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Questions applied in audio and visual environment assessment

Jan FELCYN[1, 2]; Anna PREIS[2]; Marcin PRASZKOWSKI[2], Małgorzata WRZOSEK[3]

[2] Institute of Acoustics, Adam Mickiewicz University, Poznań, Poland

[3] Szczecin University, Szczecin, Poland

ABSTRACT

The aim of the study was to examine how the way in which a question regarding audio, visual and audio-visual stimuli is formulated could influence environment assessment. To get quantitative ratings in both modalities, a numerical scale coupled with precisely formulated questions was used for all the investigated audio, visual, and audio-visual stimuli. The participants were asked either about the comfort or the discomfort caused by the perceived stimuli. The assessments of audio and visual comfort and discomfort were carried out in a laboratory settings. In all cases an 11-point numerical scale (from 0 to 10, derived from ICBEN recommendations) was used to rank the comfort and discomfort ratings. The results show that there are no statistically significant differences between the comfort and discomfort assessment of visual samples, with one exception. Actually, the comfort and discomfort ratings are equivalent in such a way that a discomfort rating can be represented as the opposite of the comfort rating, i.e. discomfort rating is equal to 10 – the comfort rating. For the audio stimuli, whether the comfort and the discomfort scales are reversible depends on both the sound level at which the stimuli were presented and on the type of stimulus.

Keywords: Environment assessment, noise annoyance, audio-visual interaction

1. INTRODUCTION

In the modern world, people are surrounded by sounds. Some of them could be harmful and influence human health. As (1, 2) have shown, noise evokes annoyance and disturbs sleep; it can also increase the occurrence of hypertension or cardiovascular diseases.

As this relation between noise and health has been observed from many years, some law regulations were made to protect people from exposure to loud noises. One of the most important regulations is the EU directive from 2002 (3) which obliges cities with more than 100 000 inhabitants to draw noise maps of the area and provide action plans in places where noise limits are exceeded.

However, as many papers have proved (4), no more than 1/3 of the variance in noise annoyance assessments made by people could be explained by values of noise factors. That is why there is a strong tendency to not rely only on them, but also to take into account other non-acoustical factors. Nevertheless, this research needs people to listen to and rate the annoyance they experience in response to different noises.

At this point it is worth describing sounds around us not only as noises and single pass-bys, but, in as more complex manner, as soundscapes. A soundscape is strongly related to human perception and should be perceived in the context of a particular time, place and activity (5). Soundscapes and their perception is a matter of interest to many researchers (6, 7). In recent years, the notion of the soundscape has become one of the crucial factors in the planning and modernization of modern cities (8–13).

With every passing year it is becoming increasingly clear that soundscapes cannot be rated only through the hearing process. People in an environment perceive it as a whole, not only with their ears but also with other senses, particularly sight. On the basis of information from every modality humans can experience their environment most effectively (14). On the other hand, more modalities lead to more sophisticated research plans and methods which have to be carefully controlled, as some interactions can be observed between the senses (15, 16).

Some experiments were conducted to evaluate sound in relation to sight (17–19). Measurement of the relationship between audio and visual components in environment assessment usually requires

[1] janaku@amu.edu.pl

quantitative scales for both modalities. To get quantitative ratings in both modalities, a numerical scale coupled with precisely formulated questions should be used (20, 21). It is a matter of discussion exactly what questions should be applied in the case of soundscape or landscape evaluation (22, 23). The next problem is whether the scale/question which is appropriate for soundscape assessment is also suitable as a tool for landscape assessment. For example, one can assume that it is more natural to ask about the discomfort associated with a soundscape, than to ask about the discomfort associated with a landscape. In the case of a landscape case, questions about the comfort associated with a given landscape seem more natural than those about discomfort. Finally, how to compare audio and visual components in total environment assessment when two different questions/scales are used?

We assumed that soundscape and landscape could be rated on two opposite scales: discomfort for soundscape and comfort for landscape assessment. These scales could be reversible, as discomfort can be expressed by 10-comfort. To our knowledge, it is the first trial to use both scales and check their convertibility in the case of audio-visual environment assessment.

The article is organized as follows: first we define the aim of the study, next the method, participants, stimuli and procedure used in the experiments are described, then the results of the two experiments are shown and discussed. Finally, we provide our conclusions.

