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Original Research Article

Perception of Sonic Distinction in the Experience of Movement in Spaces of Tabriz Bazaar*

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Abstract

Problem statement: Environmental characteristics of different urban spaces cause different acoustical behavior in them. Acoustical behavior directly affects sound waves and causes a certain auditory atmosphere in space. Thus, when distinct spaces with different physical characteristics and diverse sound sources are contiguous, various soundscapes are created together. The dispute in the acoustical behavior of the spaces, which arises from the difference in their physical characteristics, causes the quality of the sound heard and their soundscapes to be different. Therefore, diverse types of space create different soundscapes that cause the person who moves along them to have an auditory experience with a certain quality.

Research objective: The present study seeks to clarify the auditory experience of a person while moving in different spatial types of Tabriz Bazaar.

Research method: A sample of Khan, Rasteh-Bazaar and Timcheh of Tabriz Bazaar, where are next to each other, had been selected as cases of the study. In order to clarify the perceptual quality resulting from the auditory experience that is obtained due to the movement in the spatial species of the Bazaar, first, the acoustical behavior of the intended spaces is explained. Sound Pressure Level (SPL) and Reverberation Time (RT) are two components that clarify the acoustical behavior of the studied spaces. Subjective assessments have been performed to clarify how people perceive the effect of the acoustical behavior of spaces on their soundscapes.

Conclusion: The findings show that movement along with different spatial types in Tabriz Bazaar, causes a perceptual quality that can be called "Sonic Distinction". Sonic Distinction is an emotional and perceptual quality of the auditory experience of a person moving in different urban spaces and depends on the specific physical characteristics of the spaces, sources and sound events.

Keywords: *Soundscape, Sonic Distinction, Acoustical Behavior, Urban Spaces, Tabriz Bazaar.*

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Introduction

The soundscape of the city is a new field in urban studies that deals with the quality of sounds heard in urban spaces. In the vast majority of studies, the soundscape of a particular urban space, in parks, squares and streets, is examined and investigated. However, it has been neglected that the human experience in the city and the way they perceive urban spaces are not separate and divided from the spaces; while it is sensible along the sequences. In fact, when a person moves around the city and moves from one space to another, his perceptual experience of different urban spaces is not separated from each other and makes sense in general. Therefore, it seems necessary to study the urban soundscape, in addition to paying attention to the quality and desirability of the soundscape of each space, the auditory experience of people of the soundscape in a set of different urban spaces.

In the present study, in order to study the auditory experience of people from the soundscapes of different urban spaces, three types of spaces of Tabriz Bazaar have been selected. Since the quality of the sound heard is to some extent dependent on the magnitude of the sound, the effect of the physical characteristics of different spatial species on the acoustical behavior and consequently on the sound heard is investigated. Thus, this study seeks to clarify the impact of characteristics of different spatial species on their acoustical behavior and consequently, on the auditory climate of spaces. Since the soundscape is a subjective and perceptual concept, the quality of the soundscape of Tabriz Bazaar plays an important role in its status in the perception of citizens and tourists. Therefore, by identifying the factors involved in the desirability of the soundscape of Tabriz Bazaar, by eliminating the defects and reinforcing the strengths and indicators, we can take steps to improve the role of this valuable historical place. In such a way is that the sense of belonging of Tabriz citizens to Tabriz Bazaar increase and the highly memorable "sound of the bazaar" for tourists will become a bed for the development of tourism in the world's largest brick structure. In this regard, the present study seeks to respond to the following questions:

I. How do the physical characteristics of different spatial species in Tabriz Bazaar affect their acoustical behavior?

II. What is the effect of the acoustical behavior of Tabriz Bazaar spaces on the auditory experience of people while moving along different species of paces?

Research background

"Soundscape" is a new field in acoustic studies that relies on the perceptual quality of sound. In the 1970s, in a study of contemporary music by Canadian composer Murray Schafer at Simon Fraser University in Vancouver, he coined the term "soundscape" (Schafer, 1993). Researchers and specialists in the field of architectural and urban acoustics have offered several definitions of the concept of soundscape. In order to standardize the definitions of this concept, the International Organization for Standardization (ISO) defines the soundscape as follows: "Acoustic environment as perceived or experienced and/or understood by a person or people, in a context" (International Organization for Standardization, 2014). Soundscape means dealing with human perception of the sound environment. Therefore, this meaning is always closely related to the characteristics of the context, i.e. time, place and specific activities (Brown, 2010, 2011; Maculewicz, Erkut & Serafin, 2016).

The satisfaction with soundscape does not only rely on the nature of the sound and the inherent characteristics of the sound, but also depends on several factors. Therefore, in order to decide which of the soundscapes in spaces is desirable, one must pay attention to the factors that somehow affect the desirability of the soundscape. These factors can be directly related to or independent of sound. According to the review of soundscape

research, the factors affecting the desirability of the soundscape include components that can be classified into two categories of acoustic and non-acoustic factors, which are collected in Table 1 based on the results of the research.

A review of the research results shows that the investigation of the desirability of the soundscape of a space depends on many factors. In various studies, according to the specific context of each research, some of these components have been evaluated. However, what has been neglected in research is the human auditory experience in a series of urban spaces. When a person is moving around the city and moving from one urban space to another, experiences different soundscapes. Therefore, it is necessary to examine this human auditory experience from the soundscapes of neighboring urban spaces. In the present study, this gap in the field of soundscape studies has been addressed. Thus, the perceptual experience of people from the soundscapes of different types of space in Tabriz Bazaar has been studied.

Table 1. The factors affecting the desirability of the soundscape. Source: authors.

Index	Criteria	Unit	Reference
Acoustic indexes	Sound source	The classification of the sound sources The Sound source (Geophonic, Biophonic, Anthrophonic) The sound role (Keytone, Soundsignal, Soundmark) Sound Production method (point, linear, wide)	(Farina, 2013) (Hermida & Pavón, 2019) (Liu & Kang, 2016)
		The visibility of sound sources	(Hall, Irwin, Edmondson-Jones, Phillips & Poxon, 2013)
	Quantitative components of sound	Sound pressure level	(Zhao, Zhang, Meng & Kang, 2018)
		LAeq	(Li, Liu & Haklay, 2018)
		Reverberation time	(Yang, Kang & Kim, 2017)
	The meaning of sound	Emotions in the sound	(Liu & Kang, 2016)
		The sound preference	(Hong & Jeon, 2015)
Environmental indexes	Landscape	Form, geometry and volume of space	(Liu & Kang, 2018)
		The coordination between landscape and soundscape	(Herranz-Pascual, García, Diez, Santander & Aspuru, 2017)
	Function	Residential spaces	(Hong & Jeon, 2015)
		Business spaces	(Zhao et al., 2018)
		Commercial spaces	(Meng, Sun & Kang, 2017)
		Leisure spaces	(Pérez-Martínez, Torija & Ruiz, 2018)
	Current activities	The activities that take place in the space	(Meng & Kang, 2016)
		The activity the person is doing	(Aletta, Kang, Astolfi & Fuda, 2016)
Non-environmental indexes	Demography	Age category	(Li et al., 2018)
		Gender category	(Bora, 2014)
		Social status (family status and friendship network)	(Brambilla, Gallo, Asdrubali & D'Alessandro, 2013)
	Culture and society	Sounds specific to each community	(Zhao, Xu & Ye, 2018)
		Sonic memories	(Liu & Kang, 2016)
	Time	When a person hears the soundscape (hour, week days, season or the special days of the year)	(Meng et al., 2017)
		Duration of exposure to an soundscape (short-term or long-term)	(Liu, Kang, Luo & Behm, 2013)

