# Comparison between Architects and Non-architects on Perceptions of Architectural Acoustic Environments

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**Received** 10 June 2021, **Received in revised** form 3 July 2021, **Accepted** 14 July 2021

## Abstract:

The perception of the architectural acoustic environment of both architects and non-architects is important. Through interviews with architects and non-architects, theoretical frameworks on acoustic environment perception for the two groups are created in the present study. The entire perception process is summarised into four steps for both groups: attitude towards the acoustic environment of the building, perception of the acoustic environment design, factors influencing the interpretation, and the outcome of the acoustic environment. Some obvious differences between the two groups were observed. Architects tend to focus on controlling the physical parameters of sound; they recognize that the active design of the acoustic environment is difficult and problematic. Non-architects pay more attention to interpreting and experiencing acoustic environments. They tend to create a good acoustic environment using ideal sound and have a positive attitude towards shaping the acoustic environment. Furthermore, compared to non-architects, architects do not pay enough attention to the various influencing factors that affect users' interpretations of acoustic environments, and the multiple, long-term, and profound effects (e.g. behavioural, emotional, recovery, and health) of the architectural acoustic environment on users are usually ignored. Correlation analysis of these differences and phenomena reveals that the existing issues of the acoustic environment design initially focuses on two aspects: architects' understanding of the active architectural acoustic environment design is not

sufficient to overcome its inherent limitations, and architects' understanding of public preferences and demands is insufficient. According to the interviews, the future development direction may lie in the combination of acoustic environment design and architecture, support for architects, effective communication and feedback mechanisms, and the transition of architects' design thinking.

## Keywords

Architectural acoustic environment; Architects; Non-architects; Perception; Comparison

## 1. Introduction

The acoustic environment is an essential component of the architectural environment, and the satisfaction of the acoustic environment has been confirmed to have veto power in the entire evaluation of indoor environments [1]. Mourshed and Zhao found that the acoustic environment was the third most crucial design factor in medical space ahead of light, spaciousness, colour, and landscape [2]. In addition, a great deal of research has shown that the acoustic environment has a significant effect on users' emotions [3,4], behaviour [5,6], perception [5-7], recovery [8-10], and health [11,12].

In architecture, with the change from the basic three-dimensional space to a comprehensive perception of architectural space, architects began to pay attention to the architectural acoustic environment. Holl analysed the perceptible phenomena of buildings and proposed the concept of "Phenomenal Zones", in which sound is contained in eleven phenomena such as enmeshed experience, colour, detail, site circumstance and idea [13]. Zumthor put forward a similar concept of "phenomena" which described the integrity of the architecture, including colour, texture, light, temperature, activities, and sounds of humans and birds [14]. Zumthor believed that integrity is not a simple collection of all objects, and is the infinite interaction of all elements [14]. In addition, a number of studies

have explored the perceptive factors of acoustic environments in various architectural functions and demonstrated the relationship between the acoustic environment, architecture, and contextual experience. [15-18]. Although there has been some progress in relevant studies, it is still difficult for architects to systematically consider the acoustic environment design in practical projects. There are a series of acoustical problems in many buildings, such as speech privacy, noise interference, and acoustic environment design, without meeting the requirements of architectural space layout [19-21]. The current state of the acoustic environment in many existing buildings runs counter to the original design intention of the architects [22]. These problems have resulted in a low rating of the overall level of satisfaction with current architectural acoustic environments. Based on the post-occupancy evaluations (POE) of more than 90,000 respondents from approximately 900 buildings, the acoustic environment was selected as one of the factors resulting in the most dissatisfaction [23].

As the designer of the architectural environment, an architect's perception of the acoustic environment determines the direction and content of architectural acoustic design. Only by understanding the perception of architects in the architectural acoustic environment can we conduct optimisation research on how to improve it with clear objectives. In addition to the study on the perception of architects, it is also necessary to learn about the perception of non-architects in the acoustic environment because they are the users of the buildings. Building users understand their needs better than anyone else, and their opinions of architectural design have great reference value [24].

In this respect, many previous studies found that architects and non-architects differed significantly in their perceptions of the aesthetics, architectural style, historical meanings, and economic efficiency of buildings [25-28]. Devlin and Nasar confirmed that both architects and non-architects favour novelty and coherence, but non-architects prefer

simplicity and “popular” attributes, while architects prefer complexity and “high” attributes [29]. Gifford et al. confirmed that architects and non-architects have different interpretations of physical features, which leads to different cognitive properties [30]. In addition, it was determined that architects were not able to predict the public’s aesthetic evaluations of architecture [31]. Architects were unable to exchange the standards of their concepts and attributes with those of laymen, which led to incorrect predictions [32]. Architectural education and training were considered to be the reasons for the divergence between the perceptions of architects and non-architects [33-35], because it changed architects’ understanding of symbols and results in the forming a specialised language [33，36].

Beauty and suitability should be experienced not only by architects, but also by the public [30]. By following “elite guidance”, architectural design is probably not recognized by the public [37]. However, compared with the popularity of Kansei engineering in industrial design [38], in architecture, the thinking of users’ needs is always in an “ambiguous” state. According to Lawson, architectural space has become a product of architects’ personal awareness and aesthetic trends and has been captured by various doctrines. Architects have focused only on continuous innovation, while the architectural design industry has been under increasing adverse pressure and is recognized less by the public [39].

Therefore, in the present study, by exploring the perceptions of architects and non-architects of the architectural acoustic environment, the theoretical frameworks of architects and non-architects’ perceptions of acoustic environments are developed. Further comparative analyses are used to compare the differences between the two groups in the perception of the acoustic environment. Based on the two groups’ perceptions of the architectural acoustic environment, issues in the design of acoustic environments are

initially analysed, and the potential solutions and development directions of acoustic environment design issues reflected in the interviews are also discussed. This research aims to increase architects' attention, modulate the design purpose and method of acoustic environments, and promote the systematisation and conventionalisation of feedback and communication of the acoustic environment.

## 2. Method

The focus group is a method used to conduct comprehensive research on a specific question with groups of people. The members of the specific group are purposefully selected. Through mutual stimulation among participants, researchers can obtain a detailed understanding of interviewees' attitudes and responses to specific phenomena. In addition, the reasons behind an attitude or response can be explored [40]. The present study focuses on assessing the perceptions of architects and non-architects regarding the architectural acoustic environment and the reasons why they have such perceptions; therefore, the focus group is a suitable research method for this study.

### 2.1 Participants

The interviewees were divided into an architect group and a non-architect group. The architect group was composed of architecture professionals, and the non-architect group consisted of people with no background in architecture or acoustics. The interviewees in the architect group had different educational backgrounds and professional experiences in order to gain a comprehensive understanding of the architectural acoustic environment. The members of the non-architect group were of different ages, with different educational backgrounds and occupations (Table 1). Each group consisted of five interviewees and one presenter (The author). Finally, when theoretical saturation was reached, a total of 40 people were interviewed, including four groups of architects (labelled as AP01–AP20) and four groups of non-architects (labelled as NP01–NP20). Interviews were conducted during

the period of the COVID-19 pandemic between January 2020 and May 2020, so it was conducted online to avoid close contact. The average interview duration for each group was approximately 90 minutes. Moreover, ethical approval to carry out this study has been granted by the school of architecture, Tianjin University.