2. MATERIAL AND METHODS

2.1 Aim

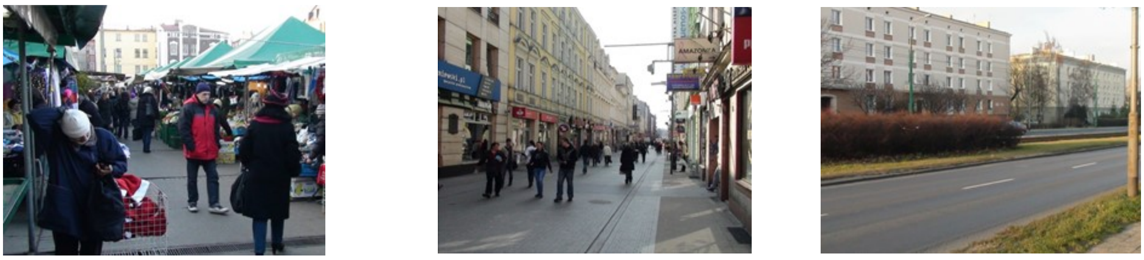
The hypothesis tested in the study is: the comfort and discomfort ratings are equivalent in such a way that a comfort rating can be represented as the opposite of the discomfort rating, i.e. discomfort rating is equal to 10-the comfort rating. This hypothesis was tested in a laboratory setting, in four different assessment conditions: (a) audio samples only, (b) visual samples only, (c) consistent audio-visual samples, and (d) non-consistent audio-visual samples. In all cases an 11-point numerical ICBEN (20, 21) scale (from 0 to 10) was used to rank the comfort and discomfort. Both comfort and discomfort assessments were collected in the same experiments. The comfort ratings have already been used in our previous publication (24). The discomfort data is the new data. This means, however, that the participants and the stimuli are the same as in the previous and the present studies. The comfort data published previously are used here only as reference data to compare the ratings as they are, and in order to test the hypothesis of this study.

2.2 Participants

Two groups of participants took part in two experiments. Seventeen university students, comprising 8 males and 9 females, aged between 22 and 30, took part in Experiment I. Fifteen participants, comprising 9 males and 5 females, aged between 22 and 26, took part in Experiment II. All had normal hearing (inclusion criterion was 15 dB maximum allowable hearing loss at hearing threshold).

2.3 Stimuli

The audio-visual samples of seven different city places (Fig. 1), each of 10-minute duration were recorded using a Sony HDR-XR200 camera and a TEDS 4101 binaural microphone, together with a Bruel & Kjaer PULSE v.12.6.0.255 system. From these recordings, audio-visual samples, each of 10s duration were created. To test the possible influence of the sound level on the environment comfort and discomfort assessments, additional soundscape samples were created with the sound level value lower (−6 dB) and higher (+6 dB) than the original recorded sound level.

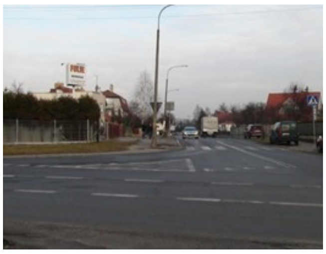


Market Boardwalk Busy Street

Park Near Busy Street

Park

Roundabout



Side Street

Figure 1. Snapshots from seven different places within Poznań area where audio and video samples were collected.

The audio-visual samples were created with the help of Adobe Premiere Pro CS5 software. In this way, 21 soundscape samples (7 points × 3 sound level) and a combination of 21 (7 points × 3 sound level) original audio-visual samples were used in Experiment I. Each soundscape and audio-visual sample was presented three times. All together 126 different stimuli (42 audio and audio-visual samples × 3 repetition) were assessed by the participants of Experiment I. In Experiment II, the comfort and discomfort caused by 7 different "landscape samples only" and 21 mixed combinations of audio-visual samples at three different sound levels, were assessed. In this case each sample was also presented three times. All together 210 stimuli (7 points plus 21 × 3 sound levels, all presented three times) were assessed by the participants of Experiment II.

2.4 Procedure

The audio and audio-visual samples were presented to the participants of Experiment I. They were asked to rate the degree of comfort and discomfort on a numerical scale from 0 to 10 while imagining they were in such an environment. The participants were sitting in front of a computer screen (PC computer with 17' LCD screen), watching and listening (Beyerdynamic DT-150 headphones) to the audio and audio-visual samples. The assessments of comfort and discomfort caused by the recorded samples were carried out in two different conditions: (a) audio samples only, (b) original audio-visual samples. Experiment II used the same setup, this time participants assessed the comfort and discomfort created by recorded samples in the other two conditions: (c) the video samples only, and (d) non-consistent combinations of audio-visual samples.

