

The Human Perception based on Memory Recall of the Multi-sensory Stimuli in Outdoor Urban Space

Ni Putu Amanda NITIDARA¹; Anugrah Sabdono SUDARSONO¹; Ranti Dwi TASSIA¹; Joko SARWONO¹; FX Nugroho SOELAMI¹

¹ Institut Teknologi Bandung, Indonesia

ABSTRACT

The human perception of environment condition is one of the aspects that greatly affect the use of open public space in a built environment. Studies related to the perception generally observe only one physical aspect in an isolated manner, in which the interrelationships between physical aspects are not considered. In the meantime, human beings are naturally multi-sensory and the human perception is exposed by multi-sensory stimuli that influence each other. This study tries to look at that relationship of multi-sensory stimuli to human perception, especially in the outdoor urban environment. In this study, we implement a semi-structured question to understand people's perception based on their memory of four outdoor urban areas in Bandung. The questionnaire explores the relationship between three physical aspects, aural, thermal, and visual. Three main perceptions were found, comfort, spatial, and age/era. There is also evidence showing that multi-sensory stimuli affect the same perception, e.g. thermal and visual affect comfort perception. The finding of this study shows preliminary evidence of multi-sensory perception in an urban area. This knowledge will be a powerful tool for understanding the perception of the urban environment and help in the process of urban area design and enhancement.

Keywords: Perception, Multi-sensory, Audial, Visual, Thermal

1. INTRODUCTION

Public open space has several benefits, it is a place for people to perform activities such as physical activity, relaxation, and also social interaction (1,2). The human perception of environment condition is one aspect that greatly influences the use of public open space (3). There have been many studies that observe the perception of comfort from the physical aspects of the environment. These research generally only observe one physical aspect and isolate it from other physical aspects (unimodal), where the interrelationships between physical aspects are not considered (4–7). Meanwhile, humans are multisensory beings and in the environment, human perception is exposed to multisensory stimuli and it is very possible that the stimuli are influencing each other (8).

This study tries to look at that relationship of multi-sensory stimuli to human perception, especially in the outdoor urban environment. This study answers the question “how is the relationship between the three physical parameters, aural, thermal, and visual, to define the human perception in a public open space?” Aural, thermal, and visual physical parameters are the main stimuli commonly found in outdoor environments, besides that these three physical parameters also have measurable objective parameters so that the relation between objective and subjective measured can be made. There has been some research showing the preliminary relationship between these sensory, for example visual – aural, visual – thermal, and aural – thermal (9–14). However, no research has been found that observes these three stimuli simultaneously for outdoor environmental conditions. This knowledge will be a powerful tool for understanding the perception of the urban environment and help in the process of urban area design and enhancement.

The method of identifying human perception usually using in situ measurement, questionnaire, and laboratory experiment (15–17). Recently an internet-based survey starts to be explored. This research, trying to explore the method of the survey using internet based and human expectation or previous collective memory about a space to judge the human perception in open public space (18,19).

2. EXPERIMENT METHOD

The experiment was conducted using an online questionnaire. This online questionnaire was distributed as a preliminary questionnaire to the participant of the soundwalk experiment the next day. Twenty-eight participants (10 males and 18 females) with age range from 20-40 years old joined the experiment voluntarily. The participants are student and lecturer of architecture, urban planning, and engineering physics. The outdoor urban spaces that were evaluated in this experiment are Alun-Alun, corridor Jalan Braga, and Taman Balai Kota. These spaces were chosen due to its popularity as well as it's iconic aspects of the city.

The questionnaire was divided into three sections: demographic, open-ended questions, and semantic scale. The open-ended questions trying to explore participant's perception using their own words, and then represented in a format of word cloud to give keywords related to the questions (19). This paper, however, will be focusing on the semantic scale part of the questionnaire and trying to extract important descriptor that could explain the multisensory perception in urban space.

A total of 29 semantics were used in this experiment. These semantics were chosen from the results of Focus Group Discussion between the research team. These semantics contain perception of the acoustic, visual, and thermal environment as well as the general ambiance of the environment. To judge the environment an 8 point Likert scale was used from -4 to 4 (middle score was removed to avoid neutral tendency). Table 1 list the semantics that was used in this experiment, Figure 1 shows the online questionnaire pages.

