

inter.noise 2000

*The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE*

I-INCE Classification: 6.1

THE MEANING OF SOUND QUALITY TO CREATE A COMFORTABLE SOUND ENVIRONMENT

S.-W. Kim*, G.-S. Jang**, K.-Y. Jung***, M.-H. Han****

* Acoustic Lab., Department of Architecture, College of Engineering Chonnam National University, 300 Yongbong-dong, Puk-ku, 500-757, Kwangju, Republic Of Korea

** Department of Architectural Engineering Dongshin University, 252 Daeho-dong, 520-714, Naju, Chonnam, Republic Of Korea

*** Department of Architectural equipment Engineering Sooncheon First College, 9-1 Dukwol-dong, 540-260, Sooncheon, Chonnam, Republic Of Korea

**** Department of Architectural Engineering Seonam University, 720 Kwangchi-dong, 590-711, Namwon, Chonbuk, Republic Of Korea

Tel.: +82 62 530-1635 / Fax: +82 62 530-0780 / Email: swk@chonnam.ac.kr

Keywords:

SOUND QUALITY, PSYCHOLOGICAL EXPERIMENT, FACTOR ANALYSIS, SOUND ENVIRONMENT

ABSTRACT

It is very important to understand the psychological attributes and meaning of sound in order to create a comfortable sound environment for indoor and outdoor spaces. According to the sound meaning, it can be decided whether to control, add, change, or preserve the sound in these spaces. Therefore, this study was designed to inquire minutely into the adjectives for expressing korean impressions or sensations, and to investigate the psychological attributes of sound and the relation between sounds and their attributes. For this purpose, first of all, the classification among adjectives and sounds were analyzed by using the method of selected description in order to classify the sensation of pleasantness and unpleasantness. Then, the evaluation factors of pleasing sounds and unpleasing sounds were analyzed respectively by using the method of rating scales against sound stimuli. On the basis of the results, it was found that there are three important factors for expressing the image of pleasing sounds, these being activity, stability and powerfulness, and there are four primary factors for evaluating the quality of unpleasing sound, these being unpleasantness, intensity, irregularity, and sharpness. Also, the relationship between these factors and sound stimuli was ascertained using MDPREF technique of multi-dimensional scaling. These results will provide important clues to analyze the physical evaluation method of sound and to create a comfortable sound environment.

1 - INTRODUCTION

It is essential to understand psychological attributes and meaning of sound in order to create a pleasant sound environment for a place. According to what meaning is sifted out from information contained in a sound one can decide on whether one should control, add, change or preserve a sound in a space. The ultimate goal in relation with amenity of sound environment is to plan and design a space with pleasant sound focused on its residents by creating a new sound environment for a building or a particular area of a city.

Amenity means 'a state where the human body and mind feel very comfortable and pleasant,' and the amenity of sound environment can be achieved by controlling the unpleasant noise as far as possible and taking advantage of the pleasant sound. Therefore, one should have a definite idea as to the meaning of both pleasantness and unpleasantness in order to get a clearer definition of sound quality. That is, one should understand what kinds of factors are operated when an unpleasing sound such as noise or

a pleasing sound affects the human psychology. In this context, this research aims at finding images of pleasing and unpleasing sounds out of all the sounds in our environment as well as major factors needed in making a judgment of sound quality, and making a proper interpretation of their meaning.

2 - METHOD OF RESEARCH

As the method of this research, two-stage psychological analysis was carried out to get the evaluation factors for sound quality out of the sounds in our environment and make interpretation of their meaning. The preliminary experiment was focused on getting a general condition concerning what kind of image people have about a sound and what meaning is given to the sound. A cluster analysis was made by using the method of selected description in order to classify a target sound into a pleasing or an unpleasing sound. For the main part performed to specify the selected sound and its meaning as well as to get images of a pleasing sound and the factors of judgment and meanings of an unpleasing sound, a factor analysis was carried out by performing a listening test through the method of rating scale.

3 - CONTENTS OF PRELIMINARY EXPERIMENT

It is very important to have an adjective word that easily and correctly defines a psychological attribute of a sound, because a linguistic expression for a sound is a very important tool in directly obtaining feelings and emotions of a people. Therefore, 628 adjective terms, as possible candidates to be used for describing sounds, were selected through major Korean dictionaries. After two preliminary examinations where inappropriate words were eliminated, 92 words were finally selected out. Selection of sounds was also performed twice, having ultimately 54 sounds, both natural and artificial. As for the method of psychological analysis, the method of selected description was taken, and words that best represent the images of a sound were recorded by 346 college students (261 men and 85 women) in 5 regions across the country. Then the cluster analysis was performed. The result showed that the sounds of environment and the adjective terms describing them were classified respectively as positive/pleasing and negative/unpleasing. Especially, as they contain sounds and words where neutral images come forth, it is concluded that they can generate a pleasing or an unpleasing emotion according to a particular situation they are used.

