Preferred listening levels – a silent disco study

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Aim: To investigate preferred listening levels (PLLs) in a dance situation and compare them to typical sound levels at dance venues (90-105 dB L_{Aeq}). *Method*: Fifty-nine young people had their individually chosen sound levels measured at a silent disco event. In a separate experiment 25 participants set their PLLs for music delivered through headphones and loudspeakers respectively, and repeated measures were conducted to test intra-rater reliability. *Results:* The sound level at the silent disco event was limited to a maximum of 89-93 dB L_{Aeq}. One-third of the 59 participants expressed a preference for louder sound levels while two-thirds were satisfied with this or even softer volumes. PLLs over headphones were on average 2 dB louder than in loudspeaker mode. PLLs varied 0.8-19.1 dB within each participant for the same input, but most participants (84%) showed a personal range of less than 5 dB in 75% of their measures. *Conclusion:* Many patrons' PLLs are noticeably lower than what is typically offered at dance venues.

INTRODUCTION

The contribution of leisure noise exposure to the risk of noise-induced hearing loss (NIHL) is a growing concern in modern society (Johnson *et al.*, 2014; WHO, 2015). One source of high levels of sound exposure is discotheques, which typically offer sound levels of 90-105 dB L_{Aeq} (Tin and Lim, 2000; Sadhra *et al.*, 2002; Cassano *et al.*, 2005). In Australian nightclubs, an average of 98 dB L_{Aeq} was found, with regular attendees spending approximately 5 hours per visit (Beach, 2013).

There is no legislation in place to regulate the sound exposure of patrons on their own time, but acceptable noise limits have been defined for workplace sound environments. Since these regulations are intended to minimize the risk of NIHL, they may be used as reference limits in leisure noise situations. The limits are based on international standards which state that working more than 8 hours at a mean exposure level of 85 dB L_{Aeq} poses a risk of developing NIHL (ISO, 2013; 2014). As such, the

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90 dB L_{Aeq} seen in the lower range of dance venue exposure would be acceptable for only 2.5 hours a day, whereas 105 dB L_{Aeq} would be acceptable for less than 5 minutes. It is therefore not surprising that many patrons of high-volume venues report sound-related difficulties. Tinnitus as well as temporary hearing loss were seen in 66-88% of more than 1,000 young respondents following concert or dance venue attendance (Mercier and Hohmann 2002; Johnson *et al.*, 2014).

The general assumption seems to be that patrons prefer the music to be played at high levels. However, research has found that many young partygoers may prefer lower levels. In one study, 90% of 500 regular clubbers self-reported that they would prefer sound levels to be softer than the levels they generally experienced (Beach, 2013), while another found 42% of 700 participants to be similarly inclined (Mercier and Hohmann, 2002). Additionally, 70% of 325 participants in a third study "felt that noise levels in nightclubs should be limited to safe volumes" (Johnson *et al.*, 2014).

So far, these indications of preferred listening levels have been tested using surveys asking for people's preferences in relation to existing volumes. Less is known as to whether such responses truly represent patrons' actual preferred levels, or to what extent they may wish for sound levels to be lowered. This study aimed to investigate these questions via a party concept known as "silent disco", which gave the opportunity to test patrons' PLLs in practice. In a silent disco there is no music in the room at large, but each patron controls their own music volume emitted from a set of headphones wirelessly connected to a transmitter playing the music. As such, patrons' actual PLLs may be measured directly during or following a silent disco event.

However, it has been found that PLL may vary depending upon whether the stimulus is presented through headphones or loudspeakers, with PLLs being quoted to be 3-19 dB louder in headphone mode than in loudspeaker mode (Rudmose, 1982; Brixen, 2001). It was therefore necessary to also compare PLL for music played through the silent disco headphones against that from loudspeakers.

The study thus aimed to better understand young people's PLL in dance venues through two related experiments. The first experiment measured actual PLL under headphones in a silent disco event. The second experiment compared the PLL preferences under headphones to those in nightclub-like loudspeaker environments.

It was hypothesised that a substantial number of participants would choose softer listening levels than the 90-105 dB typically seen at dance venues, and that their PLLs would be louder for presentation through headphones than through loudspeakers.