Table 1 - List of the semantic scale used in the experiment. Notation G = General aspect, T = Thermal aspect, A = Audial aspect, and V = Visual aspect

Semantic Scale	
Comfortable – Uncomfortable (G)	Suitable – Not Suitable (G)
Like – Dislike (G)	Interesting – Not Interesting (G)
Private – Public (G)	Aged – Young (G)
Cheerful – Depressed (G)	Dangerous – Safe (G)
Active – Passive (G)	Dirty – Clean (G)
Simple – Complex (G)	Easy – Difficult (G)
Hurt – Unhurt (G)	Hurry – Relax (G)
Soft – Rough (G)	Luxurious – Free (G)
Warm – Cold (T)	Breezy – Sunny (T)
Quiet – Noisy (A)	Boring – Vibrant (A)
Big – Small (V)	Near – Far (V)
Bright – Dull (V)	Dated – New (V)
Empty – Full (V)	Horizontalism – Verticalism (V)
Narrow – Spacious (V)	Dark – Bright (V)
Ornamented – Plain (V)	

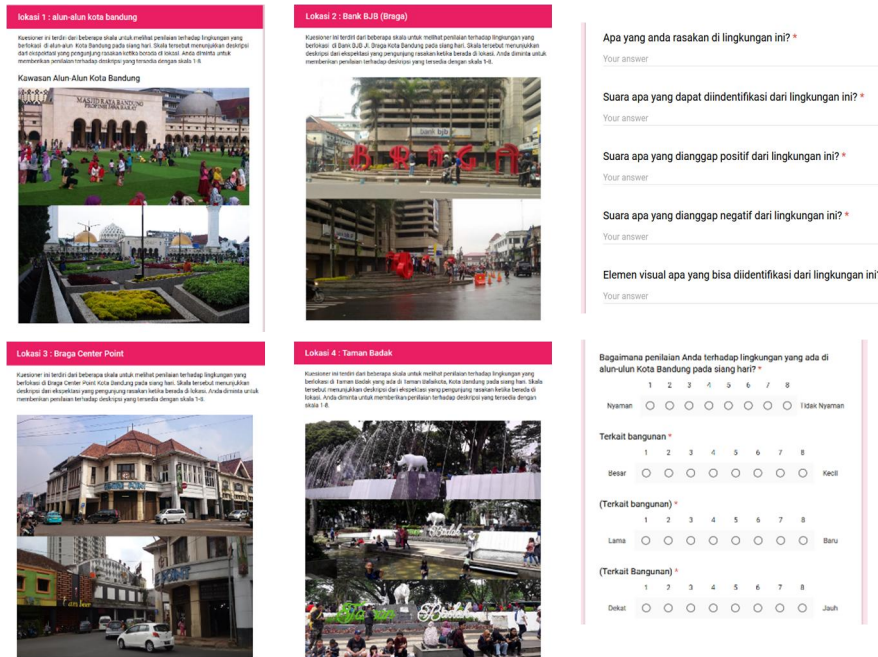


Figure 1 – Example of the online questionnaire where it shows four locations of observations, the evaluation using Likert scale and simple description

3. RESULTS AND DISCUSSION

3.1 Main Descriptors of Perception in Outdoor Urban Public Space

From the 29 variables that were used in the semantic analysis part of the questionnaire, factor analysis was performed to get the main component (descriptor) of human perception in urban spaces. The data (total of 112 data from 4 location and 28 respondents) shows a good fit to the KMO and Bartlett test. Eight main components were found that contributes to a total of 67.7% variance in the data. Table 2 shows the component matrix with the detail of variables and the percentage of variance in each component. The eight descriptors that were found in this research is related to the perception of Comfortability, Dynamicity, Age/Era, Safety, Spatiality, Accessibility, Size, and Texture (respectively from C1-C8).

A further test using Cronbach's Alpha test was performed to check the reliability of variables within the component. Since C7 only consists of one variable, the reliability test cannot be performed, for the rest of components, only five (C1, C2, C3, C4, C5) components show an $\alpha \geq 0.5$. From those six, only three components with $\alpha \geq 0.7$ which mean showing a good and acceptable correlation (C1, C3, C5) meanwhile the other three are showing a poor and questionable correlation (C2, C4). The three descriptors that are found reliable are Comfortability, Age/Era, and Spatiality. A similar study focusing on sound stimuli has found three main descriptors in an urban area which are Relaxation, Dynamic, and Communication where the comfortable aspect is included in the descriptor Relaxation (20,21).

The descriptor Comfortability (C1) contributes to 22.9% of variance and consists of the scale of Like-Dislike, Interesting-Not Interesting, Bright-Dull, Comfortable-Uncomfortable, Suitable-Not Suitable, Breezy-Sunny, and Active-Passive. This descriptor shows human preference of their environment condition. The next descriptor, Age/Era (C3), is related to the perception of age and newness of an area as shown from the scale Dated-New and Aged-Young. This descriptor contributes to 8.5% of the variance in the data. The last descriptor, Spatiality (C5), related to the scale Luxurious-Free, Narrow-Spacious, Ornamented-Plain, and Near-Far and contributes to 5% of the variance. This descriptor shows a good representation of the location, where the Alun-Alun and Taman Balaikota are spacious and full of free facilities for the visitors, meanwhile the perception of narrow and luxurious potentially coming from the Braga Street Corridor where it is full of cafe and shops.