The instruction given to the participants in Experiment I was as follows: *"Soundscape and audio-visual samples coming from different places in the city of Poznań will be presented to you. Imagine that you are in this place and would like to relax. Assess your comfort/discomfort feeling using the scale from 0 to 10, where 0 means total lack of comfort/discomfort, 10 means total comfort/discomfort. Please concentrate on the positive/negative feelings connected to a given environment"*.

In Experiment II the same instruction was given to the participants, with a change at the beginning. The words *"Soundscape and audio-visual sample (...)"* were replaced by *"Landscape and audio-visual samples (...)"*. This means that in Experiment II the comfort/discomfort assessment of the investigated places was based on visual and non-consistent audio-visual samples. In both experiments each sample was presented three times to each participant.

3. THE RESULTS OF THE COMPARISON OF DISCOMFORT AND 10-COMFORT RATINGS FOR SOUNDSCAPE AND LANDSCAPE ASSESSMENTS

3.1 The results for soundscapes only (Ex. I) and landscapes only (Ex. II)

In order to test if the discomfort and comfort ratings are equivalent in such a way that a discomfort rating can be represented as the opposite of the comfort rating, the comfort data from our previous experiment were recalculated as “10-the comfort rating”. In Figs. 2a and 2b the averaged results obtained for both scales: “discomfort ratings” and “10-comfort ratings” for soundscape stimuli (without any video) and landscape stimuli (without any audio) are presented. The results were calculated in R environment using bootstrapped confidence intervals (functions from the package ‘boot’). The differences between the means were calculated using a ‘WRS2’ package and bootstrapped version of t-tests.

In Fig. 2a the annoyance ratings of soundscape stimuli for three different sound levels, marked with different colours, for -6dB, 0dB and +6dB are presented. The “*” means that there is a statistically significant difference between the two analyzed ratings. It can be seen that for all the soundscapes presented at the original sound level, there are no differences between these two ratings. This is also the case for all the investigated landscapes presented in Fig. 2b with one exception – Boardwalk.

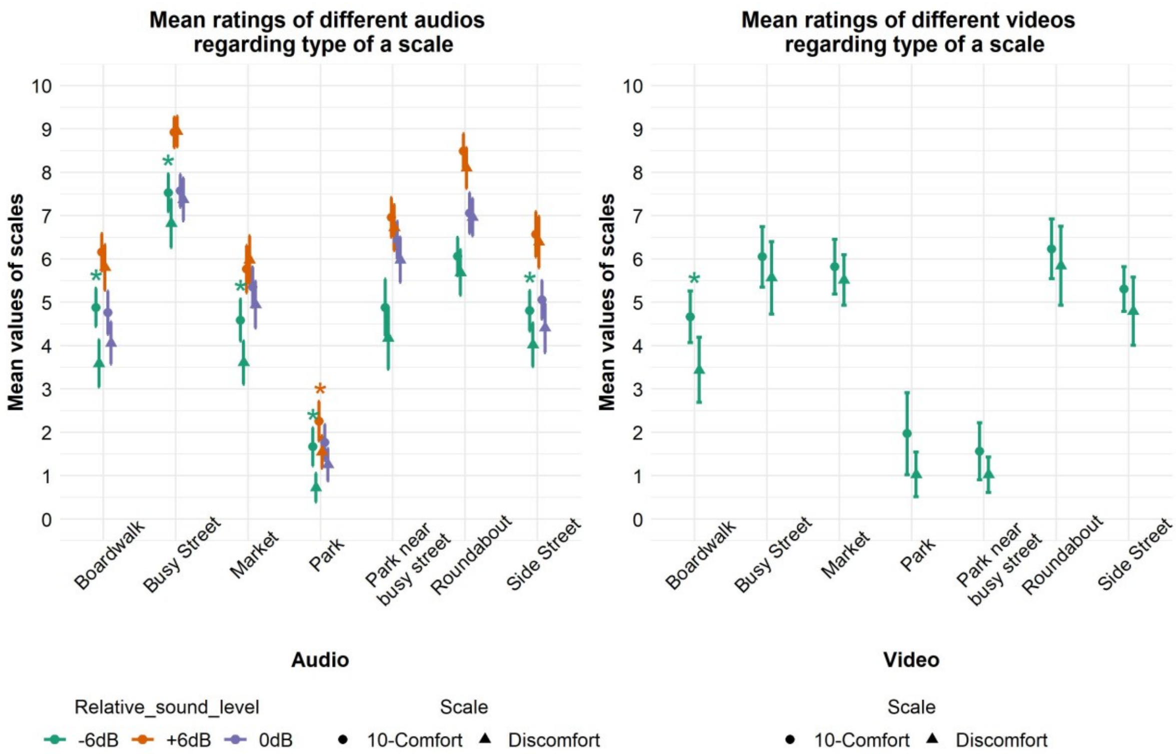


Figure 2. Averaged assessment of “discomfort scale” and “10-comfort” scale for 7 soundscapes (a) and 7 landscapes (b). Statistically significant differences between both scales are marked with ‘*’.

