EXPLORING PERCEPTUAL CONTENT IN SOUNDSCAPES

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Abstract

At the quiet and noisy sides of buildings 69 residents of three residential areas found 414 soundscapes to be similar with regard to sounds discerned. The most frequently heard sound was road traffic. At the quiet sides, children playing, talking people, birds and unidentified sounds were more often heard indoors with windows closed than outdoors. Generally, sounds heard outdoors were louder than those heard indoors. Ventilation and traffic sounds were loudest at the quiet and noisy sides, respectively. The loudest soundscapes were found at the noisy side outdoors and the least loud at the quiet side with closed window. The perceived quality of the soundscapes were assessed with 12 attributes representing the four components adverse, reposing, affective, and expressionless (88% explained variance in PCA). The outdoor soundscapes showed predominantly high agreeableness for adverse attributes and low agreeableness for the reposing attributes and the reverse indoors with closed window.

In 1977, a Canadian composer and researcher named Schaeffer (1994) introduced us to the concept of soundscape. His goal was to capture our sonic environments and to give guidance on the tuning of the world. Although it may be easier to formulate an exact impression of a landscape than of a soundscape, it was his belief that it is possible to isolate acoustic environments as a field of study, just as it is possible to study the characteristics of given landscapes. In such study, Berglund et al. (1999) advocated that it is necessary to separate the perceived soundscape and the acoustical soundscape. It is thus important to develop psychoacoustics and be able to give answers to obvious environmental needs. We would like to name this new part of environmental psychology, soundscape psychophysics.

So far, the sonic environments have mainly been characterized in terms of noise pollution, giving little attention to the good environments. Therefore, the goal of this psychophysical field study is to explore the perceptual content of soundscapes. The focus is on what features make residential soundscapes in urban areas more livable.

Method

Three road-traffic noise exposed residential areas located in cities were selected for the present soundscape field studies. In all, 69 voluntary residents participated in structured listening walks. These took place in their own living environment indoors and outdoors, 22, 23 or 24 residents in the area. They all lived in apartments that faced both trafficked streets and yards (road traffic noise exposure at facade: 50-65 LAeq.24; approx. 10-15 dB less in the yard). During individual walks, each resident listened to the soundscape for periods of 30 s at 6 listening places. Their tasks were (a) to identify the source of each sound heard, (b) to scale the source specific loudness, (c) to scale the total loudness of the 30 s soundscape excerpts, and (d) to characterize the perceived quality of these soundscapes. These tasks were conducted at each of the 6 listening places, starting indoors and ending at the trafficked street.

The places were (i) indoors in room with closed window at facade towards noisy street

Table 1. Annoyance indexes, R_{AB}, for two-component intermittent sounds (time window: T_b=4s).

Duration (ms) of Ambient Component A	Duration (ms) of Distorting Component B				
	25	50	100	250	500
25	0.500	0.663*	0.800	0.906	0.950
50	0.332(0.667)	0.500	0.633((0.338)	0.825(0.175)	0.900
100	0.200(0.800)	0.325(0.675)	0.500	0.700(0.300)	0.825
250	0.088(0.912)	0.163(0.837)	0.437(0.562)	0.500	0.650
500	0.044(0.956)	0.088(0.912)	0.250(0.750)	0.313(0.687)	0.500

* Values within parenthesis are R_{BA}–ratios.

(labeled "noisy" side), (ii) the same room but with open window, (iii) indoors in another room with closed window at facade towards less noisy yard (labeled "quiet" side), and (iv) the same room but with open window, (v) outdoors in the less noisy yard, and (vi) outdoors at the sidewalk of the noisy street. All listening places indoors were located in the residents' own home whereas those outdoors were common to the residents living in the same apartment complex.

The degree of convergence of some curves may be quantified by calculating the value of the constant n in

$$R_{tot} = ([w_c R_{c+amb}]^n + [w_t R_{t+amb}]^n)^{1/n} \quad (1)$$

where R_{tot} refers to total loudness of combined car and train sounds, R_{c+amb} refers to total loudness of a singular car sound embedded in ambient sound.

The residents were instructed to use three different methods for the soundscape assessments: (a) In identifying sounds in soundscapes, a list of 17 common sound sources was provided with the option to add other sounds. (b) A procedure of master scaling was adopted (Berglund, 1991) in which source-specific loudness of discerned sounds and total loudness of the soundscape were scaled. The procedure included the method of free-number magnitude estimation, seven sound level references of pink noise (range: 54 dB) and the calibration of each resident's loudness scale. (c) In scaling attribute-agreeableness of soundscapes, a list of 12 attributes was provided. The task was to scale the soundscape with regard to each attribute on visual analogue scale with one end representing no agreeableness and the other end complete agreeableness.