METHOD

Both experiments had ethics approval from the Australian Hearing Human Research Ethics Committee.

Experiment 1: Silent disco event

Equipment and stimuli

Music was delivered through Samsung tablets connected to three transmitters and 59 silent disco headphones provided by a local supplier. Six popular dance songs were presented in three different sound qualities (unmanipulated, bass boosted and peak clipped) to redirect the participants' attention from sound levels. Sound levels were measured in the laboratory using a Brüel & Kjær type 2250 sound level meter connected to a Kemar mannequin. The maximum presentation level varied with headphone set and was limited to between 89 and 93 dB to comply with ethics requirements.

Participants

Fifty-nine university staff and students were recruited through convenience sampling via social media and at the university bar. Of these, 32 were male and 25 female. One participant chose the "other/unspecified" gender option in the survey, one other did not answer the question. The age span was 19-35 years with a mean age of 23.5 years. The majority (N=46) self-reported having normal hearing while 13 reported that they suspected or knew that they had 'some hearing loss'.

Procedure

Participants were given a personal set of wireless headphones that enabled them to adjust the volume of the shared music individually. To avoid bias in choosing their volume, they were initially told that the study was investigating sound quality preferences, with no mention of sound levels being made. All the participants danced together for 11.5 minutes to popular music presented through the headphones. When the music ended, they returned their headphones to the researchers with the final settings intact and filled out a written questionnaire. The survey included questions on both perceived sound quality and the satisfaction with their chosen sound levels, and the answers were linked to each participant's sound level measured in the laboratory. Duration and maximum sound levels were limited to comply with ethics requirements.

Experiment 2: Comparison study of PLL in headphones vs. loudspeakers

Equipment and stimuli

Excerpts of half a minute from five of the songs from Experiment 1 were used as stimuli. Four songs were presented in three different sound qualities (unmanipulated, bass boosted and peak clipped), giving a total of 12 individual experimental sound files. The fifth song, without sound quality manipulation, was used as a "control" to investigate intra-rater reliability.

The stimuli were presented through a Samsung tablet connected to an attenuator through a Digitor 4-Way Video Switch Box C 2505. The attenuator was connected to both a silent disco transmitter sending to the wireless headphones, and to a Marantz Integrated Stereo Amplifier PM-43 feeding two Tannoy V8 loudspeakers. A dial

attached to the attenuator enabled sound levels to be manipulated in real time as the stimulus was played, in increments of 0.1 dB.

Unattenuated sound levels were measured through a Brüel & Kjær type 2250 sound level meter connected to a Kemar mannequin.

Participants

Twenty-five participants (17 female, 8 male) aged 21-36 years (mean: 26 years) and reporting normal hearing were recruited through convenience sampling.

Procedure

In a laboratory setting, participants were instructed to individually set their PLLs for a total of 16 presentations in each mode (headphone and loudspeaker) by manipulating the attenuator. For both modes, the 12 experimental sound files were each presented once, and the control sound file presented four times.

Four different presentation orders were devised to avoid order effects. The participants' chosen attenuation levels were noted and subtracted from the unattenuated maximum sound levels measured through the Kemar mannequin.

RESULTS

Experiment 1: Silent disco event

Participants' results from the silent disco were divided into four groups based on the volume setting they chose during the event. Individual sets of headphones had slightly different maxima, leading to a variation in dB L_{Aeq} within each volume setting group, as seen in Table 1. This table also shows how many people in each volume group were satisfied with the volume or felt that it should have been louder or softer.

Volume setting	Mean (dB L_{Aeq})	Range (dB L_{Aeq})	Total (n)	Were satisfied (n)	Preferred higher (n)	Preferred lower (n)
#1 (loudest)	91.1	3.7	38	17	18	2
#2	85.4	1.2	12	10	2	-
#3	79.6	1.2	5	3	2	-
#4 (softest)	73.4	2.6	4	4	-	-

Table 1: Sound level variation within volume settings and participants' satisfaction with their final sound level.

Of the 59 participants, 38 (64%) were listening to the loudest volume setting (volume #1), the remainder to softer volumes. In the softer volume groups (n=21), 81% were satisfied with the sound levels, as were 45% of the people in volume group #1. In group #1, 47% wanted it louder, 2 wanted it softer and one did not answer this question. Overall, 22 (37%) of the 59 participants wanted the music to be louder than their chosen levels, but only 18 of these were already at maximum loudness.