Table 1: Characteristics of the participants in the four architect groups and the four non-architect groups

| **Architect groups** | | **Non-architect groups** | |
|---|---|---|---|
| **Age** | **Number** | **Age** | **Number** |
| 20-30 | 9 | 20-30 | 7 |
| 30-40 | 7 | 30-40 | 5 |
| 40-50 | 3 | 40-50 | 4 |
| 50-60 | 1 | 50-60 | 4 |
| **Gender** | **Number** | **Gender** | **Number** |
| Male | 13 | Male | 12 |
| Female | 7 | Female | 8 |
| **Profession experience** | **Number** | **Occupation** | **Number** |
| Design institute | 8 | Enterprises | 7 |
| Architecture office | 7 | Students | 6 |
| Developers | 3 | Commerce /Services | 4 |
| Government sector | 2 | Agriculture | 2 |
| | | Government sector | 1 |
| **Education background** | **Number** | **Education background** | **Number** |
| Elementary & Middle | 1 | Elementary & Middle | 5 |
| University | 9 | University | 9 |
| Post graduate | 10 | Post graduate | 6 |
| **Work content** | **Number** | | |
| Project design | 8 | | |
| Construction drawing | 5 | | |
| Design management | 3 | | |
| Resident architect | 1 | | |
| Project approval | 1 | | |
| Policy research | 1 | | |
| Engineering-Procurement -Construction (EPC) | 1 | | |

### 2.2 Content of the interview

Each interview began with five basic questions about the architectural acoustic environment. During the interview, in order to ensure the openness and integrity of the data, based on further analyses of participants' descriptions and thinking, the conversations were gradually extended to follow-up questions. After the interview, all data obtained during each interview and observation were recorded in memorandums. The original and common extended questions were as follows.

**(1) Do you usually pay attention to the architectural acoustic environment? If so, how do you think of the architectural acoustic environment?**

Please describe an acoustic environment that you have noticed.

-- Why do you think it was good or bad?

-- Do you have different feelings about the acoustic environment at different times or physical and mental states?

**(2) What do you think the effect of the acoustic environment is on you?**

-- Except for an emotional response, do you ever have a physical response, like feeling flustered or fatigued, because of the acoustic environment?

-- Can these feelings affect your behaviour or other aspects?

-- Have you tried to solve the problems caused by acoustic environments using design methods?

**(3) For the architect group: Have you considered the active creation (Active use of sound in architectural design，rather than only focusing on improving negative aspects) of the acoustic environment in your design? Please give your reasons.**

-- What is the effect of the acoustic environment design on the building space and the environment?

-- Have you tried to overcome the design difficulties in creating a favourable acoustic environment?

**For the non-architect group: Do you think that an architect should consider the acoustic environment in architectural design? Why?**

-- Are you willing to pay extra for the improvement of the acoustic environment?

**(4) What do you think an excellent acoustic environment should be? What factors should be included in the acoustic environment design, such as space, sound, users, etc.?**

-- What is the connection between these factors?

-- What are the methods for achieving an excellent acoustic environment?

**(5) Do you have supplementary opinions about the architectural acoustic environment?**

### 2.3 Data analysis

Data collection and analysis were interrelated, and the analysis was performed simultaneously with data collection. The data analysis in the present study referenced the multi-step analysis technique of grounded theory [41]. After several rounds of interviews, coding, constant comparison, and theoretical sampling, theoretical saturation occurs when a dominant emerging pattern becomes saturated [42,43]. After theoretical saturation was achieved, final coding and analysis were conducted.

The coding processes included open coding, axial coding, and selective coding. In the process of open coding, based on the significance and relationship of events, the verbal transcript data were decomposed into phrases. The key phrases were further refined after comparing and correlating the phrases. Axial coding focuses on conceptualising key phrases. The conceptualised phrases were connected and distinguished according to interviewees' descriptions, thinking, and logical relationships. After the removal of unreasonable conceptualised phrases, sub-categories and core categories were created in axial coding, and the initial relationships among categories were developed. In the process

of selective coding, the core category with logical importance was selected by correlation analysis, which is a core perception or an important event unified by associated categories. Finally, the theoretical framework was formed through the logical connection of core categories. In this process, the core category can be merged or replaced [43-45]. Examples of the coding process are listed in Table 2.

DOI: https://doi.org/10.1016/j.apacoust.2021.108313

Table 2: Examples of the coding process

| Memo/Open coding | Phrase restatement & combination | Key phrases | Axial coding | Subcategories | Core categories |
|---|---|---|---|---|---|
| **Architects**: we can deal with the **noise** by **building block layouts. Building blocks** with **low acoustic requirements** can be used to **abate the noise** for the **areas with a high acoustic requirement**. In addition, I have seen buildings with **three-sided massing** abroad. The **courtyard was towards a railway or a road**. There was an independent **curtain** used to **abate the noise**. Then, **a block with complete four sides** was formed. | 1. Building block layouts, three-side massing, courtyard towards, a block with complete four sides.<br>2. Noise, a railway or a road<br>3. low acoustic requirements, areas with a high acoustic requirement<br>4. Curtain<br>5. Abate the noise | 1. Spatial layouts<br>2. Noise<br>3. Acoustic environment demand<br>4. Building constitution<br>5. Acoustics environment shaping | 1. According to the original acoustic environment, spatial layouts were used to deal with the noise, which then developed an ideal acoustic environment in the building.<br>2. The demand of the acoustic environment will have an impact on the layout of architectural space and the shaping of acoustic environments. | 1. Objective space<br>2. Circumventing noise<br>3. High demand, low demand<br>4. Design methods<br>5. Design concepts | 1. Architectural space<br>2. Original acoustic environment<br>3. Design demands<br>4. Acoustic environment |
| **Architects**: I believe the **combination** of **sound** and **architectural space** will bring more possibilities for **emotional expression**. The **music** could be **exciting, sad, natural, solemn**, and so on. It is very difficult for architects to design buildings with rich **emotion** only through **spatial design**. Therefore, such **combination** brings more potential and possibility. | 1. Sound, music<br>2. Architectural space, spatial design<br>3. Combination<br>4. Emotional expression, emotion<br>5. Exciting, sad, natural, solemn | 1. Sound, sound source<br>2. Architectural space<br>3. Context<br>4. Emotional expression of architecture<br>5. Emotional expression of music | 1. The combination of the acoustic environment and architectural space results in more emotional expression by the people using the building.<br>2. People's emotional expression could be affected by the context of the sound and the architectural space. | 1. Design methods<br>2. Design concepts<br>3. Subjective feeling of space<br>4. Context<br>5. Positive interpretation, negative interpretation | 1. Acoustic environment<br>2. Architectural space<br>3. Context<br>4. Interpretation |