4 - CONTENTS OF MAIN EXPERIMENT

4.1 - Sound sources and adjective terms

Based on the cluster analysis in the preliminary experiments, a listening experiment was performed to make out images of a sound and the evaluation factors of sound quality people have as well as their meanings. So as a means to materialize the meaning of a sound, the sound sources and adjective terms were classified into pleasing and unpleasing ones. Also, all the sound sources and adjective terms containing neutral images were included. The sound sources and adjective terms used in this experiment are specified in Table 1 and Table 2. As for the adjective terms, their number according to their similarity and frequency were reduced.

Examples of Sound	Sound Pressure Level (Dba)		Adjectives
	L-ch.	R-ch.	
1. Sound of <i>Kayagum</i>	58.7	56.1	1. Feeble
2. Croaking of a frog	74.9	65.2	2. light
3. Sound of a church bell	75.2	67.8	3. sweet
4. Sound of <i>Pansori</i>	74.6	70.7	4. lively
5. Chirping of a cricket	80.7	77.0	5. serene/calm/tranquil
6. Engine sound of a locomotive	73.7	62.7	6. pleasant-tasting
7. Chirping of a magpie	75.1	62.7	7. plaintive/sorrowful
8. Sound of stepping on fallen leaves	58.8	54.2	8. monotonous
9. Sound of <i>Nong-ak</i>	70.3	59.2	9. dynamic
10. Sound of <i>Tadumi-dol</i>	67.7	56.6	10. dull/dead
11. Noise of a cockerel	79.2	67.4	11. clear and voiceless
12. Galloping sound of a horse	74.3	66.7	12. cheerful
13. Droning of a cicada	77.7	72.3	13. articulate/distinct
14. Sound of a wooden gong	62.1	60.2	14. powerful
15. Boat whistling	66.5	54.2	15. soft
16. Sound of a fire cracker	59.1	59.1	16. refreshing
17. Sound of raining	72.3	64.0	17. vivid/animated
18. Cuckoos note	72.9	70.3	18. distinct
19. Moo of a cow	72.8	64.7	19. satisfying
20. Sound of a stream	75.1	70.4	20. cozy
21. Jingle bell song	74.5	64.1	21. solemn
22. Hoot of an owl	62.3	56.7	22. rotund
23. Sound of a hand bell	75.5	69.1	23. elegant
24. Sound of a temple bell	64.6	61.3	24. sonorous
25. Cheering-up of an audience in a stadium	74.3	68.9	25. grand/magnificent
26. Sound of stream flowing and birds singing	74.8	66.5	26. merry/pleasant
27. Chirping of sparrows	73.4	68.5	27. rhythmic
28. Classical music	65.1	60.7	28. affectionate
29. Sound of sea waves breaking	69.8	66.0	29. quiet/silent
30. Pop music sound	75.4	68.9	30. exciting
31. Waterfall sound	77.8	70.5	31. loud/blaring
32. Chirping of grasshoppers	74.3	70.1	32. extremely delightful
33. Singing of a songbird	77.9	65.4	33. peaceful
34. Toot of a train	70.0	63.7	34. vigorous/full of life
			35. joyful/delightful
			36. energetic/powerful

Table 1: List of sound stimuli and adjectives for pleasing sound.

Examples of Sound	Sound Pressure Level (Dba)		Adjectives
	L-ch.	R-ch.	
1. Sound of a dog barking	72.1	66.5	1. fierce/ intense
2. Noise of a construction site	78.7	69.8	2. strident
3. Mew of a cat	72.9	61.9	3. dissonant/discordant
4. Noise of a machine hammer working	70.9	65.4	4. violent
5. Flush of a toilet	73.6	62.7	5. straining/tensing
6. Noise of a steam engine	73.2	67.2	6. frightening/shocking
7. Sound of a blizzard	64.4	59.8	7. penetrating
8. Sound of lightening	75.3	71.2	8. detestable/dislikable
9. Siren of a police car	80.2	70.5	9. tumultuous/uproarious
10. Noise of a baby crying	62.1	61.3	10. irregular
11. Sound of an elevator in operation	70.9	66.1	11. unpleasant/offensive
12. Noise of a motorbike engine	73.7	70.8	12. speedy
13. Noise of a car passing	70.8	66.2	13. dispersive
14. Explosion of a jet engine idle	70.0	65.2	14. bothersome
15. Sound of a car	70.0	65.2	15. clamorous/uproarious
16. Sound of thunder	67.8	63.7	16. horrible
17. Sound of a PC printer working	72.4	72.9	17. noisy
18. Sound of a horn	78.2	69.9	18. irritating
19. Noise of an helicopter engine	66.5	61.2	19. (being) in disorder
20. Noise of a train starting	69.9	63.9	20. boisterous
			21. vexing/annoying
			22. loud/blaring
			23. confusing

