Do the visual cues influence annoyance perception of sounds?

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ABSTRACT

The aim of the study was to examine if visual perception of objects located at different distances modifies auditory annoyance assessment of sounds typically produced by these objects. Original audio-visual recordings were made in the city of Poznań and in the rural environment. The stimuli were 4 real objects: 2 mobile (car, train) and 2 stationary (fountain, wind turbine) recorded at 5 distances. Participants of the psychophysical experiment were asked to rate, on a numerical standardized scale, the degree of annoyance they would feel if they were present in such places and observed such objects. The experiment was carried out in the laboratory in 3 different conditions: (a) annoyance assessment of pure audio samples, presented at 3 sound levels, (b) annoyance assessment of pure video samples with objects located at 5 distances and (c) annoyance assessment of audio-visual samples. The results of the experiment demonstrate that there is no significant difference in annoyance assessment in conditions (a) and (c). We interpret this result as a support of the thesis that auditory annoyance is not modified by visual presentation of sources of annoying sounds. We also obtained a puzzling result for visual modality. The annoyance ratings of pure visual samples were higher for moving objects than for the stationary ones. It agrees with our view that in auditory domain studies on annoyance assessment should be related to the properties of sound sources (primarily, their mobility) and not to the sounds alone.

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Aim of the study

The main purpose of this study was to determine whether the visual information about the distance of an object seen in the video changes the assessment of annoyance only based on the auditory information.

The study assessed the annoyance of four different noise sources. The noise sources studied were: passenger car, passenger train, fountain and wind turbine. The participants of this study took part in three independent experiments. In the first experiment they assessed the annoyance of these noise sources only on the basis of the soundtrack (auditory information-A). The parameter that changed during this experiment was the sound level (three values of this level were presented to the participants of the experiment: L1, L2 and L3). In the second experiment the evaluation of the annoyance was only about video (visual information-V) of a given noise source. The parameter that changed during the experiment was only the distance of the source from the observer (three values of this distance were presented to the participants of the experiment: D1, D2 and D3). Finally, in the third experiment, the participants assessed the annoyance of four noise sources based on both, auditory and visual information (information -AV). Comparison of these three annoyance assessments should answer the question: does visual information about the distance of an object seen in the video change the annoyance assessment based on auditory information only.

Method

Participants

Thirty people, 14 males and 16 females aged between 20 and 30, took part in the experiment. All had normal hearing (the inclusion criterion was 15 dB maximum allowable hearing loss at threshold). They all participated in all three experiments.

Stimuli recordings and reproduction

The audio samples were recorded into a 4-channel B-format file with a first order ambisonics microphone – SoundField ST450 MKII and a high quality recorder Head Acoustics SQuadriga II. The B-Format audio samples cannot be simply reproduced in laboratory conditions. The configuration in the anechoic chamber consists of 25 loudspeakers (Yamaha HS50m) and one subwoofer (Velodyne EQ-MAX 15). All three experiments were carried out in laboratory settings.

Stimuli- audio and visual components

To find out if a there is a dependency between annoyance assessment and the distance of an object we designed an experiment that allowed visual and auditory characteristics to be controlled independently. Because the investigated noise sources were of different sizes (from 1.5 m for a passenger car, 4.3 m for a passenger train, 9.0 m for a fountain to 210 m for a wind turbine), we decided to take this fact into account by defining the optimum distance of a given object. To find the proper method for defining the three possible distances, we made an initial assumption that, at the optimal distance, the object (noise source) should cover the whole screen of the camera lens. To define the next “step” in distance, we used the well-known Weber fraction with a K equal to 0.04. This way all 3 distances for all four sources were established. The original recordings of the noise generated by these four sources were made at three distances D1, D2 and D3 calculated in this way. Naturally the values for each noise source were different.

Original audio-visual recordings were made for four different noise sources at three different distances in the city of Poznań, and in a rural environment. They had, as expected, different sound level values. To make sure that the assessment of noise annoyance is influenced only by a change of one variable, for example the distance, the second variable, for example sound level, should have a constant value. That is why we decided to present the audio part of the investigated stimuli at three sound level values, equal for all noise sources: 45, 55, and 65 dBA. These values are in the range of

the original levels for these types of stimuli. This was the only way to test how distance affects annoyance ratings of the stimuli presented at the same sound level.

Procedure

The assessments of audio-visual annoyance were carried out in a laboratory setting, in three different experiments: (1) audio samples, presented at three sound levels, (1) video samples, presented at three distances, and (3) audio-visual samples. In all experiments the participants were asked to assess how annoying (the audio in experiment (1), the visual in experiment (2), and audio-visual in experiment (3)) the samples were. The instructions given to the participants in all experimental conditions were as follows: **in experiment (1) – audio samples** *''Imagine that you want to relax in the presented conditions. Rate how annoying* the presented ***sound*** *is for you. You will be rating on the scale from 0 to 10, where 0 means 'not annoying at all' and 10 means 'extremely annoying'".* I**n experiment (2) – video samples** *''Imagine that you want to relax in the presented conditions. Rate how annoying* the presented ***video*** *is for you. You will be rating on the scale from 0 to 10, where 0 means 'not annoying at all' and 10 means 'extremely annoying'"*. **In experiment condition (3) – audio-visual samples**

''Imagine that you want to relax in the presented conditions. Rate how annoying the presented ***audio-visual stimulus*** is *for you. You will be rating on the scale from 0 to 10, where 0 means 'not annoying at all' and 10 means 'extremely annoying'"*.

Results

- Results showed that visual information, the distance, does not have an effect on the annoyance ratings of environmental audio-visual stimuli, with one exception (the wind turbine presented at sound level of 65 dBA). This means that in an audio-visual sample, the audio information is more important than the visual information. The annoyance associated with audio-visual stimuli ratings follows the annoyance ratings obtained for audio stimuli only, and ignores the results obtained in the visual condition only. If the audio part of the stimulus has a relatively higher sound level, the visual information is neglected.
- The annoyance caused by audio-visual stimuli depends on the type of sound source. This ranking is independent of the sound level at 45 and 55 dBA, the least annoying is the fountain, and all the other sound sources are assessed in the same way. There is no statistically significant difference between the annoyance ratings for the car, train and wind turbine.
- The annoyance caused by the visual stimuli creates two subsets of data: one for moving sound sources, the car and train, and the second one for stationary sound sources, the wind turbine and fountain. There are significant differences between those two kinds of noise sources for all three distances.

Additional remarks

A comparison between the results of the audio and visual conditions

From the additional analysis we can conclude that there are similar relationships between the annoyance judgement and distance, and annoyance judgement and sound level. This means it is possible to express the decrease in annoyance ratings evoked by a 10 or 20 dB change in sound level in an equivalent change in distance, and vice versa. Such results could be useful when applied to only audio or only visual annoyance assessment of a given sound source.

A comparison between the results for the audio and audio-visual conditions

There are no statistically significant differences between the annoyance ratings of the stimuli presented in the audio and audio-visual experimental conditions for all the investigated sound sources, except the wind turbine presented at sound level L3. It is clear, that there is lower 95% CI in audio-visual stimuli than in audio stimuli. People are more precise in their annoyance judgements when both audio and visual information are presented to them, than when only audio information is available.