Table 2 - The results of Principal Component Analysis with Promax rotation (KMO = 0.737 and Bartlett's test = 0.00)

Component	C1	C2	C3	C4	C5	C6	C7	C8
% of variance	22.9	12.5	8.5	6.7	5.0	4.5	3.9	3.5
Variables								
Like – Dislike (G)	0.750	-0.013	-0.060	-0.159	-0.055	0.108	0.029	0.072
Interesting – Not Interesting (G)	0.691	-0.195	-0.017	-0.108	0.133	0.108	0.057	0.202
Bright – Dull (V)	0.678	-0.182	0.426	-0.122	0.002	-0.054	0.002	0.013
Comfortable – Uncomfortable (G)	0.637	0.423	0.004	0.017	0.018	-0.051	-0.394	0.086
Suitable – Not Suitable (G)	0.610	0.144	-0.158	0.016	-0.087	0.045	-0.137	0.377
Breezy – Sunny (T)	0.599	-0.005	-0.389	-0.039	-0.222	-0.172	0.084	-0.007
Active – Passive (G)	0.416	-0.323	-0.040	-0.050	0.026	0.385	0.033	-0.004
Empty – Full (V)	-0.181	0.834	-0.036	0.028	-0.221	0.039	0.104	-0.133
Quiet – Noisy (A)	0.247	0.725	-0.129	-0.007	-0.011	-0.302	0.176	0.234
Boring – Vibrant (A)	-0.196	0.720	0.029	0.039	-0.012	0.389	-0.166	0.021
Cheerful – Depressed (G)	0.284	-0.459	-0.254	-0.359	-0.086	-0.037	-0.007	-0.065
Private – Public (G)	0.023	0.381	0.381	-0.240	0.134	-0.276	-0.001	-0.370
Dated – New (V)	-0.010	-0.159	0.970	-0.112	-0.136	0.146	0.005	-0.015
Aged – Young (G)	0.143	0.159	0.857	0.201	0.059	0.200	0.147	0.068
Dirty – Clean (G)	-0.331	-0.042	0.030	0.728	-0.032	0.075	-0.069	0.195
Dangerous – Safe (G)	-0.351	0.237	-0.199	0.709	0.092	-0.110	0.109	0.021
Hurry – Relax (G)	0.116	-0.095	0.165	0.612	-0.001	-0.435	0.120	0.009
Simple – Complex (G)	-0.271	0.426	0.003	-0.483	-0.059	0.176	0.233	0.047
Luxurious – Free (G)	-0.191	-0.129	-0.065	-0.137	0.791	-0.009	-0.126	0.129
Narrow – Spacious (V)	0.089	-0.084	-0.428	0.276	0.752	0.062	0.086	-0.172
Ornamented – Plain (V)	0.052	-0.051	0.238	0.022	0.651	-0.174	-0.081	-0.011
Near – Far (V)	0.064	-0.120	0.451	0.015	0.586	0.085	0.254	-0.024
Easy – Difficult (G)	0.047	0.131	0.269	-0.257	0.005	0.952	-0.034	0.216
Warm – Cold (T)	0.290	-0.143	0.179	0.248	-0.141	0.356	0.089	-0.059
Big – Small (V)	0.150	0.248	0.113	-0.029	0.105	0.080	0.890	0.062
Hurt – Unhurt (G)	-0.246	-0.142	0.061	0.074	-0.249	-0.204	0.681	0.234
Horizontalism – Verticalism (V)	0.326	0.021	0.063	0.171	-0.088	0.233	0.139	0.858
Soft – Rough (G)	0.032	0.096	-0.267	-0.401	0.257	0.054	0.176	0.522
Dark – Light (V)	-0.181	-0.153	0.258	0.138	0.143	-0.207	-0.203	0.506
Cornbach's Alpha Score	0.805	0.668	0.746	0.684	0.710	-	0.439	0.351

3.2 Multisensory Perception of Comfort in Outdoor Urban Public Space

A multisensory relationship was found in the descriptor Comfortability and Dynamicity. In the perception of comfort, a relationship between visual and thermal perception was found. The semantic

Bright-Dull that represent visual perception and semantic Breezy-Sunny that represent thermal perception. The other descriptor where a multisensory relationship was found is the Dynamicity. This perception consists of visual aspects with scale Empty-Full and acoustic aspects with scales Quiet-Noisy and Boring-Vibrant.

