Seoul inter-noise 2020 23 - 26 AUGUST

Effect of visual environment on auditory perception in the public spaces of shopping malls

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ABSTRACT

A laboratory experiment was conducted, in which varies scene composed of typical audio and visual elements in the public spaces of shopping malls. The participants were asked to answer questionnaires about the audio-visual scenes with which they were presented. It was found that the visual environment had little influence on people's evaluation of the auditory environment but had a significant influence on their perception of auditory elements in different types of spaces. When the visual element is consistent with the specific auditory element that conveys the same information, the percentage of correct recognition of the auditory elements decreases. Overall, the results suggest that people perceive the environment as a whole, instead of disassembling the perception into several elements.

1. INTRODUCTION

Humans receive both visual and auditory stimuli at the same time, so there is interaction and promotion, which is not simply superimposed [1, 2], but related to context semantics and environmental location. On the one hand, when the audio-visual stimulation carries the same context, namely in the audio-visual consistent case, the brain is more likely to perceive the audio-visual scene as a whole and form a result that is more than the sum of single visual and auditory stimuli, which can usually improve cognition [3-6] and promotes faster and more accurate behaviour and recognition of task target objectives [7, 8]. On the other hand, the audio-visual stimulation depends on the specific environment. For example, green plants in the environment can significantly reduce the negative evaluation of noise [9]. Through the appropriate adjustment of the visual landscape in subway station, the psychological discomfort caused by hearing the friction of the railway tracks when waiting on the platform can be greatly reduced [10]. In addition, adjustments to the visibility of sound sources can alter people's evaluation. Taking urban park as an example, the evaluation of visible noise sources is

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higher than that of invisible noise sources, which is also due to the principle of audio-visual consistency [11].

The above theories are widely used in various indoor and outdoor environments. Of course, it also applies to the interior public spaces of shopping malls. Kotler first proposed the concept of store atmosphere of shopping environment in 1973 [12], believing that store atmosphere affects consumers' feelings and behaviours in three ways of attention, information communication and emotion. The main means of creating atmosphere is to design the visual and auditory environment. In previous studies, it has been proved that visual elements, such as interior decoration elements, display style, lighting, advertising form and colour, have an impact on consumers' evaluation and behaviour [13]. For example, a cool colour environment is more likely to create a relaxed and pleasant shopping atmosphere, thus obtaining more satisfaction and praise from customers. On the contrary, a warm colour environment tends to create an exciting and energetic shopping atmosphere, thus encouraging customers to explore and participate in activities [14-18].

However, previous studies on shopping malls mainly focused on the impact of a single factor on environmental evaluation and perception, ignoring the attention to audio-visual interaction. Based on this, this paper aims to examine the impact of visual environment on auditory evaluation and auditory elements perception in the public spaces of shopping malls.

2. METHOD

With the aim of exploring the impact of visual environment on auditory perception, this study conducted a laboratory experiment with the combination of 13 audio-visual scenes to control the space types, visual elements, and colour saturation in the public spaces of the shopping malls.

2.1. Field Survey

At the beginning of this study, a field survey was conducted on six shopping malls to obtain the perceived characteristics of the audio-visual environment in the real public spaces of shopping malls. A total of 144 questionnaires were collected. While participants answering the questionnaires, the visual environment was recorded with a digital camera, and the auditory environment was recorded with a 10-channel signal collector. According to the results, the most representative visual elements and their percentage of pixels in the overall image are large advertisements (2-4%), shop fronts (16-22%), information signs (0-4%) and people (2-4%). The auditory elements includes voices, footsteps, broadcast music, and background noise. Under the guidance of the survey results, the laboratory carried out the basic setting of experimental materials, aiming to present the most representative scene that is closest to the real shopping environment. In addition, the survey results demonstrate that the public spaces of shopping malls can be divided into three spatial scales: narrow space, medium-sized space and large open space. This study focused on the medium-sized space and large open space with richer activities and more design of visual elements.

2.2. Audio-visual Scenes and Questionnaire

In the experiment, two scenes were set as the control groups, and the average colour saturation of the picture was between 10–20% [18], only containing visual elements of shop fronts, large advertising, and people. On the basis of the control groups, visual elements were added as variables, including green plants, festival decorations and the average colour saturation of the whole picture. Average saturation is divided into three levels: 0-10%, 10-20% and 20-30%. In the end, the control group, the green plant group, the festival decoration group and the colour saturation group were formed. Among them, the first three groups were taken from the large open spaces and medium-sized space, while the colour saturation group was taken from the large open space.