When the soundscape stimuli were presented at the +6dB sound level only for the “Park” stimulus there was a significant difference between the discomfort and 10-comfort ratings. In contrast, significant differences occurred for five out of seven soundscapes at the -6dB sound level.

This means that the hypothesis that discomfort and 10-comfort ratings are equivalent can be verified differently, depending on the sound level at which the stimuli were assessed: positively for the original stimuli and those presented at the +6dB sound level (with one exception) and negatively for the softer stimuli presented at the -6dB sound level. We could also try to verify this hypothesis for each stimulus independently of the sound level. As can be seen in Fig. 2, there are no significant differences between the discomfort and 10-comfort ratings for two stimuli “Park near busy street “ and “Roundabout” for all three sound levels.

3.2 The results of consistent mixes (Experiment I)

Based on the results obtained for the case of single stimulus assessment, soundscape only and landscape only, our expectation was that a similar tendency should be observed in the originally recorded audio-visual stimuli. In the original stimuli, called in the present study consistent mixes, the soundscape and the landscape information comes from the same environmental sample. Thus, the lack of differences between the type of scale for the original sound level, 0dB, and the +6dB sound level, means that a similar tendency should appear in consistent mixes. The comparison of the mean values of two annoyance scales is presented in Fig. 3.

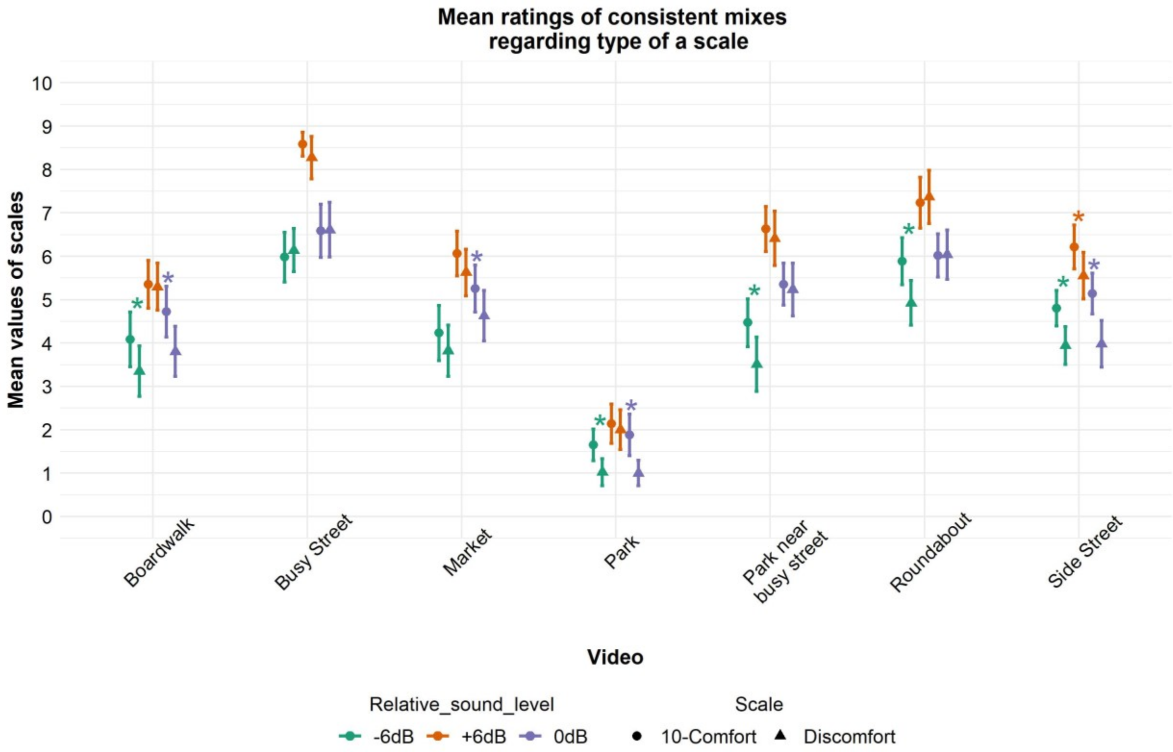


Figure 3. Mean values of discomfort and 10-comfort scales for investigated consistent mixes in 7 places in the city of Poznań. Different colours signify the sound level of the presented audio part of the mix, ‘*’ means a significant difference between annoyance assessment performed when using the discomfort and 10-comfort scales.