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| | | | | | |
|---|---|---|---|---|---|
| **Non-architects**: As middle-aged people, we **prefer quiet environments**. If the **buildings** are very **noisy**, we feel **upset**. In our **community room**, there is a **small-sized reading room**. We usually go to spend our time on **chatting** together. It is very **quiet without any disturbance**. | 1. Middle age<br>2. Prefer quiet environments<br>3. Buildings, community room, small-sized reading room<br>4. Noisy, upset, quiet<br>5. Chatting, without any disturbance | 1. Group characteristics<br>2. Personal preference<br>3. Architectural space<br>4. Positive interpretation, negative interpretation<br>5. Behaviour | 1. Users' interpretation of the acoustic environment could be affected by their preference.<br>2. The user's interpretation of the acoustic environment will affect their behaviour. | 1. Group characteristics/ personal preference<br>2. Objective space<br>3. Positive interpretation, negative interpretation<br>4. Behaviour | 1. Preference<br>2. Architectural space<br>3. Interpretation<br>4. Outcome |

# 3. Results

## 3.1 Theoretical frameworks for acoustic environment perception of architect and non-architect groups

For the architect group, 212 key phrases were created by open coding, phrase restatement, and combination, while 23 subcategories and 10 core categories were generated by axial and selective coding (Table 3). For the non-architect group, 187 key phrases, 21 subcategories, and 8 core categories were formed (Table 4) using the same method.

DOI: https://doi.org/10.1016/j.apacoust.2021.108313

Table 3: Core categories and subcategories of the architect group

| **Original acoustic environment** | **Acoustic environment** | **Architectural space** | **Context** | **Design demand** |
|---|---|---|---|---|
| Utilization | Design concept | Objective space | Consistency | High |
| Circumventing | Design method | Subjective feeling | Inconsistency | Low |
| **limitation** | **Advantage** | **Interpretation** | **Preference** | **Outcome** |
| Cost | Low cost | Positive | Group characteristic | Yearning |
| Design difficulty | Changeability | Negative | | Escape |
| | Low impact | Neutral | | Adaptation |
| | Emotional | | | |

Table 4: Core categories and subcategories of the non-architect group

| **Architectural space** | **Acoustic environment** | **Context** | **Interpretation** |
|---|---|---|---|
| Objective space | Design concept | Consistency | Positive |
| Subjective feeling | Design method | Inconsistency | Negative |
| | | | Neutral |
| **Preference** | **State** | **Expectation** | **Outcome** |
| Group characteristic | Personal state | Match | Behaviour |
| Individual preference | Behaviour | Above | Emotion |
| | Emotion | Below | Recovery |
| | | | Healthy |

Figure 1 shows the theoretical framework that explains architects' and non-architects' perceptions of architectural acoustic environments. For the framework of the architect group, initially, the comprehensive factors of "limitation", "design demand", and "advantage" interact with one another, influencing architects' concepts, methods, and attitudes regarding the design of the acoustic environment. Alongside these comprehensive factors, the "original acoustic environment" is also an important influencing factor of the design concept, the formation of architectural space, and the creation for the acoustic environment. Subsequently, from the perspective of architects, "acoustic environment" and "architectural space" have mutual influence, and with the intermediary condition of "context" they constitute the architectural audio-visual environment. The users make an "interpretation" of the audio-visual environment and architects consider this "interpretation" to be influenced by "preference". Finally, under the "interpretation" of the audio-visual environment, users generate a kind of "outcome". Moreover, architects' perceptions of the expected users' responses to an architectural audio-visual environment will, in turn, affect the acoustic environment design. The core categories of "acoustic environment", "architectural space", and "context" contribute the most key phrases, play a crucial role in the entire framework, and are primarily related to the shaping of the architectural audio- visual environment. Therefore, it can be deduced that consideration of the audio-visual environment is the core of architects' perceptions of the architectural acoustic environment.

For the framework of the non-architect group, while the logical relationships of the theoretical framework share some similarities with the architect group, there are apparent differences in the content of core categories. In contrast to the architect group, "context", "interpretation", and "outcome" contribute the most key phrases and play a crucial role in the framework of the non-architect group. Therefore, the core of non-architects' perceptions of the acoustic environment is the "interpretation" and "outcome" of architectural acoustic environments. This is consistent with the research of Jennings and

Cain using the Kano model, in which the acoustic environment is only an intermediary in users' perceptions of an architectural space; most users pay more attention to their activities in the buildings, rather than listening to the sound and assessing its aesthetic quality or pleasantness [46].

