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## Comparative Analysis of Visual and Auditory Perceptions in Urban Environments Using Mental Mapping

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### ABSTRACT

Visual and auditory elements in urban environments play a critical role in shaping spatial perception and experience. However, systematic investigations comparing the influence of these sensory modalities remain limited. This study applies a mental mapping approach to examine the relationship between visual-auditory experiences and physical space. Participants generated sketch maps based on familiar environments and annotated their perceptions of visual and auditory elements within those spaces. The collected data were digitized and analyzed using Geographic Information System (GIS) tools to construct cognitive models incorporating spatial and sensory attributes. These models enabled comparative analysis of how visual and auditory components contribute to spatial experience and their respective spatial distributions. The results demonstrate that mental mapping is an effective method for integrating sensory perception into spatial analysis. The findings reveal distinct patterns in how visual and auditory elements influence spatial cognition, offering valuable insights for multisensory urban design and planning.

**Keywords:** Soundscape, Mental map, Soundscape map

### 1. INTRODUCTION

Urban environments are not only experienced through direct contact, such as walking through streets or observing buildings, but are also mentally reconstructed by individuals in the form of mental maps [1]. These maps are

representations of the environment that people build based on their everyday activities, memorable places, and sensory impressions. They reflect not only where buildings are located, but also how individuals feel about those places, which routes they consider important, and what areas they tend to notice or ignore. As Lynch [2] emphasized in his study, people construct mental representations of cities using main components such as paths, landmarks, and districts, which collectively form the 'imageability' and 'legibility' of urban space.

While the concept of the mental map has been widely explored across disciplines such as environmental psychology, tourism, and behavioral geography, much of the existing research has concentrated on identifying spatial cognitive structures. These structures refer to the representations of spatial layouts such as the location of landmarks, the sequence of paths, and the relative distance and direction between places. Recent work in tourism studies [3] and urban geography [4] has demonstrated that sketch maps can serve not only as tools for capturing spatial cognition but also as a medium to express affective and sensory evaluations.

Despite the growing use of sketch maps in various fields, most studies have primarily focused on visual elements such as buildings, streets, and spatial layouts, while overlooking the role of auditory experience in shaping mental representations of urban space. In Lynch's research, visual clarity played a central role in defining the legibility of a city. However, contemporary urban environments are increasingly understood through multisensory experiences, especially sound. Previous research on urban soundscapes [5,6] and environmental perception [7,8] has shown that auditory impressions—such as the presence of water sounds, traffic noise, or bird calls—significantly influence people's comfort, attention, and emotional responses within a space. Given these limitations, recent research calls for an expanded understanding of mental maps that incorporates not only visual cognition but also the auditory and emotional

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dimensions of spatial experience. Integrating sketch mapping with subjective evaluations of both visual and auditory stimuli allows for a more comprehensive assessment of perceived urban environments. This study employs a sketch mapping method combined with sensory evaluation, enabling an approach to spatially interpret how individuals recall and represent both visual and auditory components of the urban environment.

This study aims to explore how individuals perceive and evaluate urban space through a combination of cognitive and sensory dimensions. By analyzing sketch maps annotated with spatial elements (paths and landmarks) and sensory evaluations (pleasant, unpleasant, and distinctive sound experiences), this research seeks to uncover how visual and auditory impressions are integrated into mental representations of place. Through this approach, the study contributes to expanding the methodological scope of sketch map research and provides insights into the multi-sensory structure of perceived urban image.

## 2. METHODS

### 2.1 Participants

A total of 43 participants (20 males and 23 females) took part in the sketch mapping and sensory evaluation study. All participants were undergraduate or graduate students who were familiar with the study area through regular use or prior visits. Their ages ranged from 19 to 27 years, with a mean age of 22.1 years and a standard deviation (SD) of 1.7 years. Before the experiment, participants received a short orientation session explaining the study's objectives and instructions for completing the sketch mapping and sensory evaluation tasks. This session helped ensure a common understanding of the procedures and reduced individual interpretation bias. To avoid interaction effects, participants performed the tasks individually in a quiet indoor setting. Each session included the sketch map drawing followed by a short questionnaire assessing visual and auditory impressions. All participants provided written informed consent, and the study was conducted in accordance with institutional ethical guidelines.

### 2.2 Study area

The case study area of this study was located in Daejeon, South Korea. The selected site comprises a mix of pedestrian walkways, riverside promenades, small plazas, and adjacent commercial facilities. This area was chosen not only for its diverse spatial composition and rich auditory environment

but also because it is a space that is frequently used and well-recognized by local residents and university students. As such, it provides an appropriate context for examining the interaction between spatial cognition and sensory perception in a real-world urban setting. The site includes both natural and anthropogenic sound sources, such as the flow of the river, wind through trees, pedestrian activity, and traffic noise.

### 2.3 Procedure

In the sketch mapping task, participants were instructed to draw a mental map of the study area from memory. The task followed a structured sequence to ensure consistency. Participants first sketched the main paths they remembered, including walkways, riverside routes, and significant streets. They then identified and marked landmarks that they considered memorable or important within the space, such as buildings, public art, or visual focal points. Lastly, they annotated locations where they recalled experiencing pleasant, unpleasant, or distinctive sounds, based on their personal impressions.

Following the mapping task, participants completed a brief questionnaire evaluating their overall sensory impressions of the area. The participants rated the quality of visual and auditory elements using a 5-point Likert scale, ranging from 1 (very poor) to 5 (very good). The entire session lasted approximately 60 minutes per participant.