As can be seen in Fig. 3, it is only when original stimuli were presented at the +6dB sound level that there are no significant differences for either scale, with the “Side Street” stimulus as one exception. In contrast there are statistically significant differences between two scales for 4 out of 7 stimuli and for 5 out of 7 stimuli when stimuli were presented at 0 dB and the -6dB sound level respectively. When each consistent mix is analyzed separately, it is only with the “Busy street” stimulus that there are no significant differences between the discomfort and 10-comfort ratings. For three stimuli there is only one significant difference, at the relative level of presentation equals -6dB for “Park near busy street“ and “Roundabout” and for “Market” at the original level of 0dB.

3.3 Results of non-consistent mixes (Experiment II)

The non-consistent mix means that the audio information does not match the visual information in the investigated sample of an environment. In Table 1 all variants of non-consistent stimuli are presented regarding differences between ‘discomfort’ and ’10-comfort’ scale for each case. Similarly to the results of the consistent mixes, the largest number of differences between two annoyance scales were observed when the stimuli were presented at the -6dB sound level (19 cases). The number of different pairs decreases when the sound level of the stimuli presentation increases. For the original sound level of the stimuli presentation there were 11 different pairs, while for the +6dB sound level stimuli presentation there were only 4 such cases. The sound level at which the stimuli were presented to the participants of the experiments has an influence on the equivalence of these two annoyance scales in the following way: the louder the stimuli, more similar the discomfort and 10-comfort ratings. In contrast, the softer the stimuli, the larger the differences between those two annoyance scales.

Table 1. All non-consistent combinations of audio and visual stimuli used in the experimental procedure. All cases when a statistically significant difference between both scales (discomfort and 10-comfort) were observed are marked with ‘*’.

			Video						
			Boardwalk	Busy Street	Market	Park	Park near busy street	Roundabout	Side Street
Audio	-6 dB	Boardwalk		*			*	*	*
		Busy Street							*
		Market	*	*				*	*
		Park	*				*		*
		Park near busy street		*	*				
		Roundabout							
		Side Street	*	*	*	*	*		
	0 dB	Boardwalk		*				*	*
		Busy Street			*				
		Market							*
		Park	*	*	*			*	
		Park near busy street							
		Roundabout							*
		Side Street			*				
	+6 dB	Boardwalk							
		Busy Street							
		Market						*	
		Park		*	*				
		Park near busy street							
		Roundabout							
		Side Street			*				

4. DISCUSSION

Regarding the results from the analyses it seems that with an increase in the relative sound level, there is a drop in the number of cases when both scales (Discomfort and 10-Comfort) are significantly different.

To examine if that drop is statistically significant, we did a chi square test to find out if the number of cases changes significantly. The test confirmed our findings, with chi = 15.565 and p = .0004. It is also worth noticing that when the relative sound level was -6dB, only 25 out of 49 cases were found to be equal on both scales. While the level increased to 0 dB, the proportions changed to 34:15 and finally became 43:6 when the relative sound level was equal to +6 dB.

To sum up, these two experiments showed that generally it is possible to treat comfort and discomfort ratings as the same in the way that discomfort is equal to 10-comfort. This convertibility is observed for 6 out of 7 video stimuli presented without any audio. It is also true for audio stimuli only when they are presented with the original sound level. However, when the sound level is artificially changed (especially to a softer level), this tendency is not clear and the scale becomes less reversible.

When it comes to consistent audio-video mixes, it seems reasonable to say that while the sound level increases, the scales become more similar and more mixes are rated convertible with regard to both scales – the scales were statistically different 5 times when the sound level was -6dB, 4 times with 0dB and only once when the sound level was 6dB higher than originally.

The same tendency could be observed for non-consistent mixes, the louder the audio part is, the less ambiguous both scales are.

5. CONCLUSIONS

In this article we simply show that both scales can be convertible with the exceptions, depending on both sound level of the stimuli presentation and on the type of stimuli. The louder the audio part of a stimulous is, the more agreement between both scales is observed. Finally, it is worth to mention that in almost all observed cases ‘pure’ discomfort ratings were slightly lower than ‘10-comfort’ ratings. It can be interpreted that, theoretically, when a stimulous represents the same comfort and discomfort, comfort would be rated with lower values than discomfort.

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