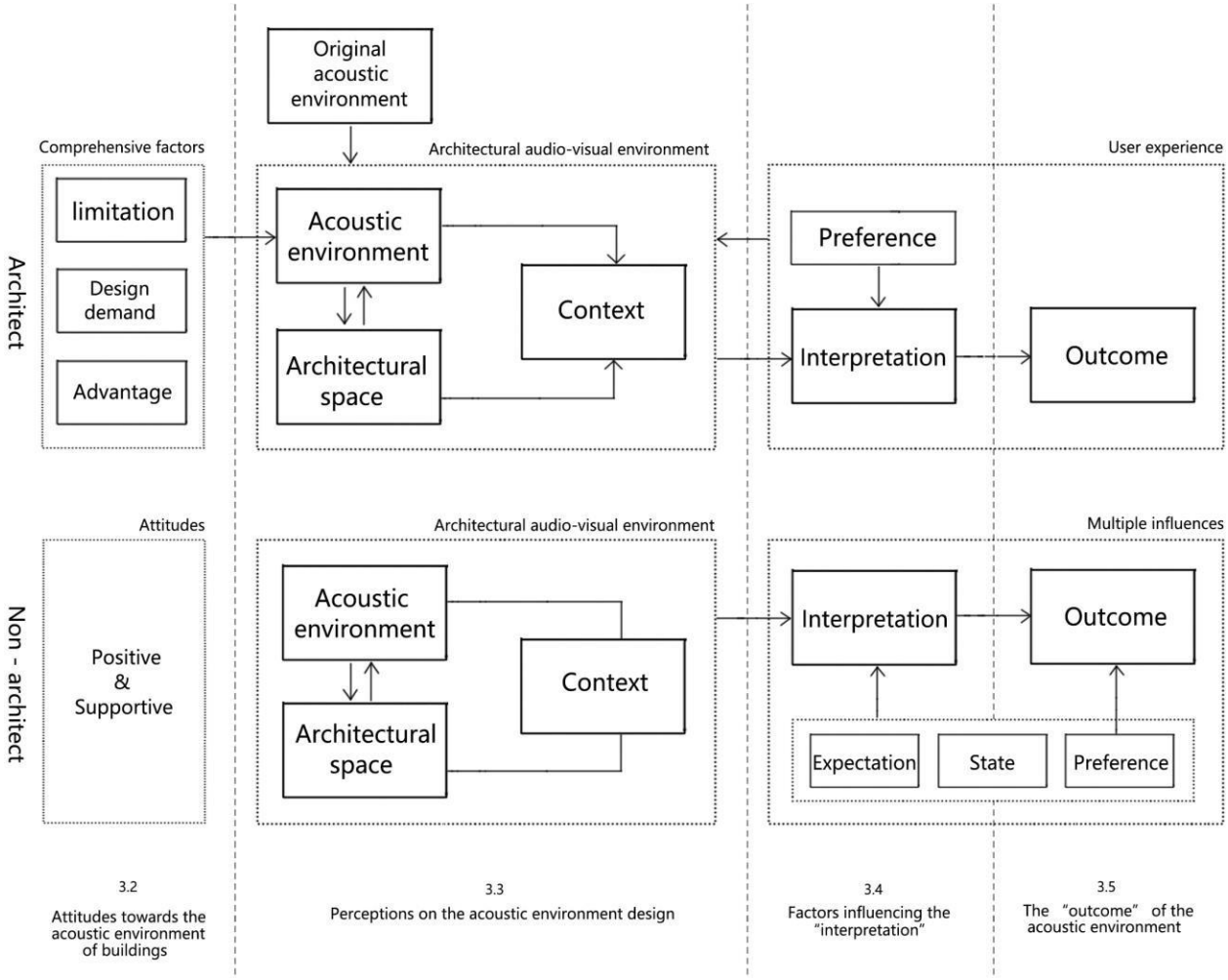


Figure 1: Theoretical frameworks for the architect and non-architect group perceptions of the acoustic environment, and the corresponding relationship between each section and the framework content

### 3.2 Attitudes towards the architectural acoustic environment

There are great differences between architects and non-architects in the attitudes towards the architectural acoustic environment, which are mainly reflected in the

comprehensive factor part of the architect group and the attitude part of the non-architect group (cf. Figure 1).

Interviews with the non-architect group revealed that most participants considered the acoustic environment to be an essential part of the architectural space, which should be taken into consideration by architects (e.g. NP18). It was also observed that most non-architects were willing to pay a cost for a better acoustic environment (e.g. NP11), which is consistent with Chung's finding that participants are willing to sacrifice a degree of building space in order to reduce the noise pressure level [47]. In contrast to the non-architect group, the architect group generally considered it difficult to incorporate the acoustic environment fully into the architectural design, and the design of the acoustic environment was constrained by many factors (e.g. AP10). The "comprehensive factors" in the theoretical framework of the architect group reflect the limitations faced by architects with respect to acoustic environment design.

**Non-architect (NP18):** Architects should design a comfortable architectural acoustic environment, and so on.

**Non-architect (NP11):** Of course, you cannot achieve the best of everything in building design. There will be some trade-offs, and it also depends on what is sacrificed for a beautiful sound.

**Architect (AP10):** It is difficult to grasp how to design the acoustic environment in the architectural space, and few of my colleagues pay attention to this matter.

In the theoretical framework of the architect group, the comprehensive factors include three core categories: "design demand", "limitations", and "advantages". Architects consider and weigh each factor of the acoustic environment design from multiple perspectives. In terms of "design demand", they generally considered that acoustic design

is only necessary in acoustic-related or high-level building spaces (e.g. AP10). In some cases, because clients had no particular requirements for the overall acoustic environment, it was unlikely that they would have the necessary budget for acoustic environment design. (e.g. AP2 and AP5). Furthermore, architectural design is a multi-factorial synthesis and, in comparison with other design factors, the original acoustic environment and acoustic environment design were not considered to be key factors that affect architectural design (e.g. AP4, AP7). With respect to "limitations", architects were aware of the inherent difficulty of regarding sound as a design factor. There were no clear design rules or classic design cases to follow, and no friendly architectural software could be used to design acoustic environments (e.g. AP2, AP12). In terms of "advantage", four aspects of the advantages of acoustic environment shaping were mentioned: low cost, changeability, low impact, and emotional content (e.g., AP15, AP20). Architects paid the most attention to changeability and low impact. As described by AP11, an audio system is a low-impact way of shaping an architectural environment because it can be conveniently installed in the space, has fewer conflicts with other design elements (low impact), and can be adjusted according to the users' feedback (changeability). The core categories of "design demand", "limitation", and "advantage" interact with each other and determine whether, and how deeply, architects think about the shaping of the architectural acoustic environment.

**Architect (AP10):** I feel that the acoustic environment has a higher level of demand. When designing a building project with general requirements, we often do not have extra effort to consider the acoustic environment.

**Architect (AP2):** In general, our clients have little demand and budget for acoustic environment design. In addition, there are few relevant design cases. I have never heard of a building known as a masterpiece because of its good sound environment.

**Architect (AP5):** The client has few requirements for the acoustic environment, let alone providing the budget for acoustic environment design.

**Architect (AP4):** I will think about the acoustic environment, but it is not my starting point or core factor of building design. Usually, I ensure that there is no big issue in the acoustics.

**Architect (AP7):** When we set up a fountain, it is not only for the water sound. We need to consider aesthetic, waterproofing, cost, maintenance, flow line, and so on.

**Architect (AP12):** Consider light as an example. I will use software to simulate light repeatedly to determine the effect. But it's hard to simulate the acoustic environment directly. It's hard to determine whether using water sound is a good idea. Which song should we play? How loud is the best volume?

**Architect (AP15):** Once an architectural project is complete, it is fixed. It is difficult to adjust according to user feedback; therefore, people must adapt to the building. By contrast, users can easily give feedback on the acoustic environment and make some adjustments, such as changing the volume or playing different sounds at different times of the day. The interaction between users and sound creates a better acoustic environment in buildings.

**Architect (AP20):** Music can convey various emotions; however, the architectural space itself struggles to express such emotions. The combination with sound enriches the emotions expressed by the buildings.

In summary, there are huge differences between architects and non-architects in their attitudes towards the architectural acoustic environment. Although acoustic environment design has been widely recognized and supported by the public, architects still struggle to incorporate it into architectural space design. The benefits of acoustic environment shaping and the ability of architects to design acoustic environments are still insufficient to overcome the various limitations that architects need to face.

### 3.3 Perceptions on the acoustic environment design

There are similarities and differences between the architect and non-architect groups in terms of their perceptions of acoustic environment design. This phenomenon is mainly reflected in the core categories of "acoustic environment", "architectural space", and "context", which appear in both theoretical frameworks, as well as the core category of "original acoustic environment", which only features in the theoretical framework of the architect group. Among these, the difference is mainly reflected in the category of "acoustic environment" (cf. Figure 1).