Theoretical foundations

The general perception of the environment is a combination of all the senses that provides the final assessment (Preis, Kociński, Hafke-Dys & Wrzosek, 2015). Individuals with information that they receive from their various senses, understand and orient their surroundings (Shams & Kim, 2010) . The subjective assessment of the environment and its impact on humans is the result of the perception of the environment by all human senses in an instant moment (Preis et al., 2015). Therefore the subjective assessment of the soundscape should also be considered as a part of the overall perception of the environment and its effect on individuals. Since the soundscape is based on subjective analysis, environmental assessment based on dividing the senses separately is not appropriate (ibid.).

Studies show that human response to sound is not merely based on physical perception, but is an aesthetic sense received from the environment (Aucouturier, Defreville & Pachet, 2007). In general, the interaction between the visual and auditory senses can affect the overall assessment of the environment (Hong & Jeon, 2014; Hong & Jeon, 2013). Numerous studies have focused on how visual and landscape factors affect soundscape perception. For example, the perception of soundscape and its desirability are closely related to landscape features, including the aesthetic quality of space, simplicity and sense of enclosure (Hong & Jeon, 2015). The interaction between auditory and visual perception, especially when the sounds are related to the situation, gives people a sense of participation and comfort (Kang, 2006).

All visual information affects the hearing of people in space in different ways (Viollon, Lavandier & Drake, 2002; M. Zhang & Kang, 2007). Evidence shows that the visual quality of the environment can affect the assessment of a soundscape (Carles, Barrio & de Lucio, 1999; Meng, Kang & Jin, 2013; Viollon et al., 2002). Some studies also point to the important role that the geometry of urban spaces plays in the desirability of visual perception (Shi, Gou & Chen, 2014). The Geometry of space, form, size and numerical proportions among its dimensions, distance of components from each other lead to some spatial qualities such as the degree of enclosure or openness, static or dynamic of the space. Spatial qualities are topological qualities of space that depend on interactions resulting from relationships that are geometric (Pakzad, 2010). Enclosure is the ratio of the height of the walls to the width of the space, which also depends on the degree of continuity of the walls. The ratio of the length to the width of the space also indicates the static or dynamic nature of the space. The lower the ratio , the more static the space; Also, the higher the ratio, the more dynamic the space (Ching, 2009).

The geometry of urban spaces, in addition to affecting people's visual perception, also affects their auditory perception in various ways. As shown in a study (Bora, 2014), 70% of people were able to correctly define spaces as open, semi-open, or enclosed by simply listening to the sound of the environment in the laboratory. In fact, the geometry of space directly affects its acoustical behavior and specifically the way people perceive a soundscape.

The two components of Sound Pressure Level (SPL) and Reverberation Time (RT), which clarify the acoustical behavior of spaces, are influenced by the geometry of space as two important and effective variables in sound desirability (Yang et al., 2017). The acoustical behavior of urban environments, along with the elements present in space and materials used in man-made environments, more than anything depends on the geometry and spatial characteristics of urban spaces. In fact, urban places with similar geometric properties are perceived similarly in terms of sound perception (de la Prida, Pedrero, Navacerrada & Díaz, 2019). Besides space proportions play an important role in the rate of noise pollution. It has been shown that there is a direct relationship between the ratio of width to height of the street and the amount of noise pollution (Liu & Kang, 2018). Depending on whether the studied urban environment is large-scale or micro-scale, the factors affecting the acoustical behavior of space vary. In micro-scale spaces, the shape and characteristics of the roof, the dimensions and size of

the walls, the amount of traffic and weather conditions are influential indicators of how sound waves are distributed. In general, the effective factors in sound propagation between transmitter and receiver can be examined in five cases: A sound reflection by surfaces (Ground surface, walls, floors and obstacles), diffusion from edges (Edge of obstacles and buildings), scattering from hard surfaces (such as irregular building Facades) refraction by temperature and wind and attenuation of sound waves by air absorption (Hornikx, 2016). According to the research results, the factors affecting the acoustical behavior of urban micro-scale spaces can be summarized according to Table 2.

According to what has been mentioned, in order to determine the acoustical behavior of the spaces and the factors affecting them, which is done based on the evaluation of the Sound Pressure Level and Reverberation Time as basic variables, the indicators specified in Table 2 should be considered. In the present study, the Sound Pressure Level and Reverberation Time are measured as two basic acoustic variables to determine the acoustical behavior of the studied spaces. Also, the effect of enclosure, static or dynamic, congestion and brightness of spaces as spatial qualities affecting the subjective perception of the soundscape have been studied. To clarify whether these differences can be understood by humans or not, using a questionnaire, soundscape descriptors and the acceptability of sound sources of spaces will be evaluated.

Research method

• Methodology

The present study seeks to investigate auditory experiences in the motion along with different spatial species. This study is based on differences in the acoustical behavior of spaces and their effect on how the sound of the environment is perceived. As mentioned in the previous section, the acoustical behavior of spaces is directly related to the geometry and geometric proportions of the space. Geometric relationships of spaces In addition to the clear impact it has on how space responds to sound waves, also create special space qualities. Spatial qualities affect a person's perception and understanding of the environment and, according to research results, also affect his perception of the soundscape. In fact, the geometric relationships of spaces affect the subjective perception of people from a soundscape in two ways; first, they have an effect on the

Table 2. Factors affecting the acoustical behavior of urban micro-scale spaces. Source: authors.

Index	Criteria		Reference
Metric properties	Volume		(Long, 2005)
	Dimensions and size		(Liu & Kang, 2018)
	Spatial proportions		(de la Prida et al., 2019)
	Enclosure		(Liu & Kang, 2018)
Shells	Horizontal shell (floor)	Materials	(Hornikx, 2016)
		The geometry	
	Vertical shells (walls)	Materials	
		The geometry	
Physical barriers	Dimensions and size		(Ariza-Villaverde, Jiménez-Hornero & De Ravé, 2014)
	Materials		(Hornikx, 2009)
	Position relative to the sound source and listener		(Yang et al., 2017)
Sound sources	Volume		(Zhang, Ba, Kang & Meng, 2018)
	Frequency spectrum		(Morillas, Escobar & Gozalo, 2013)

acoustical behavior of the spaces and the quality of the heard sound and secondly, they have an indirect effect on the perception of people from the soundscape through spatial qualities.