Table 2: List of sound stimuli and adjectives for displeasing sound.

4.2 - Experiment procedure

Recording and editing of sound sources were carried out to reproduce the original sounds by using sounds in CDs currently available on the market. Recording was done to DAT and re-edited at random, and its reproduction was made by using headphones. As for the psychological measurement, the method of rating scale was used to evaluate a sound degree along with the 7-stage monopole scale. Testees were all 52 college students (37 men and 15 women) who have normal hearing.

5 - RESULT OF THE EXPERIMENT

5.1 - Factor analysis of pleasing sound

The result of a varimax rotation carried out after the principle component analysis of the adjectives for the pleasing sounds is shown in Table 3. The result of analysis produced 5 factors.

FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
ACTIVITY	STABILITY	POWERFULNESS		
Cheerful	Serene/calm	Rotund	Pleasant-tasting	Monotonous
Merry/pleasant	/tranquil	Grand/magnificent		Feeble
Articulate/distinct	Cozy	Energetic/powerful		
Lively	Soft	Loud/blaring		
Vivid/animated	Peaceful	Powerful		
Exciting	Quiet/silent	Extremely delightful		
Refreshing	Sweet	Sonorous		
Joyful/delightful	Elegant	Dull/dead		
Vigorous/full of life	Solemn			
Satisfying	Affectionate			
Rhythmic	Plaintive			
Distinct	/sorrowful			
Clear and voiceless				
Light				
Dynamic				

Table 3: Factor analysis of pleasing sound.

The first factor has variables each of which gives a pleasant feeling to those who hear it, creating active atmosphere. Therefore, it becomes the factor of activity since it is important for the image of a sound to create an active atmosphere. The second factor has variables that give calmness to those who hear them with images creating stable atmosphere. So, it becomes the factor of stability. The third factor is one of powerfulness since its variables have images of powerfulness creating an active atmosphere. The fourth and fifth factors are classified into other factors as they have fewer variables which are less significant. Therefore, the first three factors are the ones more important than others in defining the quality of a sound. With a pleasing sound one is able to create an emotional atmosphere such as 'activity', 'stability' and 'powerfulness' in addition to the existing visual atmosphere of a space.

5.2 - Factor analysis of unpleasing sound

The result of the varimax rotation carried out after the factor analysis of the adjectives that represent unpleasing sounds is shown in Table 4. Four major factors were produced from the process.

FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
UNPLEASANTNESS	INTENSITY	IRREGULARITY	SHARPNESS
Detestable/dislikable	Fierce/intense	Dispersive	Straining/tensing
Vexing/annoying	Violent	(Being) in disorder	Frightening/shocking
Bothersome	Dissonant/discordant	Irregular	Horrible
Strident	Loud/blaring	Confusing	Penetrating
Unpleasant/offensive	Boisterous	Clamorous	
Irritating	Tumultuous	/uproarious	
Noisy	/uproarious		
	Speedy		

Table 4: Factor analysis of unpleasing sound.