Using the correlation matrix between components (only reliable component were included) a model of comfortability in urban public space were made as illustrated in Figure 2. Additional descriptor Dynamicity was included in the model as it consists of the multisensory relationship as well, even though the reliability of the component itself is still questionable ($\alpha = 0.668$). An inverse relationship was found between component Comfortability and the rest of the components (Dynamicity, Age/Era, and Spatiality). Trying to interpret the results, first is to compare the Comfortability with the Dynamicity descriptors, the model suggests that a comfortable public space is expected with a condition that is full, a lot of visitors and vibrant in sound. In terms of Age/Era, a young and new space was preferred. On the other hand, a more spacious area with free access for the public is preferred.

From this model, it can be interpreted that comfortable urban public space is preferred/expected to have a visual condition that is bright, and thermal condition that is breezy. However, the acoustic aspect is not directly affecting the Comfortability descriptor. It means that a noisy acoustic condition in the urban environment does not necessarily make the space perceived as uncomfortable. On the other hand, a vibrant and live acoustic environment was indirectly affecting the Comfortability descriptor through the Dynamicity descriptor where for urban public space a vibrant acoustic environment is preferred. This result shows an agreement with Bruce and Davies research about the expectation of sound and how it affects the soundscape perception (18). In this case, since the visitor of urban public space have an expectation of a crowd visiting the space, a vibrant sound is expected and thus make urban space still deemed comfortable for them even though the noise level might be high.

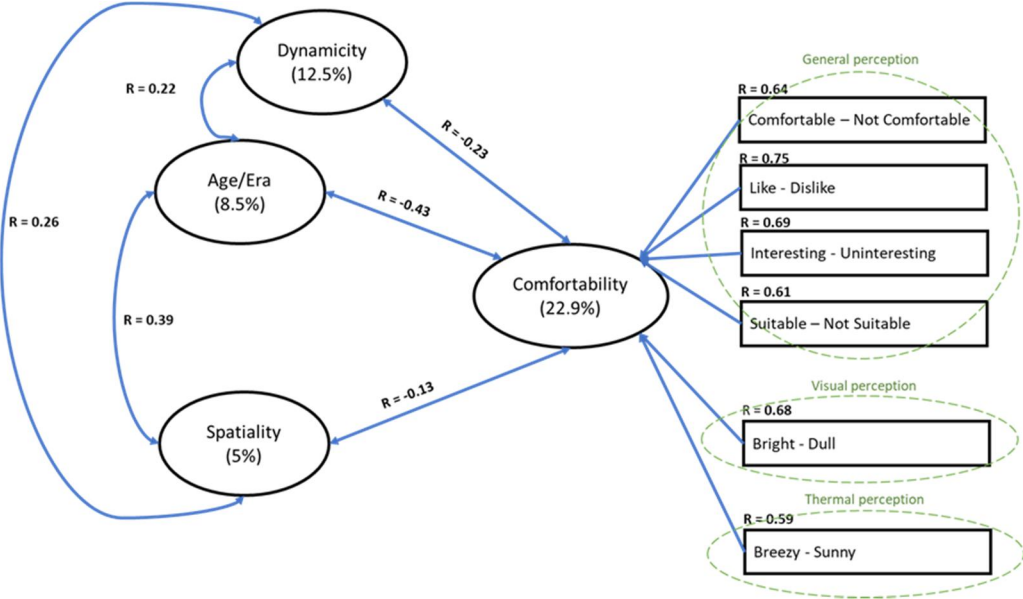


Figure 2 - Model of multi-sensory comfortability in outdoor urban public space

4. CONCLUSIONS

This research using an internet-based questionnaire to find the main perception that is expected in the urban outdoor public space and find the multisensory relationship in that perception. Three main components with an acceptable and good reliability Cronbach's Alpha score were found namely Comfortability, Age, and Spatial. Visual and thermal perception were both found affecting the perception of comfort. The acoustic condition, even though it is not directly affecting the comfort perception, it is highly affecting the perception of dynamicity in the urban area together with visual perception. This result shows a preliminary relationship between multisensory perception in the urban public space area. Further research on these findings will be performed with a comparison to the objective measurement of the physical aspects in order to fully understand the multisensory behavior in outdoor urban public space.

ACKNOWLEDGEMENTS

This research is funded by Institut Teknologi Bandung Research Scheme.