To achieve the aim of the research, it is needed to collect quantitative and qualitative data and analysis on them. Therefore, due to the nature of the subject and purpose of the research, to conduct this research, the adoption of a quantitative-qualitative method is suggested as the optimal method. The research model is shown in Fig. 1.

- **Study area**

Tabriz Bazaar, in addition to architectural features, variety of uses, typology of space, special environmental features and qualities and the role it plays in the structure and ossification of Tabriz,

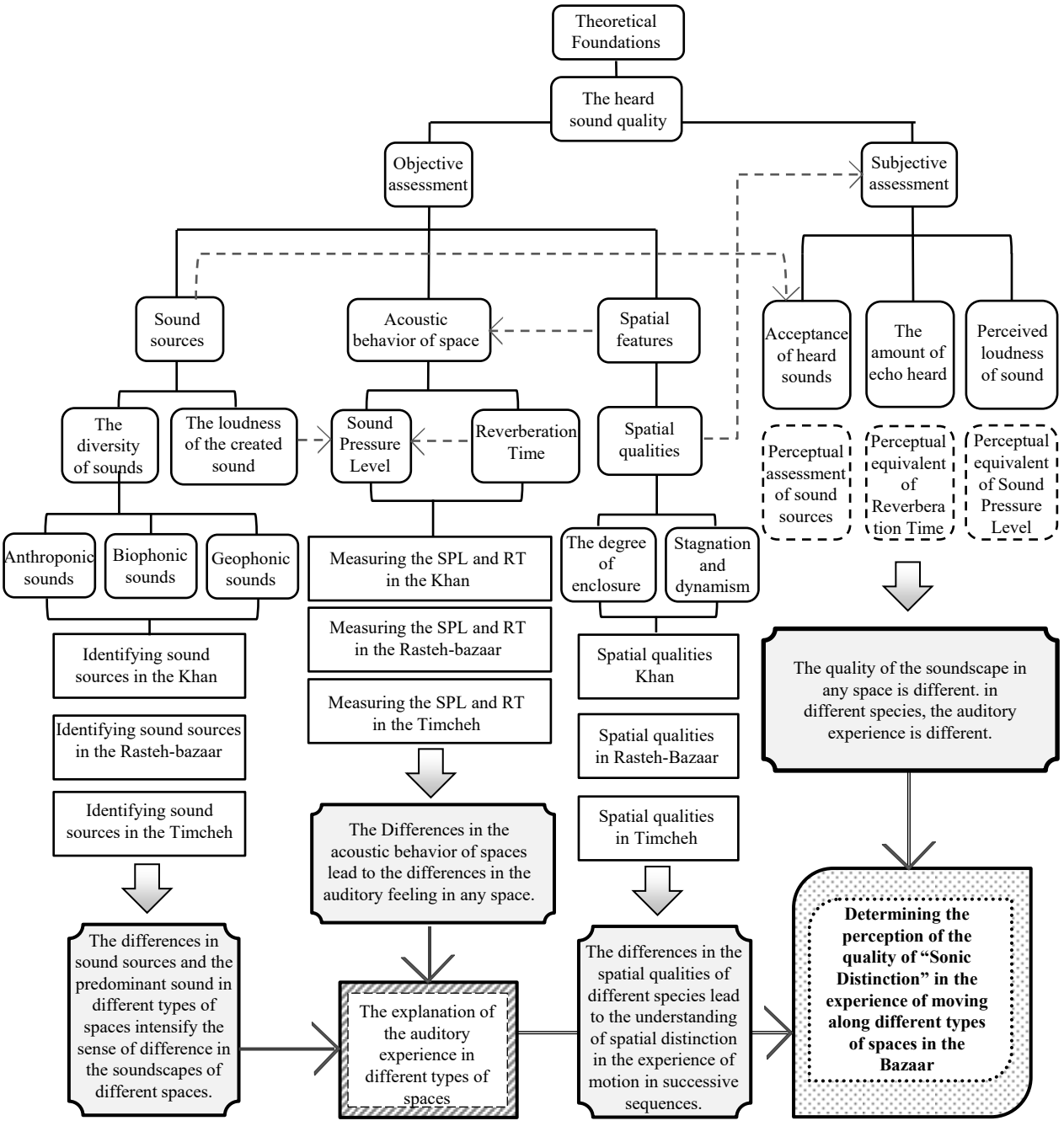


Fig. 1. Research model. Source: authors.

also has a unique soundscape. One of the factors that determine the superiority of the soundscape of this urban space is the absence of urban traffic and its noise in the bazaar, whose wide area has caused the central spaces to be free from any common noise of industrial cities. Fig. 2 shows the location of Tabriz Grand Bazaar in the city and its relation to the adjacent main streets.

- Selection of studied spaces

Rasteh-bazaars, Timchehs and Saras (Khans) are three prominent spatial species in Tabriz Bazaar. For the present study, a hypothetical route has been selected in which a person passes through three spatial species and experiences their soundscapes. This route starts from Middle Haj Hosseinqoli Khan, continues along Sarrajan Rasteh-Bazaar and ends at Mozzafarieh Timcheh. The reason to choose these spaces is that they are considerably far from adjacent crowded streets to make them ineffective on both objective measurements and subjective assessments. Fig. 3 shows the location of middle Haj Hosseinqoli Khan, Sarrajan Rasteh-Bazaar and Mozzafarieh Timcheh, as well as the hypothetical route under study.

• Collecting information

In the present study, the Sound Pressure Level and Reverberation Time have been evaluated as components of acoustical measurements, which are described as follows.

- Collecting objective data

Sound Pressure Level is physically the logarithmic magnitude of the effective sound pressure relative to the reference size (Farina, 2013). The reference size is the set of human hearing thresholds for a young person at 1000 Hz. SPL is perceptually related to the concept of loudness (Long, 2005). A variety of tools can be used to measure this component. In this research, the ACAM 100 Acoustic Camera has been used in one-minute shots of audio-graphing of the three studied spaces to measure the SPL in these spaces.