### 2.4 Data analysis

All collected sketch maps were scanned, georeferenced, and digitized into vector layers using QGIS 3.24. Spatial features drawn by participants were classified into paths, landmarks, and sound-related annotations. Paths were recorded as linear features representing remembered movement routes, while landmarks were coded as point features corresponding to visually or cognitively salient locations. Sound annotations were categorized into three types based on participant labels: pleasant, unpleasant, and distinctive. Each annotation was treated as a label for spatial analysis. Following the theoretical framework proposed by Lynch [2], this study focused on two core elements: paths and landmarks. Among Lynch's five elements of city image paths, edges, districts, nodes, and landmarks these two are the clearest representation in freehand sketch maps, making them suitable for comparative analysis across participants.

To identify shared spatial perceptions, the frequency with which each path and landmark appeared across participants' maps was calculated. Elements that appeared most



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frequently were interpreted as components of the site's public image, reflecting spatial features that were commonly recognized and mentally represented by multiple individuals. Visual and auditory quality scores obtained from the questionnaires were matched with each participant's sketch map based on annotated areas. These sensory assessments were then interpreted in spatial terms to identify locations associated with positive and negative impressions.

## 3. RESULTS

### 3.1 Paths and landmarks

Among the 43 collected sketch maps, several paths and landmarks were repeatedly drawn by participants, indicating high levels of spatial recognition. The riverside walkway and the central pedestrian road near the university emerged as the most frequently sketched paths.

Landmarks such as the bridge connecting both riverbanks, a central plaza space, and a cluster of cafés near the plaza were also commonly represented. These were identified not only due to their spatial prominence but also due to their frequent use or symbolic meaning. Based on frequency analysis, these elements constitute the public image of the site, reflecting places that are widely recognized and mentally anchored in participants' memory.

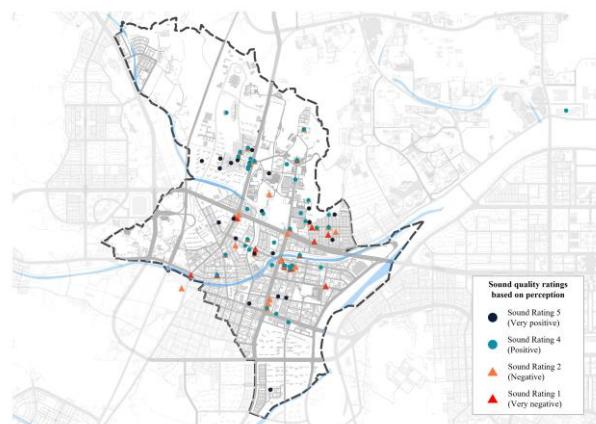
### 3.2 Acoustic element

After drawing the sketch maps, participants were asked to indicate locations they perceived as acoustically meaningful. These locations represented places where the sound environment was experienced as pleasant, unpleasant, or distinctive, and were marked using three distinct symbols on their maps: a circle (○) for pleasant sounds, an X (✗) for unpleasant sounds, and a triangle (△) for distinctive or unique sound experiences. The triangle symbol in the sketch maps was used to indicate locations where participants experienced distinctive soundscapes. These places were memorable or unusual due to their contrast with the surroundings, a variety of sounds, or unique contextual features. The impressions were not necessarily positive or negative but stood out in the participant's auditory experience.

Figure 1 presents a digital map created by georeferencing these annotated sound points in QGIS. This figure visualizes the spatial distribution of sound-related impressions across the study area and combines symbol-based sketch map annotations with questionnaire-based auditory evaluations.

Dark blue circles denote areas rated 5 in the sound quality questionnaire, commonly associated with tranquil, nature-oriented environments such as riverside paths and green zones. Light blue circles represent areas rated 4, reflecting positive sound experiences. On the other hand, red triangles correspond to locations that received the lowest score, often located near busy roads, intersections, or commercial zones where mechanical noise and human activity were pronounced. Orange triangles indicate locations rated 2, suggesting a lower degree of sound comfort.

The visual comparison of mapped sound impressions and auditory ratings reveals that positively or negatively perceived soundscapes tended to appear near frequently drawn paths and landmarks, suggesting a relationship between cognitive salience and soundscape preference.



**Figure 1.** Spatial visualization of mental maps on visual and auditory evaluations across the case study area. Symbols such as circles (○) and triangles (△) indicate locations where pleasant sounds, and unpleasant sounds were experienced.

## 4. CONCLUSION

This study explored how individuals perceive an urban environment through the combined use of the sketch mapping approach. By analyzing spatial elements frequently drawn in participant maps, particularly paths and landmarks, and comparing them with subjective assessments of sound elements, this study revealed how visual and auditory impressions affect the mental image of urban environments. The results showed that certain spatial features, such as riverside walkways and landmark plazas, were consistently represented across sketch maps and were also associated with positively evaluated soundscapes. Conversely, areas marked as acoustically unpleasant were often located in





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peripheral or traffic-dense zones. Soundscapes indicated through triangular annotations were not necessarily associated with positive or negative evaluations, but rather with the uniqueness of the sound itself or the specific setting in which it was experienced. The findings indicate that spatial familiarity and cognitively salient features influence how urban soundscapes are perceived and remembered. Integrating auditory experience into sketch map analysis allows for a better understanding of how people interpret urban space. This approach can inform the design of public spaces that are more aligned with users' perceptual and experiential factors.

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