For the 34 participants (58%) who reported being satisfied with their final volume, the mean PLL was 86.0 dB L_{Aeq}. Overall mean PLL was 87.6 dB L_{Aeq} and mean sound level for those who would have preferred it to be louder was 89.7 dB L_{Aeq}.

Experiment 2: Comparison study of PLL in headphones vs. loudspeakers

The mean PLL for all participants and all songs was 71.3 dB L_{Aeq} in headphone mode and 69.3 dB L_{aeq} in loudspeaker mode. A paired *t*-test yielded a significant difference of 2 dB [$t(25)=2.92$, $p=0.007$], indicating that preferred levels under headphones were significantly higher than those heard through loudspeakers.

Intra-rater reliability

Measures from the reference song (heard four times across the experiment) showed a noticeable variation in PLLs, with intrapersonal differences in the PLL of 0.8-12.4 dB in headphone mode and 1.5-19.1 dB in loudspeaker mode. This difference was termed consistency range (CR). Seventeen participants (68%) showed CRs above 5 dB in one or both presentation modes (see Fig. 1).

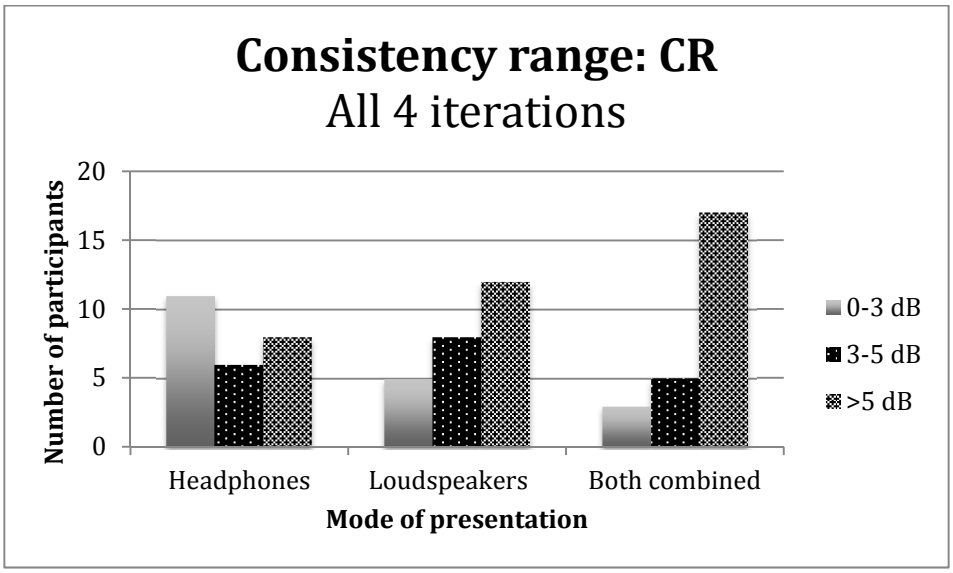

Fig. 1: The number of participants who had 0-3, 3-5 or above 5 dB L_{Aeq} difference between their loudest and softest chosen volume (CR) for the reference song, ordered by presentation mode.