Reverberation Time is the time when the SPL drops to 60 dB after the sound source is cut off (Ghiabaklou, 2018). This variable is measured in the central points of Timcheh and Khan and in the joint points of the Rasteh-bazaar by frequency spectrum. Factors that are involved in the acoustical

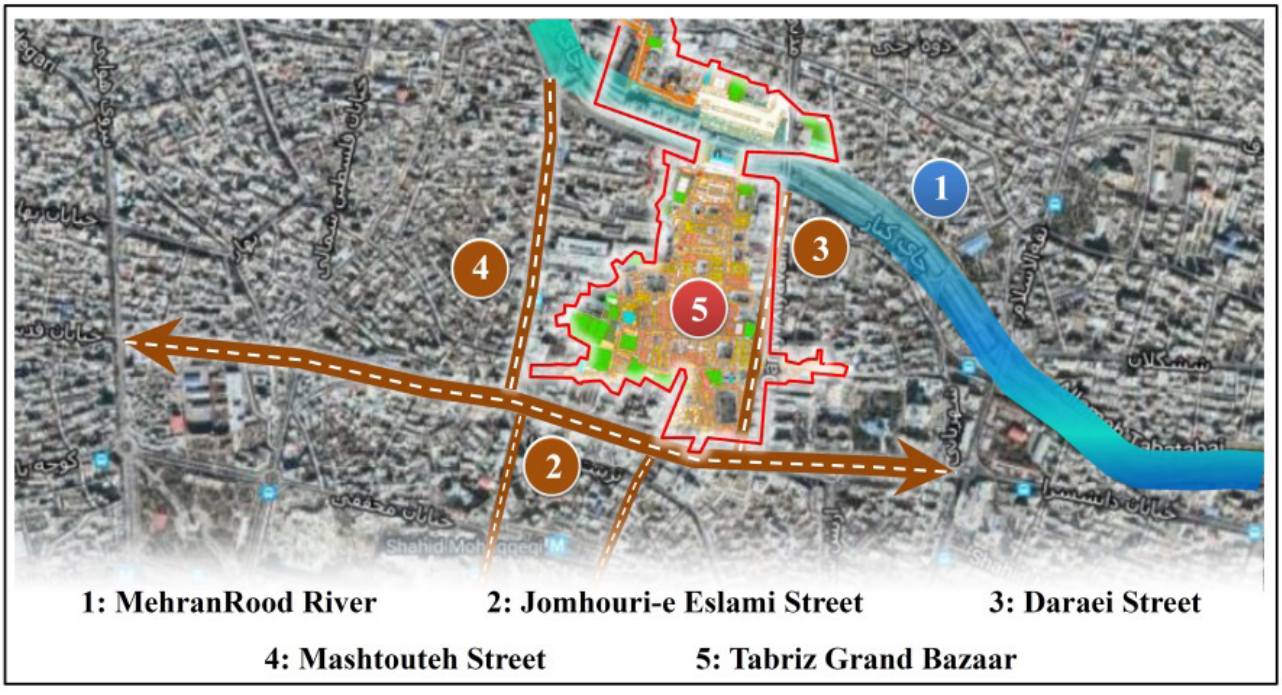


Fig. 2. Location of Tabriz indoor Bazaar in the city. Source: authors.

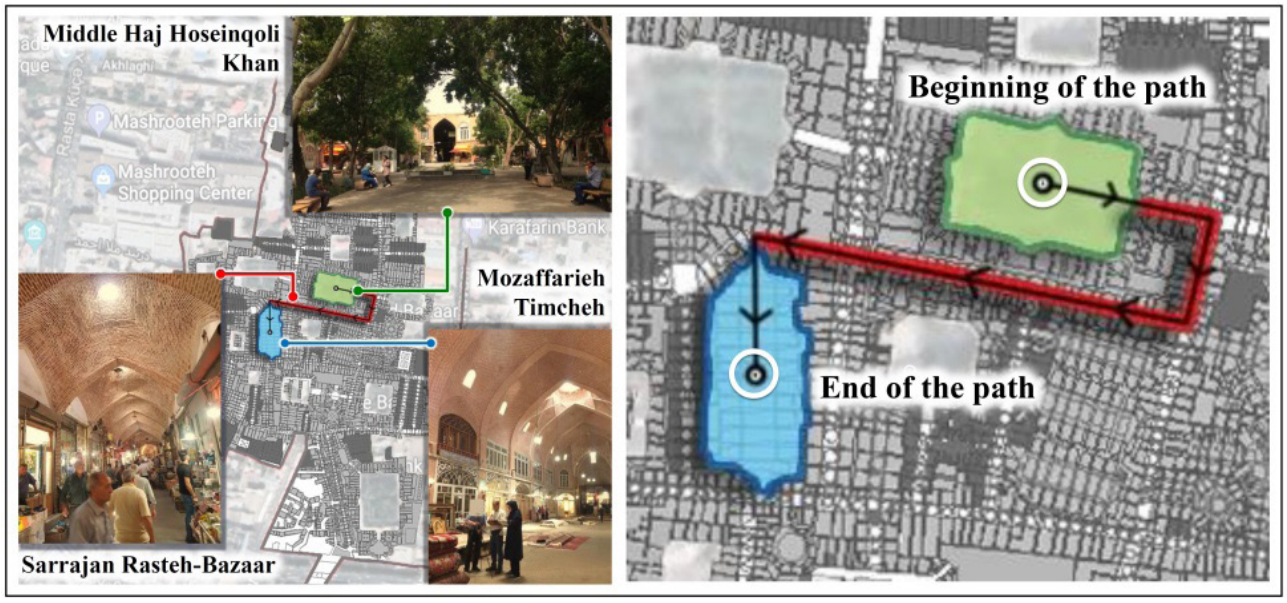


Fig. 3. Location of Middle Haj Hosseinqoli Khan, Sarrajan Rasteh-Bazaar, Mozzafarieh Timcheh and the selected route in the bazaar. Source: authors.

behavior of each space in some way are identified separately. The Kjær & Brüel Model 2260 polygonal speaker set, amplifier and sound meter were used to measure the reverberation time.

- Collecting the subjective data

The environmental sound can cause mental reactions that may be suitable, familiar, pleasant and useful for orientation. Such traits and meanings have a profound effect on soundscape assessment (Cain, Jennings & Poxon, 2013). Addressing the perceptual structures, many researchers have examined the perceptual elements of sounds using psychological assessment. Among the perceptual components of the sound, the pleasure, memories, sense of security, the loudness of sounds and sonic comfort could be mentioned. A variety of sound sources are also related to the perceptual components of the soundscape (Axelsson, Nilsson & Berglund, 2010).

In the present study, three subjective components of the soundscape are evaluated through a questionnaire in the 5 Likert spectrum, which includes perceived sound loudness, echo-heard and desirability of sound sources. The perceived loudness of sound with two pairs of loud/slow antagonists and perceptual echo levels are evaluated with two pairs of echo/mortal. People's willingness to hear or not to hear a sound, by marking options (very pleasant, normal, annoying and very annoying) facing any sound source, indicates the acceptability of the sound sources of each space.

The validity of the questionnaire with pre-test was calculated with 40 samples and Cronbach's alpha 0.913. The number of people who filled in each space has been prescribed by the Morgan Table at the rush hour. The rush hour is specified with the presence of the researcher in place and observing and questioning the tradesman of the bazaar. Thus, in Middle Haj Hosseinqoli Khan 36 people, in Sarrajan Rasteh-Bazaar 54 people and in Mozaffarieh Timcheh 32 people were tested.

Discussion

In this study, based on the values of SPL and RT, the acoustical behavior of the spaces is explained and based on subjective assessments, the impact of the effect of acoustical behavior on the audio experience and the soundscape perception is

examined. In the beginning, geometric proportions of the studied spaces and sound sources are reviewed. Next, the findings from the assessments are analyzed.