Results and Discussion

Sounds Discerned and Their Source-Specific Loudness

Altogether 414 soundscapes were evaluated by 69 residents living in three residential areas. Figure 1 shows the results of the identification task for soundscapes outdoors (triangle), indoors with open window (squares) and with closed window (circles). In short, the side of the building facing the yard is called "quiet side" (left panel) and the road-traffic noise exposed side "noisy side" (right panel). The frequencies of the 17 identified sounds are given in percent of the number of soundscapes. At the noisy side, road-traffic noise and sounds from

Figure not available

Fig. 1. Identification in percent of 17 common sounds in 414 indoor and outdoor soundscapes assessed at the noisy side of buildings (right panel) and at the quiet sides (left panel).

cars are the most common both indoors and outdoors, followed by people talking, birds and ventilation. More rare are sounds from TV, dogs, motorcycle, rail/subway, construction, garden machinery and refrigerators. The soundscapes at the quiet side exhibit approximately the same pattern of identifications but a number of sounds are more frequently heard indoors with closed window than outdoors in the yard, for example, bus, children playing, talking people, birds, aircraft and unidentified sounds.

The two panels of Figure 2 display the source-specific loudness of the 17 identified sounds in the same order as in Figure 1, again with the quiet side and noisy side to the left and right, respectively. The individual loudness scales were calibrated with the aid of pink noise references whose individual psychophysical functions were transformed to a master function empirically determined in Berglund, Berglund and Lindberg (1983). Each resident's scale values of loudness for the 17 sounds discerned in the soundscapes during the walks were then transformed to the same master scale of (perceived) loudness by utilizing the same transformation factors (power group transform), (Berglund, 1991). The difference in loudness is small for most sounds at the quiet side indoors with open or closed window, whereas the loudness of most sounds indoors with open window fall in between the loudness of the same sounds outdoors and indoors with closed window. The exceptional loudness values found outdoors for the bus at the quiet side, and the rail/subway at the noisy side are associated with few identifications of these potentially loud sounds (cf. Fig. 1).

Total Loudness of Soundscapes

The total loudness of the 414 soundscapes was also assessed during the listening walks. Figure 3 shows the range of the master scaled total loudness of these soundscapes grouped for the quiet and noisy sides of buildings. The six distributions of total loudness scale values are given in the order outdoors, indoors with open window and outdoors with closed window. The six sets of soundscapes all show positively

Perceived Quality of Soundscapes

The residents' attribute profiles of agreeableness were calculated for the 414 soundscapes, that is, separately for each resident and each listening place of the walk. The 12 attributes are listed in Figure 4. The similarities among these attributes' representations of these soundscapes were assessed as Pearson's coefficients of correlation and the resulting matrix was subjected to a principal component analysis. A varimax rotated orthogonal solution represents the data well (88% explained variance). Four components were extracted and labeled adverse, reposing, affective, and expressionless. Each attribute named in the following within parenthesis is given together with its component loading. Six of the attributes refer to adverse or detrimental soundscapes (disturbing, 0.91; stressful, 0.90; noisy, 0.88; loud, 0.85; intrusive, 0.84; and hard, 0.72). Two attributes refer to reposing soundscapes (soothing, 0.93; and pleasant, 0.92), that is, the composition of sounds create a harmony restful to the ear and mind. Another two attributes refer to affective soundscapes (exciting, 0.88; and eventful, 0.70) that are associated with or induce feelings or emotions. The remaining two attributes represent expressionless soundscapes (light, 0.79 and dull, 0.76).

The qualitative profiles of the 414 soundscapes were obtained on a visual analogue scale. The scaling behavior on the analogue scale was "calibrated" by setting the degree of agreeableness for loudness on this scale equal to the master scaled total loudness value for the same soundscape given by the same resident. The same multiplicative transform was then used for the visual analogue scale values given for the other attributes. These individually calibrated agreeableness scales were then averaged over the residents separately for the different listening places. Figure 4 shows these attribute profiles for outdoors and indoors with closed or open window for the quiet sides (left panel) and noisy sides (right panel). At the quiet side, the outdoor soundscapes showed predominantly high agreeableness for adverse attributes and low agreeableness for the reposing attributes. The reverse was found for the indoor soundscapes

The indoor soundscapes with open window are inbetween in agreeableness. The same pattern is shown for the noisy side although the agreeableness is higher for the adverse attributes and lower for the reposing attributes. Interestingly, the attribute dull came out as highly agreeable for the indoor soundscapes with closed window at the noisy side, and as equally agreeable as the reposing attributes at the quiet side.

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