In terms of design concepts, most architects only focused on controlling the physical parameters of the acoustic environment, such as reverberation time, sound pressure level, and speech intelligibility (e.g. AP11, AP6). Although architects put forward some ideas about the active use of sound (e.g. AP13), dynamic and static partition was almost the only acoustic environment design element combined with architectural design in a practical project. Furthermore, acoustic design was usually considered after the architectural design was completed, which is also one of the reasons why active use of sound is problematic (e.g. AP1, AP12). By contrast, non-architects considered that the active use of elegant sounds in an architectural space improved their experience of the building. They paid more attention to the use of beautiful sounds than the control of physical indicators (e.g. NP4), and this is also reflected in the type of acoustic sources most frequently mentioned in the interviews (Table 5). For instance, the most often mentioned acoustic source by non-architects was water sound. They considered that an appropriate water sound can enrich their architectural experience, and make them feel pleasant and relaxed from the sensory experience. Furthermore, the water sound was mentioned in various ways, including the decorative shallow pool, a fountain, a fish pond, a waterscape

adorned with plants, a pool which children can play in, etc. (e.g., NP5, NP18) Abundant forms may also be the reason why the water sound was mentioned frequently.

Table 5: Most-mentioned sound sources in architect and non-architect groups

| **Architect group** | | **Non-architect group** | |
|---|---|---|---|
| **Sound source** | **Number** | **Sound source** | **Number** |
| Man-made noise | 27 | Water sound | 27 |
| Traffic noise | 23 | Music | 17 |
| Mechanical sound | 19 | Man-made noise | 16 |
| Music | 14 | Animal sounds | 9 |
| Water sound | 10 | Traffic noise | 5 |

**Architect (AP11):** My idea is to use the partition and floor to ensure sound insulation.

**Architect (AP6):** I think we must ensure speech intelligibility in the meeting room. In many large rooms, sound cannot be heard clearly.

**Architect (AP13):** I think it is interesting to use space and acoustic design to engender different distributions of sound pressure level and reverberation in order to generate dramatic spatial organisation.

**Architect (AP1):** Generally, architectural design is considered first, and acoustics design is considered after the architectural design has been determined.

**Architect (AP12):** It is very difficult to consider acoustics in the process of building style, streamlining, and space division design.

**Non-architect (NP4):** We could create a pool inside the hall of the building. The water sound makes us feel natural and colourful. It could sooth my emotions during my daily work.

**Non-architect (NP5):** There is a fountain in front of the CapitaLand Mall next to my home, where children like to play in summertime. People shop there, children play there, and with the sound of the fountains, it's a very lively place.

**Non-architect (NP18):** I went to a restaurant which has a large waterscape. Various plants mingle with the water droplets and water sound. It is just like being among nature.

In contrast to the design concept, there is no conflict between architects and non-architects with regard to the design method for acoustic environments. Architects considered two principal methods of sound production: shaping the real sound and using an audio system. The former was generally considered to be better than the latter (e.g. AP17), even though some architects recognized that it was not their role in deciding what sounds to broadcast through the audio system during the use of the building (e.g. AP3). Non-architects similarly considered the sound of an audio system to be unnatural, and that shaping real sounds is a better method (e.g. NP9). In addition to the method of sound production, the regional characteristics of sound, the interaction between sounds and users, and the ability for users to control and adjust the acoustic environment were also mentioned by architects.

**Architect (AP17):** We should try to create a real sound. For example, in the atrium, if we set up an acoustic space in which people can communicate, the voices in the atrium will be natural. If a loudspeaker is used to broadcast the voices, it would be too weird.

**Architect (AP3):** After the building is put into use, it is difficult for architects to control the use of the building. For example, in a shopping mall, no one will listen to an architect's advice on what sounds to broadcast.

**Non-architect (NP9):** Of course, it is good to shape the real sound. An audio system feels too fake.

No essential differences were revealed between architects and non-architects in the understanding of "architectural space". In the two theoretical frameworks, the core category of "architectural space" and "acoustic environment" constitutes the architectural audio-visual environment, and the two core categories were thought to have mutual influence. Regarding the impact of architectural space on the acoustic environment, architects already had some concepts or a basic understanding; for example, it is well understood that the volume of space and materials are used to affect reverberation time; unreasonably shaped spaces may lead to acoustic defects, and people are more tolerant of noise in open spaces (e.g. AP16). However, regarding the effect of the acoustic environment on the subjective feeling of an architectural space, although it was recognized by most architects, the systematic analysis of the effect and utilisation of sound was still difficult for architects (e.g. AP9).

**Architect (AP16):** Inside buildings, people may be more tolerant of noise in open spaces than in closed spaces. In addition, sound sources (such as the human voice or air conditioners) in different sized places may have different effects on users.

**Architects (AP9):** The sound environment influences the interpretation of users of the architectural space. However, it is difficult to determine what sound and sound levels should be used in different spaces. This depends on an architect's intuition.

Both architect and non-architect groups considered "context" to be an important factor in the architectural acoustic environment. Almost every interviewee mentioned "context" in their interviews (e.g. AP16, NP19). In ISO 12913-1, context is defined as the interrelationships between person and activity and place, in space and time [48]. However, in these interviews, it was understood more specifically as an intermediary relationship or coordination between the sound environment and the architectural space. Generally, personal factors (such as emotional state, personal activity, and expectation) do not affect

the evaluation of this relationship (e.g. NP9). Consistency between acoustic environments and architectural spaces engenders a sense of immersion among users, leading to the acceptance of otherwise unsatisfying sounds (e.g. NP2). However, inconsistency increases the annoyance and jarring of the user and draws attention away from the architectural space (e.g. AP20). Sometimes, architects deliberately use inconsistency to create a particular atmosphere in some art spaces (e.g. AP2).

**Architect (AP16):** A suitable acoustic environment can make users sense architectural spaces better and form a dialogue with them, which is a kind of combination and immersion. However, an unsuitable acoustic environment is a type of opposition to the architectural space and functions.

**Non-architect (NP19):** I agree that it would be better to design a coordinated sound. For example, the acoustic environments in art galleries, churches, and office buildings should be created differently. I once went to a small church in northern Europe where the music was natural and warm, and I was instantly immersed in that environment.

**Non-architect (NP9):** Of course, it is appropriate to put cheerful music in a shopping mall, even though I personally like it to be quiet, and sometimes I want to rest when I go for dinner after work.

**Non-architect (NP2):** There is a children's entertainment area in the nearby shopping mall. Although that area is quite noisy, it is still interesting to see many children greeting each other and playing inside. I'm okay with that.

**Architect (AP20):** In Peace Pastry, there is some background noise of merchants selling their wares, which makes people feel like they are back to the old Beijing hutongs. However, sometimes, it is very noisy because there are too many visitors, and this makes people lose interest in sensing the environment of the building.

**Architect (AP2):** The majority of sounds in contemporary art exhibitions are depressive, grotesque, and even harsh. This is the atmosphere and imagination that modern art wants to create.

The "original acoustic environment" is a core category specific to the architect group, and architects take the original acoustic environment of the design site into consideration when designing the architectural environment. If the site is noisy, architects will consider avoiding noise. Landscaping, spatial zoning, and construction methods were mentioned by architects during the interviews (e.g. AP5, AP6). If the site has active sounds, architects will consider utilising them. For example, an elegant outdoor sound can be used either to mask indoor noise or to match the indoor acoustic environment so that it can blur the boundary between inside and outside and create an excellent acoustic environment combination (e.g. AP1).