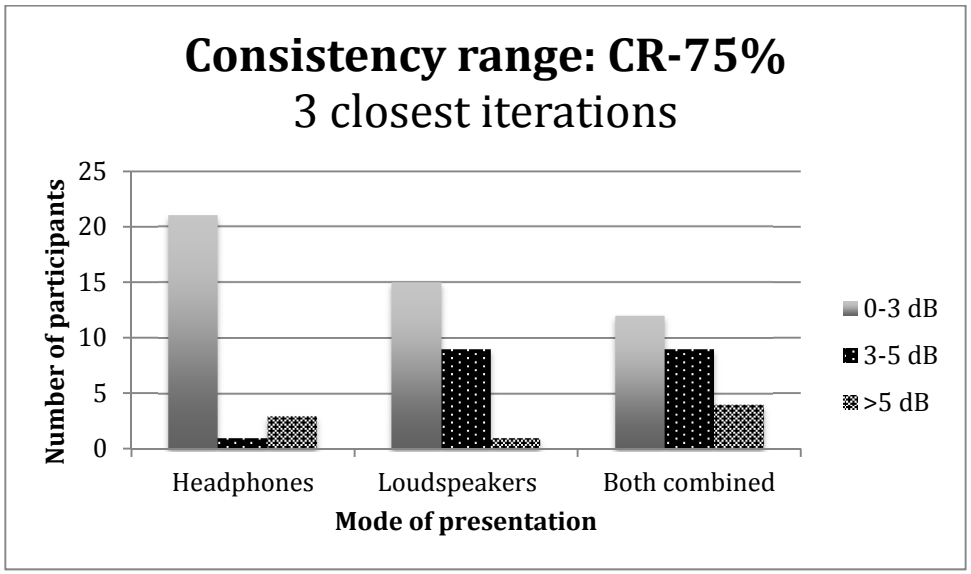

Fig. 2: The number of participants with a difference of 0-3, 3-5 or above 5 between the three PLLs for the reference song that were closest to each other, ordered by presentation mode.

Focusing on the three closest PLLs for each participant yielded CRs for 75% of the presentations, termed CR-75%. Twenty-one participants (84%) had a CR-75% below 5 dB in both presentation modes, and 12 of those (48% of all) were also below 3 dB (see Fig. 2).

DISCUSSION

PLL at dance venues

Two-thirds of the participants at the silent disco event chose the maximum volume of 89-93 dB L_{Aeq}, which is relatively low compared to the 90-105 dB L_{Aeq} usually offered at regular dance venues. The fact that half of these patrons would have preferred the music to be louder is therefore not surprising. However, the other half seemed satisfied with their sound level, as did most of those who deliberately chose even softer listening levels. This strongly indicates that two-thirds of the entire sample did in fact have lower preferred listening levels than what is typically offered at regular dance venues.

A few in the loudest volume group reported wanting softer listening levels while some in the softer volume groups said they would have preferred louder levels. It is unclear why these individuals did not simply adjust their individual volume controls to accommodate their preferences. Possible answers include that they had some difficulties using the volume controls, that they believed they were already at the loudest/softest level, that they wanted a smaller adjustment than the 6 dB offered by the equipment, or that they perhaps misread the survey when answering. Only the 18

listeners who were already at top volume and wanted it louder did not have the opportunity to self-adjust to their satisfaction.

For those satisfied with their sound levels in Experiment 1, the mean PLL under headphones was 86 dB L_{Aeq}. Experiment 2 showed that PLL for headphones were generally 2 dB higher than for loudspeakers. Taken together, the results suggest that the PLL for these participants in a standard venue may be more likely in the range of 80-90 dB L_{Aeq} than 90-105 dB L_{Aeq}.

Overall, the findings obtained from observing actual sound level choices match well with previous survey-based studies showing that 42-90% of young people prefer sound levels to be softer than what is typically offered at dance venues.

Intra-rater reliability

Participants initially appeared quite inconsistent in choosing their PLLs in Experiment 2, yielding consistency ranges of up to 19 dB with two-thirds of the participants being above 5 dB in at least one presentation mode. However, due to the number of measurements per participant and the fact that most showed a CR-75% below 5 dB, the results were deemed sufficiently valid for further analysis.

These results show that intra-rater reliability is an important factor to consider when designing studies that ask participants to set their preferred listening level, and it is highly recommended that future research includes repeated measurement for added validity and that previous research is reviewed with this in mind.

Limitations

The results presented here were obtained in a brief, volume-limited silent disco event that was specifically designed for research purposes. It may be that people's preferred listening levels would be higher if their exposure were extended to several hours as at a typical night out rather than the 11-12 minutes of this experiment. Similarly, those who consciously reported being satisfied with the maximum volume presented through the headphones might have selected a higher setting if it had been available.

CONCLUSION

The majority of young people seem to prefer sound levels noticeably softer than what is usually offered at regular dance venues. People are reasonably consistent in setting their preferred listening levels in a controlled laboratory study across repeated measures, and any single measurement should be considered in this context. Future research in this area should therefore involve repeated measures wherever possible, and caution is advised when reviewing previous research on preferred listening levels.

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