The default settings for auditory elements of the experimental scenes included footsteps, voice and background noise. On this basis, the set sound variables included background music and the music tempo. According to the field survey, piano music accounts for the majority of the background music played in shopping malls. Therefore, piano music with markedly different tempo were selected, including fast tempo (156 and 160 bpm), and slow tempo (90 and 96 bpm).

The questionnaire (Table 1) was used to investigate the participants' evaluation and perception of the auditory environment, including audio comfort, satisfaction, and perception of the audio elements.

Table 1: The list of questions in the questionnaire

Items	Questions
Auditory Evaluation	1. Do you feel comfortable with the sound you are hearing? Very uncomfortable 1 2 3 4 5 6 7 Very comfortable
	2. Are you satisfied with the sound you are hearing? Very unsatisfied 1 2 3 4 5 6 7 Very satisfied
Perception of Auditory Elements	3. What sounds have you heard? □ Talking voices □ Footsteps □ Music □ Sound of vending □ Sound of machines □ Sound of children playing □ Sound of broadcasting

After processing the scores of the questions about the auditory element perception, they were marked in comparison to the situation of each scene. When an element did not exist in a scene and was not mentioned as an answer, and when an element existed and was mentioned, it was marked as "correct perception" (CP). The number of correct perceptions out of the total number of possible correct perceptions in a scene was defined as the correct perception proportion (CPP).

2.3. Participants

Based on previous studies, it can be found that young people are more sensitive to auditory stimuli [19, 20]. Therefore, the participants selected for this experiment were adults aged 18-45. A total of 34 adults, 11 males and 23 females, participated in the experiment. As for the age of the participants, 21 were between 18 and 30 years old, and the remaining 13 were between 30 and 45 years old. The participants, students and staff from a university, took part in the experiment via the recruitment notice issued by a social communication application. All participants self-reported normal or corrected normal hearing and vision, and were informed and agreed to participate in the experiment.

2.4. Laboratory and Experimental Procedure

The experiment was conducted in the environmental behaviour laboratory of a university in Harbin, China. The laboratory is located on the underground floor, thus there is less external interference. Images were displayed on a desktop computer and a 22-inch 16:9 LCD. Sennheiser RS170 wireless headphones were used to reproduce the indoor sound environment.

Upon arrival, participants were allowed five minutes to familiarize themselves with the laboratory environment and the operation instructions. During the experiment, each scene was played for 20-30 seconds [19, 21]. Participants answered the questionnaire based on the corresponding scene. In order to minimize additional errors, 13 scenes were randomly arranged to form 7 random scene sequences. The whole experiment time was controlled within 20 minutes.

2.5. Statistical Analysis

The results were classified and processed. According to the different elements in the visual environment, all scenes can be divided into three groups: human + shop front (HS), human + shop

front + green plant (HSG), and human + shop front + festive decoration (HSF). According to the average colour saturation, all scenes can be divided into three groups: low saturation (S_0), medium saturation (S_1) and high saturation (S_2).

SPSS software was used to analyse the differences of each group. The statistical analysis of experimental data is based on different variables. Independent sample T- test was used to test the significance of the mean differences between the two categories of variables. Analysis of variance (ANOVA) was used to test the significance of the mean differences between three or more categories of variables. To perform multiple comparative analyses of the effects of different visual elements and different colour saturation on the auditory perception, p-values was Bonferroni corrected.

3. RESULTS AND DISCUSSION

3.1. Auditory Evaluation

According to the experimental data, there was no significant difference in the auditory evaluation between groups with different visual elements and groups with different colour saturation in the large open space, indicating that visual environment has no significant influence on auditory evaluation in the large open space. In the medium-sized space, there are significant differences in the auditory satisfaction between the HS group as the basic control group and the HSG group, as well as in auditory comfort between the HS group and the HSF group. It is indicated that adding green plants or festive decorations to the visual environment will reduce the auditory evaluation to a certain extent in the medium-sized space. Due to the limited scale of the medium-sized space compared with the large open space, the addition of more visual elements will weaken the perceptual attention of the subjects to various audio-visual elements. In other words, the richer the visual elements are, the lower the comfort and satisfaction of auditory sense will be.

3.2. Auditory Elements Perception

First of all, based on the overall data, one-way ANOVA was used to analyse the auditory perception under different visual elements. According to the results, there were significant differences in the perception of footsteps, music and the sound of vending with different visual elements.

Through further multiple comparative analyses, it can be found that in the large open space, there are significant differences between HSF group and the other two groups in footstep sound perception, between HSG group and HSF group in music perception, as well as between three groups in vending sound perception (Figure 1). CPP of footsteps in HSF group is significantly lower than that in HS group and HSG group, while CPP of music in HSG group is significantly lower than that in HS group and HSF group. CPP of the vending sound is significantly low in HS group compared with that in the other two groups. In the medium-sized space, CPP of footsteps in HSG group and HSF group is significantly higher than that in HS group. CPP of background music in HSF group is significantly higher than that in the other two groups.