**Architect (AP5):** In addition to reasonable spatial zoning, I prefer to integrate the architectural design with the landscape closely to abate the noise.

**Architect (AP6):** For buildings close to noise sources, I would try to shield the noise through the treatment of terrain and plants. In addition, in terms of construction, better sound insulation of doors and windows is necessary.

**Architects (AP1):** I might consider playing some natural sounds in the architectural space and combining these with the outdoor environment. This method causes people's sensations to break through the barriers of architectural space. The space is tangible, but the sound is intangible. Sensations can penetrate a restricted space.

Overall, although the two groups share similarities in their perceptions of architectural acoustic environment design, there are still significant differences between them. In contrast to the non-architect group, who focused on enhancing the acoustic

environment with elegant sounds, the architect group still took noise control as the main point of consideration. Although the interviews revealed some ideas and suggestions relating to the active use of sound, almost none of the architects had used active sound design in their actual projects. For professional reasons, it may be reasonable to prioritise controlling the physical parameters of sound; however, architects should pay more attention to the active use of sound, as noise control is not a sufficient way to create a positive and supportive acoustic environment [49].

### 3.4 Influence factors on the "interpretation"

There are obvious differences between architects and non-architects in the factors that influence the "interpretation" of the acoustic environment. This phenomenon is mainly embodied in the influencing factors of the core categories of "interpretation" in the respective frameworks (cf. Figure 1).

Interviews with the non-architect group revealed the presence of factors influencing the interpretation of acoustic environments, which can be assigned to three core categories: "expectation", "state", and "preference". "Expectation" depends largely on the function of the building and the user's previous experience; if the user has a low expectation of the acoustic environment, then the acoustic environment may be perceived more favourably (e.g., NP15). "State" also plays an important role in "interpretation". It encompasses three subcategories: personal states, emotions, and behaviours. Personal state includes both an individual's sensitivity to the acoustic environment (e.g. NP16) and the individual's physical state (such as fatigue, illness, etc.) (e.g. NP8). Emotion represents a user's psychological state at the time (e.g. NP9). Behaviour includes the type, duration, and frequency of users' activities in the space (e.g. NP19). The third core category, "preference", indicates that different users have different judgments on the acoustic environment. The

contrasting views reported for a library are a case in point; NP2 and NP10 considered quietness as the ideal condition for a library, but NP8 considered a very quiet environment to be inhibiting in terms of behaviour and emotion, making users feel uncomfortable (NP8).

**Non-architect (NP15):** My wife is in poor health, so I often go to the hospital. The hospital has been noisy for many years, and I am used to it.

**Non-architect (NP16):** I feel that not all people are the same. Some people do not care about the noise from decoration, while others cannot bear the sound of chopping vegetables by neighbours.

**Non-architect (NP8):** I think I can only pay attention to the acoustic environment when I have energy. If I'm very tired from work on any given day, I don't care about these things at all.

**Non-architect (NP9):** Sometimes, feelings depend on one's mood. For example, it was a rainy day, and I was dejected after work; the cheerful and aggressive music being played in the community made me very upset. If it is a New Year's Eve family reunion, playing cheerful music is acceptable.

**Non-architect (NP19):** It is okay to play some natural sounds occasionally in the hall or elevator. But if you play the same sound in the office all day, or even for several years, it's unbearable.

**Non-architect (NP8):** I usually go to the library during my spare time. The library is a mental recovery space for me. However, sometimes I feel constrained when it is too quiet. As long as we do not intentionally make noise, it would be better for everyone to be freer.

In comparison with the discussion of "expectation", "state", and "preference" among the non-architect group, the architect group's discussion focused on group (rather than individual) characteristics in acoustic environment design. Architects acknowledged that architectural acoustic environments having different functions (for example, kindergarten

and nursing homes) should be different (e.g., AP19). In fact, in the interviews, architects have a certain understanding of the individual factors that influence the "interpretation" of the acoustic environment, such as personal preferences and personal emotions, but they struggle to incorporate the many possible factors entailed into an already complex design (e.g., AP1, AP6).

**Architect (AP19):** We have different design directions for different users. Some groups like lively environments, while others prefer quiet environments.

**Architect (AP1):** Each user has different feelings, but the architectural space usually serves multiple people. It's contradictory to cater to all tastes.

**Architect (AP6):** Some users stay for a long time, some for a short time, some are sad, and some are happy. We can't take all these into account in the architectural design.

It is clear from this analysis that architects do not pay enough attention to the factors that affect users' interpretations of the acoustic environment. In this regard, designing a multi-level acoustic environment system is a feasible method for adapting to the states and preferences of a greater variety of users. By way of illustration, the challenge of contrasting preferences for the acoustic environment of the library could be achieved in a number of ways: for example, through the design of "dynamic" areas in the overall quiet environment, the creation of "semi-quiet zones", or even by exploring the possibility of controlling the acoustic environment by users themselves, rather than seeing it as an insoluble contradiction.

### 3.5 The "outcome" of the acoustic environment

Architects and non-architects were also found to have great differences in the perception of the outcomes achieved by the acoustic environment, which is mainly

reflected by the core categories of "outcome" appearing in both theoretical frameworks (cf. Figure 1).

In the non-architect group, the core category "outcome" includes four subcategories: behaviour, emotion, recovery, and health. Hence, the effects of the acoustic environment on users were not only a kind of feeling or immediate response, but also a profound and long-term impact (e.g. NP5, NP9, NP10). Furthermore, "outcome" is also influenced by personal preference; the same interpretation may lead to different outcomes for different interviewees. For example, when confronted with disturbing decoration noise, NP7 chose to listen to music or play video games with soundproof earphones, while NP11 preferred to go outside to escape from the noise.

**Non-architect (NP5):** When I'm at work, I like to stay in a quiet place during lunchtime and refresh myself.

**Non-architect (NP9):** My workplace is close to the corridor, and people walk around and make phone calls all day, which makes me very irritable.

**Non-architect (NP10):** I feel that this is a virtuous cycle. Architects design a good public space with a graceful acoustic environment for us in the community, so everyone enjoys playing and exercising there; we will then make friends and improve our mood and health.

For the architect group, the core category "outcome" consists of three subcategories: "tendency", "escape", and "adaptation". A positive acoustic environment helps users have a better interaction with the architectural environment, improving their experience in the architectural space, and leading to a kind of immersion in, or yearning for, the architectural space (e.g. AP2). In contrast, a negative acoustic environment causes users to lose concentration and escape from the space or, at best, adapt to the negative acoustic

environment (e.g. AP5, AP12). However, in the core category "outcome", architects focused primarily on the interaction between users and the architectural space, and how to ensure a better architectural experience for them, ignoring the profound, long-term impact of the acoustic environment on users.

**Architect (AP2):** In ancient Chinese buildings, there is a design method that allows the user to hear an attractive sound before seeing the building; the area can be invisible in advance.