• Physical characteristics affecting the acoustical behavior

Since the acoustical behavior of the space depends on the dimensions of the spaces and materials and physical characteristics, in Table 3, these studied characteristics are examined in the case of Khan, Rasteh-Bazaar and Timcheh.

Given the physical characteristics of the spaces located in the selected path for research, by moving in the sequence of these spaces, visually, certain spatial qualities are experienced. The placement of spaces with different spatial features ultimately leads to the perception of "Sonic distinction" in the experience of moving along them. Fig. 4 shows consecutive sequences of movement in the selected path.

In addition to the visual-spatial qualities, the change in the existing sound sources of the spaces, the subjective and perceptual differences of each sequence are felt in the experience of movement. According to the Farina classification, sound sources are divided into three categories: Geophonic sounds (such as wind, lightning) Biophonic, (such as the sounds of birds and animals) and Anthrophonic, (sounds related to human activities) (Farina, 2013).Accordingly, the sounds present in the three studied space species, which were collected during the field survey with the direct presence in space, are as described in Table 4.

• Analysis of research findings

As mentioned before, the present study is based on objective and subjective assessments. In the following, these two types of findings are analyzed separately.

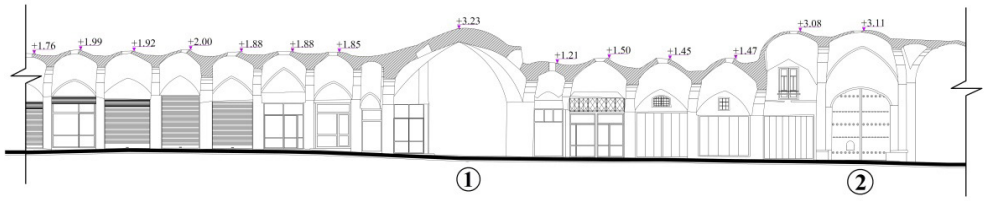
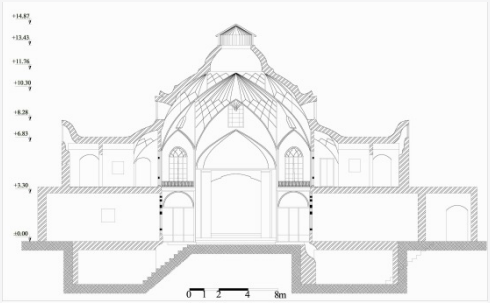
- Analysis of the results of SPL measurement

SPL values were measured in Middle Haj Hosseinqoli Khan in 9 central and pivotal points, in Sarrajan Rasteh-Bazaar in 18 positions in articulated points and Charsouqs and Mozzafarieh Timcheh at 2 central points and 2 entry points to Timcheh by an acoustic camera, different frequencies can be examined. In each of the studied spaces, the values of the average SPL were calculated separately by frequency and the diagrams of each were drawn followingthe normal equal-loudness-level contours (Barr & Buckley, 2011). SPL graphs of Middle Haj Hosseinqoli Khan, Sarrajan Rasteh-Bazaar and Mozzafarieh Timcheh, are drawn in Fig. 5 concerning the normal equal-loudness-level contours.

The graph of SPL in the three studied spatial types compared to the normal equal-loudness-level contours shows that the ascending or descending trend of graphs of SPL in all three spaces in the frequency ranges are similar. With the exception of Mozzafarieh Timcheh, which, unlike Middle Haj Hosseinqoli Khan and Sarrajan Rasteh-Bazaar, has two peaks in the SPL values and the highest SPL is higher than Khan and Rasteh-Bazaar. Middle Haj Hosseinqoli Khan is the quietest space studied at frequencies above 200 Hz and has a relatively higher SPL at frequencies below 200 Hz; however, its amount is so low that it is difficult to hear. Mozzafarieh Timcheh has the lowest SPL values at frequencies below 200 Hz and the highest at frequencies above 300 Hz. Sarrajan Rasteh-Bazaar is louder than the other two spaces at frequencies between 200 and 400; but, except for the peak points of Mozzafarieh Timcheh, it has a relatively similar situation with the Timcheh.

In general, in all three studied spaces, very low-pitched sounds are not heard or are difficult to hear. The highest values of SPL also belong to the range of human speech. However, this issue is not unexpected, because in the bazaar environment, the voice of conversation and humming prevails over other voices. The values of SPL in the range of human speech in middle Khan of Haj Hosseinqoli are clearly less than Rasteh-bazaar

Table 3. Geometric proportions of the selected spaces and materials used in the walls (Maps by. Mohandesin-e Moshaver-e Emarat-e Khorshid). Source: authors.

Item	Explanation					
Middle Haj Hosseinqoli Khan	Length	Width	Height	The degree of enclosure	Stagnation and dynamism	Wall materials
	52 Meters	34 Meters	7.5 Meters	Threshold of feeling enclosed	Static	Brick with plaster pointing
	Transverse view (western front)					
						
Sarrajan Rasteh-bazaar	Length	Width	Height	The degree of enclosure	Stagnation and dynamism	Wall materials
	122 Meters	4 Meters	6.5 Meters	Complete	Dynamic	Brick with plaster pointing
	Guide Plan			Part of the transverse view (southern front)		
						
	1: Second Charsouq :2 / Entrance of Mozaffarieh Timcheh					
Mozzafarieh Timcheh	Length	Width	Height	Cross section (North Front)		
	65 Meters	10 Meters	13 Meters			
	Enclosure	Stagnation and dynamism	Wall materials			
	Complete	Relatively dynamic	Brick with plaster pointing			

and Timcheh. In general, all three spaces of middle Haj Hosseinqoli Khan, Sarrajan Rasteh-Bazaar and Mozzafarieh Timcheh are in a calm and tranquil state (Ghiabaklou, 2018).

- Analysis of the results of measuring the reverberation time

In the middle Haj Hosseinqoli Khan, the sound source is located in the center of the space and