REFERENCES

1. Krenichyn K. "The only place to go and be in the city": women talk about exercise, being outdoors, and the meanings of a large urban park. *Heal Place*. 2006;12(4):631–43.
2. Payne SRS. Urban Park Soundscapes and Their Perceived Restorativeness. In: Proceedings of the Institute of Acoustics & Belgium Acoustical Society [Internet]. Ghent; 2010. p. 264–71. Available from: http://wrap.warwick.ac.uk/47717/1/WRAP_Payne_urban_park_soundscapes.pdf
3. Goličnik B, Thompson CW. Emerging relationships between design and use of urban park spaces. *Landsc Urban Plan*. 2010;94(1):38–53.
4. McCormack GR, Rock M, Toohey AM, Hignell D. Characteristics of urban parks associated with park use and physical activity: A review of qualitative research. *Heal Place* [Internet]. 2010;16(4):712–26. Available from: <http://dx.doi.org/10.1016/j.healthplace.2010.03.003>
5. Nikolopoulou M, Lykoudis S, Kikira M. Thermal comfort in outdoor spaces: field studies in Greece. *Proc fifth Int Conf urban Clim Lodz*. 2003;1–5.
6. Stathopoulos T, Wu H, Zacharias J. Outdoor human comfort in an urban climate. *Build Environ*. 2004;39(3):297–305.
7. Yang W, Kang J. Acoustic comfort evaluation in urban open public spaces. *Appl Acoust*. 2005;66(2):211–29.
8. Shams L, Kim R. Crossmodal influences on visual perception. Vol. 7, *Physics of Life Reviews*. 2010. p. 269–84.
9. Pheasant RJ, Fisher MN, Watts GR, Whitaker DJ, Horoshenkov K V. The importance of auditory-visual interaction in the construction of ' tranquil space .' *J Environ Psychol*. 2010;30:501–9.
10. Van Renterghem T, Botteldooren D. View on outdoor vegetation reduces noise annoyance for dwellers near busy roads. *Landsc Urban Plan* [Internet]. 2016;148:203–15. Available from: <http://dx.doi.org/10.1016/j.landurbplan.2015.12.018>
11. Bjerre L, Santurette S, Jeong C. thermal comfort and soundscape internoise.pdf. 2013;3613–20.
12. Engel MS, Paas B, Schneider C, Pfaffenbach C, Fels J. Investigation of the relationship between acoustic perception and thermal comfort of an urban park in Aachen Investigation of the relationship between acoustic perception and thermal comfort of an urban park in Aachen. 2018;(March):2–6.
13. Lin TP, Tsai KT, Hwang RL, Matzarakis A. Quantification of the effect of thermal indices and sky view factor on park attendance. *Landsc Urban Plan* [Internet]. 2012;107(2):137–46. Available from: <http://dx.doi.org/10.1016/j.landurbplan.2012.05.011>
14. Chau CK. Investigating the Effects of Greenery on Temperature and Thermal Comfort in Urban Parks. 2016.
15. Jeon JY, Hong JY, Lee PJ. Soundwalk approach to identify urban soundscapes individually. *J Acoust Soc Am*. 2013;134:803–12.
16. Nguyen TA, Semidor C. Relationship between urban activities and soundscape : commercial areas in Bordeaux and Hanoi. In: *The 23rd Conference on Passive and Low Energy Architecture*. Geneva; 2006. p. 6–8.
17. Liu F, Kang J. Relationship between street scale and subjective assessment of audio-visual environment comfort based on 3D virtual reality and dual-channel acoustic tests. *Build Environ* [Internet]. 2018;129(November 2017):35–45. Available from: <https://doi.org/10.1016/j.buildenv.2017.11.040>
18. Bruce NS, Davies WJ. The effects of expectation on the perception of soundscapes. *Appl Acoust* [Internet]. 2014;85:1–11. Available from: <http://dx.doi.org/10.1016/j.apacoust.2014.03.016>
19. Sudarsono AS, Nitidara NPA, Sarwono J, Martokusumo W, Poerbo HW, Djimantoro M, et al. The implementation of text mining in the study of the perception of the urban area. In: *The 4th International Conference on Indonesian Architecture and Planning*. 2018.
20. Kang, Zhang. Semantic differential analysis on the soundscape of urban open public spaces. *J Acoust Soc Am* [Internet]. 2002;112(5):2435. Available from: <http://scitation.aip.org/content/asa/journal/jasa/112/5/10.1121/1.4779999>
21. Sudarsono AS, Lam YW, Davies WJ. Soundscape Perception Analysis Using Soundscape Simulator. In: *Internoise 2016*. Hamburg; 2016. p. 6868–75.