**Architect (AP5):** Some noise is unavoidable, and office workers, including myself, have adapted to the sound of the keyboard and printer. I sometimes wear headphones to isolate myself from the acoustic environment.

**Architect (AP12):** When I visited the Louvre, there were too many tourists and the sound environment was too noisy. I could not be calm and appreciate the building and exhibits.

Although the core category of "outcome" is common to both architect and non-architect groups, the content is quite different. Although architects tend to focus on the interaction between users and architectural space, such as users' responses to the space or their behaviours within it, the non-architect group is more concerned with behaviour, emotion, recovery, and health effects after the interaction with the acoustic environment. It is evident that architects' perceptions of the "outcome" are not sufficiently deep, and it would bring benefits for them to give more consideration to the multiple, long-term and profound effects of the acoustic environment on users.

# 4. Discussion

## 4.1 Issues on the design of the acoustic environment

The differences between architects and non-architects are phenomena that exist in many fields of architecture. Naturally, not every difference is a problem or mistake. Some researchers believe that the gap between architects and non-architects is beneficial [50], while others perceive it as harmful [51]. The purpose of a comparative analysis is not to eliminate these differences, but to explore the issues, ideas, and development directions worthy of attention that are informed by these perceptions and differences.

In the present research, as shown in Figure 2, Section 3.3 focuses principally on the concepts and methods of acoustic environment design. The analysis in this section indicates that architects are still in a relatively passive state with respect to their consideration of the acoustic environment design, and it remains challenging for them to grasp the impact of actively designing the acoustic environment on architectural design. Consequently, it is difficult for architects to surmount the limitations of architectural acoustic design, as described in Section 3.2, and their attitude towards acoustic environment design tends to be negative. Sections 3.4 and 3.5 focus on the interpretations and outcomes of the acoustic environment, and the results show that architects do not pay enough attention to the factors influencing users' "interpretation" of the acoustic environment, or on the "outcome" of the acoustic environment with respect to users. As a result, architects are unable to realise the demands of the public regarding acoustic environments and the importance of acoustic environment design. Consequently, architects cannot design an acoustic environment with clear objectives, and their motivation is insufficient to overcome the limitations of architectural acoustic design, as outlined in Section 3.2. Therefore, they tend to have a negative attitude towards acoustic environment design. In contrast, non-architects pay more attention to the active use of sound and the effect of the acoustic environment on

themselves, and their attitudes towards acoustic environment design tend to be positive. Taken together, all these perceptions and the relationships between them form the architect group's theoretical framework, which focuses on audio-visual environment design, and the non-architect group's theoretical framework, which concentrates on the interpretations and outcomes of the acoustic environment (Section 3.1).

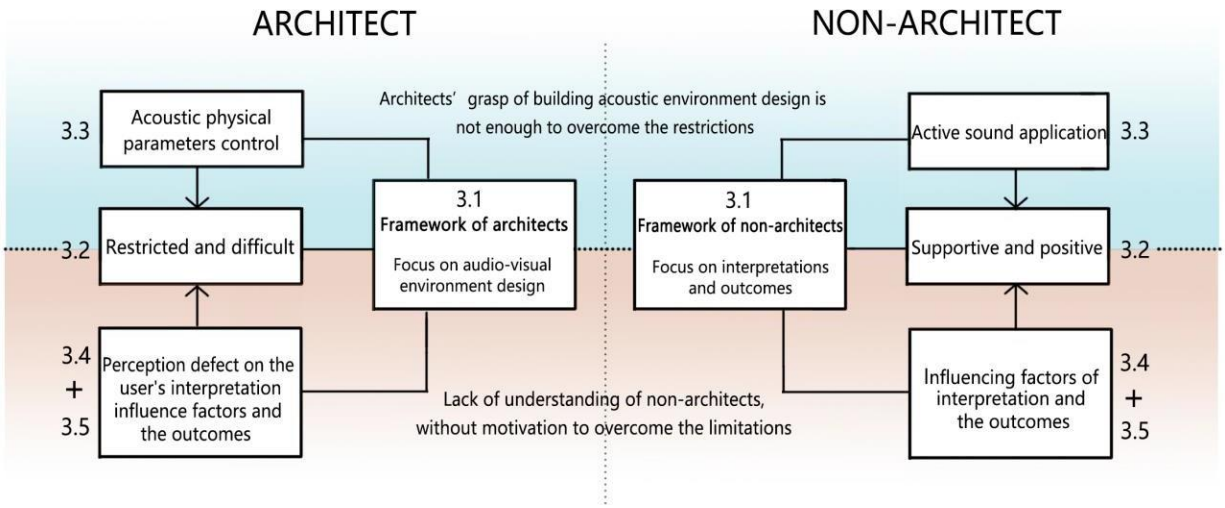


Figure 2: Differences in the perceptions between architects and non-architects, and correlative analysis of the differences and issues worthy of attention

According to the overall analysis of these perceptions and differences, there are two issues worthy of attention: the first issue (the upper part of Figure 2) mainly focuses on the acoustic environment design itself, the design methods of the acoustic environment, and the various limitations. It can be initially identified as the architects' understanding that the active architectural acoustic environment design is not sufficient to overcome its inherent limitations. The second issue (the bottom part of Figure 2) mainly focuses on the architects' understanding of the public's preferences and needs, and the direction of thought on acoustic environment design. It can be initially identified that architects lack an understanding of public preferences and demands, leading to a lack of clear objectives in the design of the acoustic environment, and a lack of motivation to engage in an intense acoustic environment design.

### 4.2 Potential ideas and development directions reflected in the interviews

Regarding the two issues above (Section 4.1), there are many ideas and viewpoints reflected in the interviews that provide us with potential solutions and development directions. Among these, the combination of acoustic environment design and architecture focuses on the design methodology and the realisation of architectural acoustic environment design, which is mainly concerned with issue one (the upper part of Figure 2). The effective communication and feedback mechanisms and the transition of design thinking focus on architects' understanding of the public and the resultant transition of acoustic environment design thinking, which is mainly concerned with issue two (the bottom part of Figure 2).

#### 4.2.1 The combination of acoustic environment design and architecture

The acquisition of experience by people is a combination of multiple senses [52]. If architectural research does not elaborate on the architectural design with basic visual elements, such as space, appearance, and function, it is not so much an explanation of a direction as it is a kind of evasion [53]. During the interviews, we found that the nature of practices in the architectural profession led architects to take the architectural space itself as the core content of design, while sound is considered to be either problematic or superfluous as a starting point or core factor of architectural design. The design of the acoustic environment should not be in opposition to the basic architectural design method. Architects and researchers should focus on integrating the design of the acoustic environment into the overall process of designing an architectural environment, rather than considering the impact of sound separately.