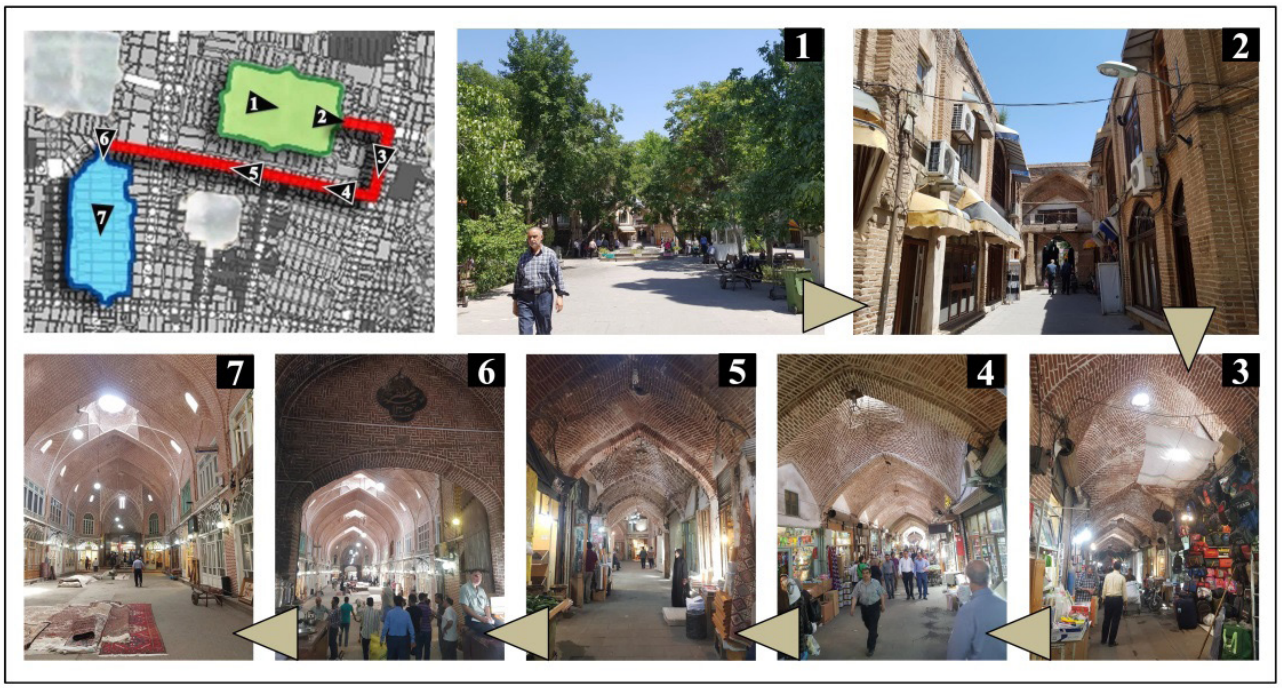


Fig. 4. Consecutive sequences in the experience of moving in the selected path. Source: authors.

Table 4. Sound sources present in the selected spaces. Source: authors.

Studied space	Sound source type																			
	Anthrophonic													Biophonic				Geophonic		
	Motorcycle	Airplane	Moving and shaking devices)	Water (washing)	Cart (trolley)	People walking	Rasteh-bazaar humming	Music	Selling food and tea	Warning (Ya Allah!!)	Children's voices	Talking people	Adhan	Dog	Cat	Sparrow	Crow	Water (pond and fountain)	Leaves of trees	Wind
Middle Haj Hosseinqoli Khan	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sarrajan Rasteh-Bazaar	*		*		*	*	*		*	*		*	*							
Mozzafarieh Timcheh			*		*	*	*		*	*		*	*							

to measure the effect of different factors, the values of RT have been measured at three points. Table 5 describes the location of the equipment in Middle Haj Hosseinghli Khan, the diagram of the values of RT and the factors affecting it. In middle Haj Hosseinqoli Khan, two main factors were identified in reducing and eliminating the echo; Trees by scattering sound waves and cavities

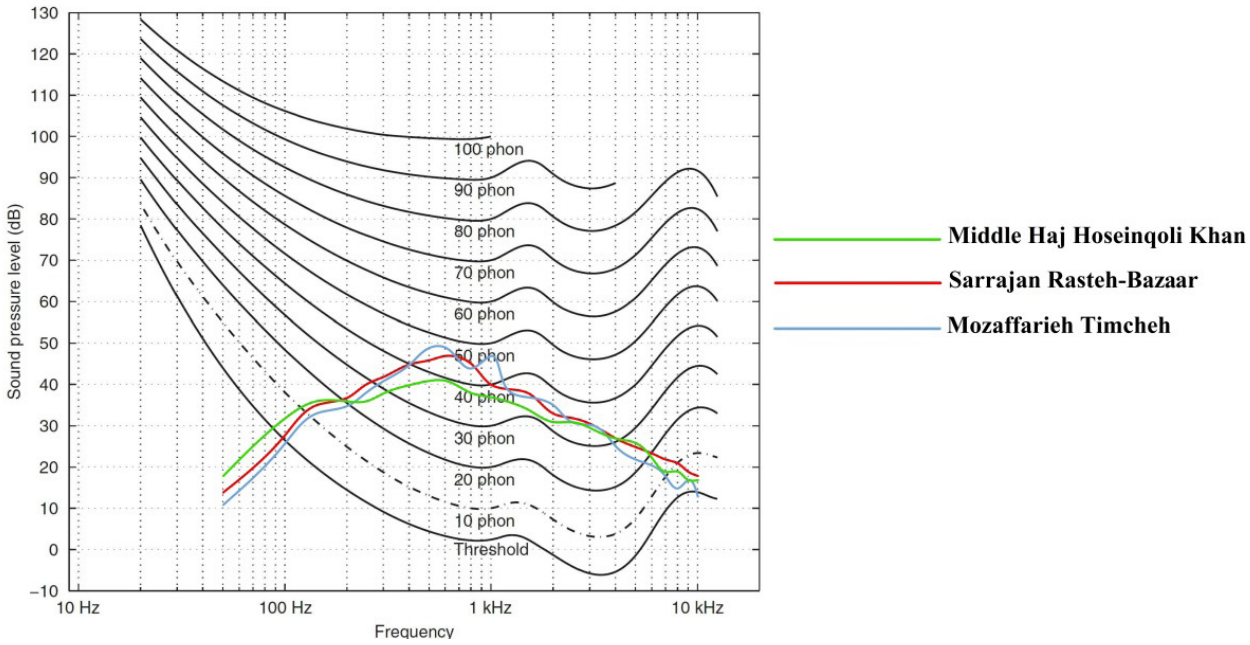
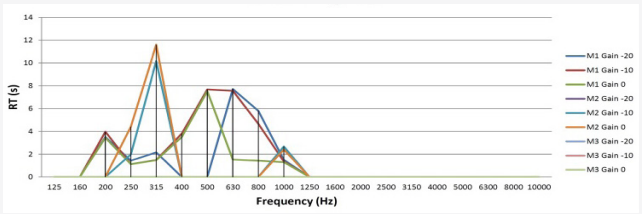
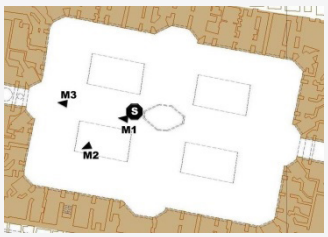


Fig. 5. SPL in Middle Haj Hosseinqoli Khan, Sarrajan Rasteh-Bazaar, and Mozzafarieh Timcheh compared to the normal equal-loudness-level contours. Source: authors.

