scale the number of objective L_{Aeq} measurements was relatively high, whereas for other points, there were only a few objective measurements, e.g., for point '3' on the scale, n = 46, but for point '9', n=7.

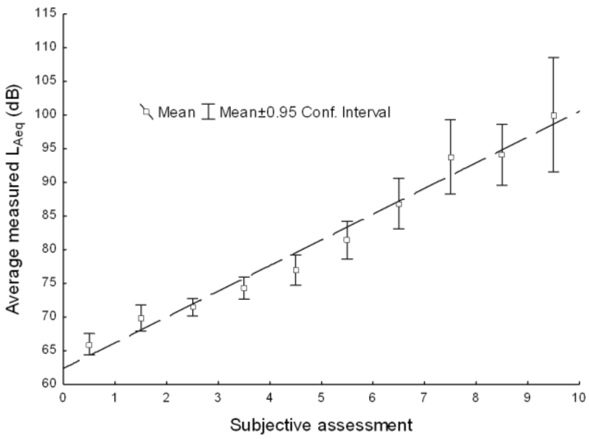

Figure 2. The relationship between objective (L_{Aeq}) and subjective assessment of the noise levels of individual events. Note: The relatively large 95% CIs result from the small number of sample points at that particular subjective value.

The regression equation derived from the linear regression analysis is:

Expected event noise level (L_{Aeq}) = 3.6 x (subjective assessment) + 61.1 dB.

Although a first approximation, this equation is potentially very useful because it could be used to estimate the noise level at events using simple ratings on a 10-point scale, without the need to measure actual noise levels.

DISCUSSION

The results presented here show that young adults can reasonably estimate the noise level of events using a simple 10-point Likert scale. The strong correlation between subjective noise level assessments and objective noise measurements suggests that young adults 'know' when an event is loud. Future noise prevention campaigns could exploit this knowledge by encouraging young adults to take protective action when they find themselves in a noisy situation. Importantly, all events that were rated at 8 or more on the scale were objectively measured at greater than 84.3 dB. Since point 8 was labelled: “You need to shout to be heard by someone 1 metre away, difficult to hold a conversation” it is suggested that in future, campaigns would be justified in using (or continuing to use) this 'rule of thumb' to explain when noise is at potentially dangerous levels. This could alleviate the need to refer to noise levels in terms of decibels, which tend to be misunderstood in the community (Williams 2004; Marks & Florentine 2011) and allow campaigns to send a more easily understood message directly to their target audience.

A further implication of these results relates to research methodology. Having shown that young adults can make reasonable estimates of the noise level of their environment, this could mean that in some circumstances, objective measurements of noise, which are often time-consuming, costly and intrusive to perform, may not be necessary when researchers wish to obtain an indication of the noise level of particular events. These findings suggest that subjective noise assessments of events can provide a reasonable estimate of actual noise levels and could therefore be used as an alternative to objective measurements, particularly in the context of hearing loss prevention.

Conclusion

The results reported here indicate that young adults are able to make a reasonable estimate of the noise level of events in their daily lives. While they may not be able to express this level in terms of sound pressure level or decibels, there is good correlation between the subjective estimates and the objectively measured L_{Aeq}s.

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