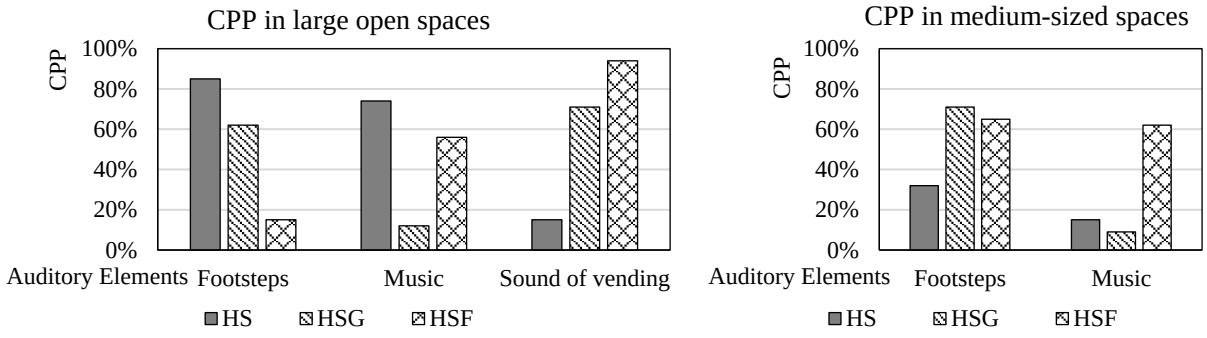

Figure 1: CPP of auditory elements in scenes with different visual elements

Secondly, a one-way ANOVA was conducted on the CPP of sound elements with different colour saturation. The results showed that CPP of background music and the sound of children playing with different saturation were significantly different (Figure 2). According to multiple comparative analysis, significant differences can be found in CPP of background music perception between high-saturation scene S_2, low-saturation S_0, and medium-saturation scene S_1. As for the perception of sound of children playing, the higher the saturation is, the lower the CPP is. Previous studies [18, 22] suggested that the higher the overall saturation of the scene is, the lower the overall evaluation is. Therefore, it can be concluded that the existence of background music can improve the evaluation of shopping environment and people's perception of music, so as to make up for the negative impact caused by high saturation.

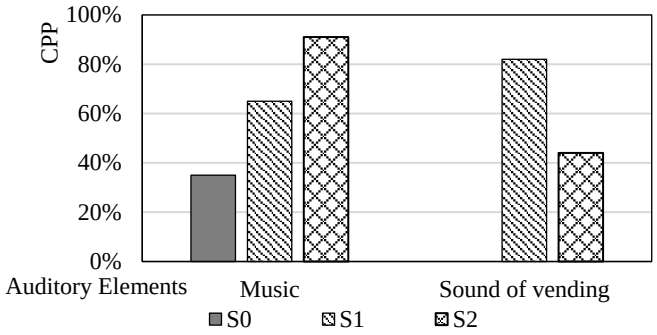

Figure 2: CPP of each audio element in scenes with different colour saturation

By analysing the characteristics of the auditory and visual elements, it can be found that specific visual elements and auditory elements have higher scene rationality and audio−visual consistency in combination with a significantly lower CPP. For example, as mentioned above, sound of footstep is a sound element in all scenes. In scenes with festive decorations, the festive atmosphere implied by footsteps and decorations form a potential audio−visual consistency with a large number of people. People evaluated this auditory element with audio-visual consistency as a whole, and regarded footsteps as a component of the whole environment without paying special attention and distinction, so the CPP of footsteps decreased [23]. Similarly, in the perception of background music in HSG scenes, green plants create a soothing and relaxing environment [19], which is consistent with the perception provided by background music. Therefore, audio−visual consistency is formed, which significantly reduces the CPP of background music. High-saturation environment is usually suitable for children's activities, in which audio−visual consistency will reduce the CPP of children's playing sound [23].

4. CONCLUSIONS

To sum up, in the large open spaces of shopping malls, visual elements and colour saturation have no significant influence on the evaluation of auditory environment. In contrast, the complexity of the visual environment in the medium-sized spaces will reduce the comfort and satisfaction of the auditory environment. The change of visual environment in different types of space has a great influence on the perception of auditory elements. There is a law of "consistent-weakening" phenomenon in the perception of audio-visual environment. When audio-visual elements form a consistent scene, people's perception of the corresponding auditory element weakens, and the correct perception proportion also reduces significantly.

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