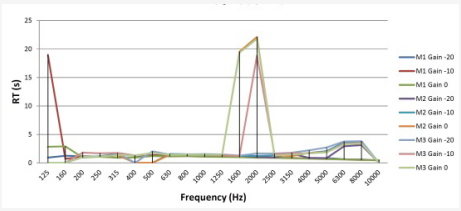
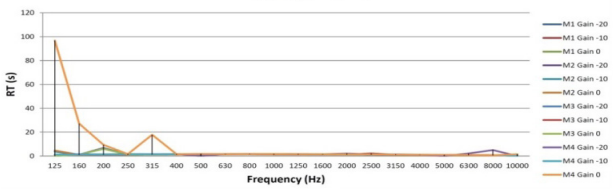
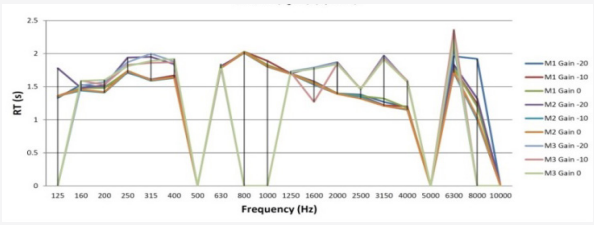
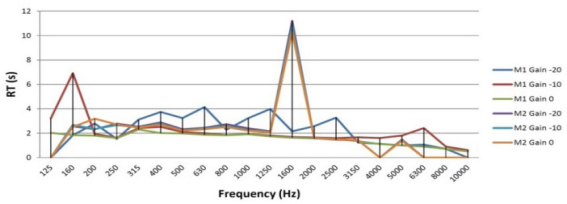
Table 5. RT Values in Middle Haj Hosseinqoli Khan. Source: authors.

Item	Explanation
Middle Haj Hosseinqoli Khan	Graph of RT values by frequency  Speaker (S) and Microphone (M) (sound meter) installation points  Remarks: Analysis of effective factors in reverberation time values - In the immediate area of the sound source, bass and relatively bass sounds have no echo effect in the space. - Despite the perfectly regular design of Khan and the walls, the existence of numerous sound barriers, causes irregular patterns over time. - At high volume, the glasses intensify some frequencies due to their high reflective effect. - At low volume, the trees eliminate the effect of intensifying the glass windows by scattering the sound waves. - By trapping sound waves, the entering dome of Khan from the side of the corridor, reduces its bending time to zero in any intensity and at all frequencies.

of semi-domed walls with sound retention. In contrast, glass surfaces attached to the wall, as well as elements such as a metal guard post, intensify sound waves and echoes.

Due to the location of the curvature at the end of the Sarrajan Rasteh-Bazaar and to clarify its effect on the acoustical behavior of the Rasteh-bazaar, speakers have been installed in four points of this space, which have been measured in different modes of RT (Table 6).

Table 6. RT Values in Sarrajan Rasteh-Bazaar. Source: authors.

Item	Explanation	
Sarrajan Rasteh-Bazaar	Graph of RT values by frequency	Speaker (S) and Microphone (M) (sound meter) installation points
		
	Remarks: Analysis of effective factors in RT values - In very treble sounds, the phenomenon of sound intensification is observed. But since in the real condition the intensity of the following sounds is very low in the Rasth-Bazaar, there is no noise caused by low-frequency sounds. -On both sides of Sarrajan Rasteh-Bazaar, when the sound source and microphone are very close to each other, the acoustical behavior is quite similar.	
Sarrajan Rasteh-Bazaar	Graph of RT values by frequency	Speaker (S) and Microphone (M) (sound meter) installation points
		
	Remarks: Analysis of effective factors in RT values -In two similar cases where the microphone is located at the same distances from the sound source, the values of the RT are almost the same. In fact, space shows similar behavior. -Environmental characteristics of this Rasteh-bazaar in order to eliminate sound waves through frequency confinement in cavities of space.	
Sarrajan Rasteh-Bazaar	Graph of RT values by frequency	Speaker (S) and Microphone (M) (sound meter) installation points
		
	Remarks: Analysis of effective factors in RT values -Physical changes in the form of curvature and curves in the paths, lead to changing the acoustical behavior of space. In fact, the observed turbulence is due to drastic changes in the specific order and pattern of the Rasteh-bazaar body.	
Sarrajan Rasteh-Bazaar	Graph of RT values by frequency	Speaker (S) and Microphone (M) (sound meter) installation points
		
	Remarks: Analysis of effective factors in RT values -The graph of frequency teeth 221 to 2211 Hz shows that in this frequency in the low range of sound intensity, the behavior of space in creating echoes is not predictable. -Charsouq, in all three sound intensities, has completely eliminated the three frequencies of sound waves emitted from the beginning of the Kaghazforushan Bazaar.	

The findings of the measurements indicate that at all the sound intensities at different distances from the sound source in both directions, the acoustical behavior of the space is the same and in order to eliminate and attenuate sound waves, especially in high frequencies. In some of the treble frequencies, sound intensification is observed, which due to their low intensity in real conditions, are not able to create echoes and noise in the Rsteh-bazaar. In fact, the humming is of the same quality throughout the Rasteh-bazaar at common distances from sound sources. Why so the amount of the RT is almost the same in the frequency spectrum.

Throughout the Sarrajan Rasteh-Bazaar, the shape and materials of the space shell are the same and its general form is a modular and regular repetition of arches and domes. However, the curve at the end of this Rasteh-bazaar is seriously changing this repetitive pattern. The disturbance of the modular order in a homogeneous space causes the uniform behavior of space facing sound waves to be different.

Comparison of the two values of RT at the three measuring points, which include the beginning of the curvature and the end point and outside the curvature, shows that major changes in the body of space clearly affect the acoustical behavior of space. In other words, the amount of echo varies along the way and consequently the heard hum is more or less felt. On the other hand, sincethe echo phenomenon is not the same for all frequencies of the path, the type of heard noise, bass or treble, is also different.

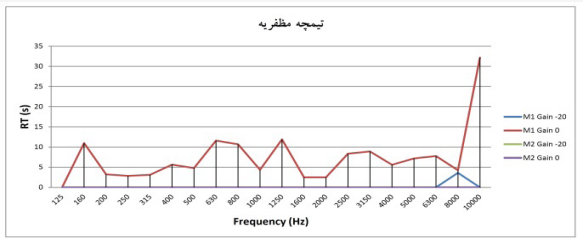
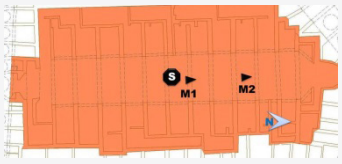
In Mozzafarieh Timcheh, the sound source is located in the center and measurement is performed at two points (Table 7).

The constituent elements of the original form of Mozzafarieh Timcheh, micro-scale domes of the roof, entrance hemispheres, delicate fractures in the shell and on the other hand its materials, bricks with plaster pointing, can keep Timcheh's RT values low by diffusion and trapping sound waves. But the measurements show that the additions added to Timcheh, glass showcases, have a strong effect on RT values and cause the phenomenon of echo in Mozaffariyeh Timcheh.

- Summary of the acoustical behavior of the studied spaces

The results of the measurements show that the RT in middle Haj Hosseinqoli Khan is very low due to diffusion and retention of sound waves by trees and domes. In some cases, echo is observed when the microphone is close to the glass windows or metal barriers. In Sarrajan Rasteh-Bazaar, which

Table 7. RT Values in Mozzafarieh Timcheh. Source: authors.