Architectural design needs to weigh various factors; it includes not only traditional objective spatial factors such as scale, shape, and material, but also building function,

spatial emotion, building surroundings, and even seasons, light, regionality, etc. On the one hand, we need to consider the combination of various factors in order to avoid situations in which opening windows cannot meet the demand of noise control, and closing windows cannot meet the ventilation requirements [54]. On the other hand, we should not constrain architects in a rigid way (for example, weight and formula), because physical parameters alone are not sufficient to assess the architectural environment [55], and the process by which users assess each spatial factor is continuously balanced, that is, a good factor could compensate to some degree for a relatively poor one [56]. Instead, we need to put the acoustic environment into a holistic thought and balanced system of architectural design that is natural and normal, such as that done for material and light, so that comprehensive judgement of the audio-visual becomes a normal step for architects.

#### 4.2.2 Support for architects in acoustic environment design

In the interviews, architects generally reflected that they did not have enough support (basic rules, software, budget, policy, etc.) to implement acoustic design. Soundscape enriches the acoustic environment as an active, abundant, and potential environment [57], and virtual reality assists architects with comprehensive audio-visual expression [58]. Support for architects to better design the acoustic environment is gradually developing. However, the interviews also showed that there seem to be some barriers between existing research content and design practice.

Taking basic rules as an example, although architectural design is full of creativity and originality, architects need some basic rules to support their architectural design process. As AP8 said: “Warm colours make the space feel narrow, and cold colours make the space feel spacious. We do not have similar basic rules or classic design cases for the acoustic environment.” Here, the relationship between colour and space is based on a

design language, and whether we can provide some relationship between existing acoustic environment dimensions or indicators and a design language is imaginable.

#### 4.2.3 Effective communication and feedback mechanisms

Effective and routine communication and feedback mechanisms (such as POE and participatory design) are necessary for architects to understand the public's opinions of acoustic environments. These mechanisms promote the production of bottom-up concern and expectation datasets. At present, these mechanisms only focus on noise control, with almost no participation in the design of the acoustic environment [59].

In addition, it is difficult to obtain positive feedback regarding the design of the acoustic environment, and this is also a concern for architects. As A3 said: "It's hard to say whether the shaping of the acoustic environment is effective or not, when complying with the acoustic specifications, it may be a more direct way to make the space richer and more spacious with the same time and budget." Compared with other design factors, the support provided by the acoustic environment to users may be relatively subtle. It is a feasible method to provide appropriate and scientific "reward" for design of the acoustic environment in POE or other building evaluation systems. For example, the establishment of an area of restorative acoustic environment and improvement of the controllability of the acoustic environment will result in higher scores, even if it is not the ultimate goal.

#### 4.2.4 The transition of architects' design thinking

There were some differences between the acoustic environment design and architectural design architects and non-architects' in the interviews. These differences suggest that architects should try to change their design thinking with regard to the design of the acoustic environment. First, there was no essential difference in the interpretation of

a specific sound between the two groups, and more differences appeared in the thinking of the use conditions. For instance, in architectural design, non-architects consider circles and more ornaments to represent something meaningful, while architects think that meaningfulness comes from more metal cladding [30]. However, in the acoustic environment, almost everyone thinks that the sounds of water and bird calls are more natural. Compared with the sound to play, the acoustic environment design emphasizes the factors (expectation, state, and preference) that influence the user's interpretation of the acoustic environment. In view of the complexity of users' expectations, states, and preferences, creating a multi-level acoustic environment system to meet users' manifold needs is a direction worth thinking about. Second, architects often emphasize the uniqueness of architectural design [29,39]. However, in the design of the acoustic environment, both architects and non-architects emphasize the role of "context", with consistency being the common choice of the two groups. Shaping the "resonance" between the acoustic environment and the architectural space will provide users with a better experience, rather than over emphasizing uniqueness.

In addition to the design methods, the transition of architects' notions was still the most essential problem encountered during the interviews. Even with the development of the indoor environmental quality system [60] and soundscape [11, 57], the impact of the acoustic environment on human well-being has been confirmed. However, many architects still think that a positive and supportive sound environment design is difficult to achieve. In fact, just as architects no longer only pay attention to satisfying the architectural function, but also think about the importance of negative space and the ability of the architecture to support users' various demands, architects should also break away from their inherent impression that sound environment design only involves noise control, and then proactively attempt the possibilities (for example, behavioural, emotional, recovery, and health) of sound environment design for users.

### 4.3 Limitation

All the interviewees that participated in this research were Chinese architects. There are some differences in design concepts and design concerns among architects in different regions [61,62]. They may also have different perceptions of the architectural acoustic environment. The exploration of the situations in different countries and cultures is expected in further studies.

## 5. Conclusion

Through focus group interviews, this study explored architects' and non-architects' perceptions of the architectural acoustic environment, deriving theoretical frameworks on acoustic environment perception for the architect and non-architect groups. The architect group's theoretical framework revealed the thinking process of architects on architectural acoustic environment design, the limitations on shaping the acoustic environment of buildings, and the expected responses of users to the acoustic environment. In contrast, the theoretical framework of the non-architect group revealed a focus on the formation process and influencing factors of the interpretations of the acoustic environment, and the various outcomes achieved by the acoustic environment. Further comparative analyses revealed the following five essential differences and outcomes.

1) Architects and non-architects have a different emphasis in their perceptions of the architectural acoustic environment. Architects tend to focus on shaping the audio-visual environment, while non-architects tend to focus on the interpretations and effects of the acoustic environment. 2) Architects and non-architects have different attitudes towards acoustic environment design. The non-architect group had a relatively positive attitude towards the shaping of the acoustic environment, while the architect group considered the

design of the acoustic environment problematic because of high levels of design difficulty and lack of support. 3) Architects and non-architects have different design concepts regarding acoustic environments. Architects concentrate on controlling the physical parameters of sound, while non-architects focus on the creation of a good acoustic environment using ideal sound. 4) Architects do not pay enough attention to the various factors (e.g. expectation, state, and preference) that influence users' interpretations of the architectural acoustic environment. 5) Architects focus primarily on the architectural experience of users, and their perception of the possible outcomes (e.g. behavioural, emotional, recovery, and health) of the acoustic environment for users is inadequate.

Based on a further correlation analysis of the differences, it was found that the existing issues in the design of the acoustic environment are mainly focused on two aspects. First, architects' grasp of the active architectural acoustic environment design is insufficient to surmount its inherent limitations. Second, architects' understanding of public preferences and demands is insufficient. Architects cannot design an acoustic environment with clear objectives and lack motivation to engage in an intense acoustic environment design. Regarding the two issues, the interviews mainly reflected the following ideas and development directions. 1) The acoustic environment should be considered in a holistic thought and balanced system of architectural design, naturally and normally. 2) More support based on design language should be provided to architects in architectural acoustic environment design. 3) Effective and routine communication and feedback systems should be established for acoustic environment design, and appropriate and scientific "reward" for the acoustic environment design should be provided. 4) Architects need proactive attempts with a positive and supportive acoustic environment design, and the acoustic environment design should meet the public's perception of the characteristics of the acoustic environment.

## Funding

This research was supported by the National Natural Science Foundation of China under Grant (Nos. 51978454 and 51678401).

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