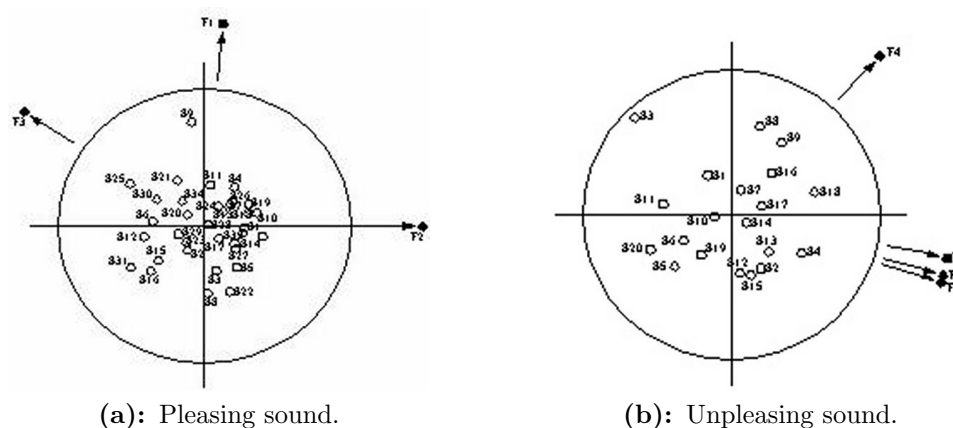
The first factor has variables that produce very unpleasant and irritating atmosphere when heard. As they represent unpleasant state of human psychology they can be grouped under the factor of unpleasantness. The second factor is made up of variables related with the physical loudness or intensity of a sound, and thus the factor of intensity. The third factor is one of irregularity since it is made up of variables containing images of temporal changes or/and irregular state of a sound source. The fourth factor, that of sharpness, is made up of variables connected with an element of pure tone in a sound or changes of its pitch. In sum, the quality of an unpleasing sound is decided by one or more of these factors that effect state of mind, and thus one is able to evaluate the quality of a noise by correctly extracting the element of a sound.

5.3 - Interrelationship between a sound and the factor of its quality

The quality of a sound is multi-dimensional in its psychological expression. That is, as a sound is

affected by each psychological factor in a complex way, it is necessary to interpret it not just by a single factor by all the evaluation factors of sound quality. Here the interrelationship between a sound and the factors that affect its quality through major pleasing and unpleasing sounds was discussed. For this, the interrelationship between the major factors gathered through the factor analysis and each sound was sought after, and an interpretation of it was made. A preference analysis (MDPREF) was carried out by using the multi-dimensional scaling in order to know the relationship between the 3 major factors of a pleasing sound and 34 kinds of sound as well as 4 major factors of an unpleasing sound and 20 kinds of sound. The result is shown Figure 1. As for a pleasing sound, the major factors of an adjective are placed in a dimension different from each other, and relevant sounds are arranged.

As for an unpleasing sound, its factors of unpleasantness, intensity, irregularity have common characters while the factor of sharpness has a different relationship from them. As shown here, superiority or inferiority of a psychological factor is defined by the character of a sound source, and one can greatly improve a sound's quality by reducing the major factors affecting it. The quality control of a noise should also involve comprehensive control of the 4 factors, making a change for the better quality.



(a): Pleasing sound. (b): Unpleasing sound.
Figure 1: Two-dimensional solution from an MDPREF (S: Sound, F: Factor).

6 - SUMMARY

The purpose of this study is to get a closer approach towards the spacial composition of sounds as well as controlling noises by objectifying the subjective evaluation of a human being, and seeking after the images or evaluation factors that can be found through the quality of a sound. The quality of a sound can generally be classified into pleasantness and unpleasantness. And, a pleasing has as its psychological character 3 images of activity, stability and powerfulness while an unpleasing sound has 4 factors such as unpleasantness, intensity, irregularity and sharpness, providing important factors needed for evaluation of a sound's quality. Therefore, in order to create a more pleasant sound environment it is necessary for one to control the unpleasing sounds as far as possible while taking advantage of the pleasing sounds more actively. A newer and more creative space can be generated from such a process.

REFERENCES

1. **S.Namba, S.Kuwano, T.Hashimoto, B.Berglund, Z.D.Rui, A.Schick, H.Hoege and M.Florentine**, Verbal Expression of Emotional Impression of Sound: A Cross-Cultural Study, *J. Acoust. Soc. Jpn (E)*, Vol. 12, 1, pp. 19-29, 1991
2. **S.Namba**, Individual and Cultural Differences of the Preference of Sounds, *J. Acoust. Soc. Jpn (J)*, Vol. 46, 9, pp. 776-780, 1990
3. **S.Namba, S.Kuwano, A.Schick**, A Cross-Cultural Study on Noise Problems, *J. Acoust. Soc. Jpn (E)*, Vol. 7, 5, pp. 279-289, 1986
4. **M.H.Han, K.Y.Jeong, J.S.Kim, C.Kook, S.W.Kim**, An Analysis on the Structure of Meaning for Amenities of Sound Environment-A Classification of Sounds and its Meaning, *Journal of the Architectural Institute of Korea*, Vol. 14, 4, pp. 235-246