Item	Explanation
Mozzafarieh Timcheh	Graph of RT values by frequency  Speaker (S) and Microphone (M) (sound meter) installation points  Remarks: Analysis of effective factors in RT values -At low intensity, the dome of the center of Timcheh is able to eliminate reflections of glass surfaces and RT is zero. However, when the sound intensity is high, the holes in the horizontal shell cannot attenuate the effect of the volume of sound bounces from the glass surfaces. -Due to the coverage of a significant part of the wall surface with glass, the amount of RT and echo is high.

is a longitudinal space and its body consists of regular and repetitive forms, due to the diffusion of sound waves by the roof domes and their refraction through wall fractures, RT is a fixed and desirable value. At the end of Sarrajan Rasteh-Bazaar, where the direct axis of the Rasteh-Bazaar deviates, the values of RT are subject to major changes. Given the disruption of spatial order, the almost constant values of RT also change. Although the amount of crowd in the Rasteh-bazaar is significantly higher than Mozzafarieh Timcheh, Fig. 5 shows that the amount of SPL in these two spaces is almost the same. Even in Mozzafarieh Timcheh, two peak points can be seen, which is higher than the graph of Sarrajan Rasteh-Bazaar. This high volume intensity does not depend on the loudness of the sounds produced in space; Rather, it is influenced by the high values of RT in Mozzafarieh Timcheh, In fact, the occurrence of echo in Timcheh, due to the large glass surfaces in its walls, causes the SPL and the amount of noise in the space to increase.

- Analyzing the results of subjective assessments

In order to clarify the subjective and perception of the people present in the studied spaces from the two components of SPL and RT, subjective assessments were performed based on loudness [or slowness] of the sound, descriptive echo or mortality and sound source acceptability. Table 8 shows the average score given by the test subjects in each space to the slowness of the sound, echo, or mortality of the sound and the acceptability of the sounds heard.

The people present in the studied spaces perceive the heard sound in the middle Haj Hosseinqoli Khan more slowly than Sarrajan Rasteh-Bazaar and in Mozzafarieh Timcheh Bazaar more calmly. The graphs in Fig. 5 can be somewhat consistent with this subjective assessment. Why so the SPL in Mozzafarieh Timcheh with two peaks is higher than the SPL graph of Sarrajan Rasteh-Bazaar. The SPL diagram in the Khan has also a significant gap compared to the other two diagrams.

The score given by the respondents in the subjective assessment to the amount of echo heard is completely consistent with the results of the objective assessments. The echo of Mozzafarieh Timcheh is definitely higher than Sarrajan Rasteh-Bazaar. Although the echo in Haj Hosseinqoli Khan is almost similar to that of Rasteh-bazaar, subjective assessments have placed it between Timcheh and Rasteh-bazaar. This seems to be due to the way the dominant sound is heard in space than to the actual size of the RT.

The loudest and most continuous sound that can be heard in the Khan of Haj Hosseinqol is the sound of birds nesting on large trees. These birds include crows and sparrows and the sound of crows is much louder. The arrangement of trees in Khan is in the form of Charbagh. Consequently, birds are present in four directions and in almost all parts of the Khan. When a bird sings from one branch of a tree, a bird in another branch or tree may sing at the same time or at short intervals thereafter. Hearing the sound of birds is not a precise, regular and consistent accompaniment; rather, minor delays occur at short intervals. Listening to this

Table 8. Subjective assessments of the quality of sound heard in the three selected spaces. Source: authors.

	Perceived slowness	The degree of heard echo	Acceptance of sound sources present on space		
			Anthrophonic sounds	Biophonic sounds	Geophonic sounds
Middle Haj Hosseinqoli Khan	3.56	3.23	3.36	3.17 Average: 3.57	4.19
Rasteh-Bazaar Sarrajan	3.27	2.90	3.03	-	-
Mozaffarieh Timcheh	2.99	4.00	3.67	-	-

set of songs creates a feeling similar to an echo for a person sitting in the Khan or passing by. Moreovert, this type of human-perceived echo does not dependent on acoustic issues but is influenced by hearing a repetitive sound in time sequence and from different parts of space.

The acceptance of the sounds heard in Haj Hosseinqoli Khan, under the influence of the desirability of geophonic sounds, is significantly higher than in Sarrajan Rasteh-Bazaar and is in a situation almost similar to Mozzafarieh Timcheh. The interesting thing about comparing the acceptability of the heard sounds in Rasteh-bazaar and Timcheh is that the sound sources are the same, except for motorcycles, but their acceptance is significantly higher in Mozzafarieh Timcheh. This can be affected by two issues. The first is the annoyance of the sound of motorcycles, which is due to the difference in the SPL that it creates at the moment of entering space. Another point is the essential difference between Rasteh-bazaar and Timcheh. In fact, the spatial differences that exist between the natures of these two types of space may affect the comfort of those present and their perception of the sounds heard.

- **Discussion on the results of the data**

What is clear is that the sound climate is different in Rasteh-bazaar, Timcheh and Khan. The measured values of the SPL in the three studied spaces show that the difference in sound intensity in these spaces can to some extent cause this difference in the soundscape. On the other hand, the RT determines the amount of echo heard in space and the measured values show that the RT is different in different space species. The amount of echo can greatly affect the quality of the heard sound; especially in the case of the Rasteh-bazzar, where the dominant sound is of the broad type and is heard everywhere.

As mentioned, the measurements performed show that some components affect the amount of echo. The presence or absence of these components in different types of space and even in different parts of each space is different from each other and naturally “what is heard” and “as heard” are different in various parts.

In the middle Haj Hosseinqoli Khan, at the central point around the pond, the dominant sounds are the sound of water, the leaves of trees, sparrows and crows. The crows’ song may be the answer to each other; first, heard from a tree in one corner of the Khan and a few seconds later from a tree in another corner. At the same time, the difference in hearing a particular sound can cause some degree of feeling echo for the listener. When moving from the center of the Khan to the sides, the entrance of the corridor that connects the Khan to the Rasteh-bazaar is gradually reduced to the sound of crows and sparrows and the sound of the wind and with the voice of people, footsteps and carts. Joint points are the entrances of the corridors, special points in terms of space as well as a soundscape. In these places, due to the location of the dome at the starting point of the corridor, the RT is zero and no echo is felt at that point. However, at this point, the person also hears the sounds of geophony and biophony of the Khan and the talking or activity of the people present in it, on the other hand, the Rasteh-bazaar humming is heard; and the natural light of the Khan can be felt, on the other hand, the dim space of the corridor and then the Rasteh-bazaar is seen; The difference between temperature and humidity in the interior of the Rasteh-bazaar, among other factors, causes all five human senses to feel that the situation is changing.

After passing by the corridor that connects the Khan to the Rasteh-bazaar, upon entering the Rasteh-bazaar, the state of the soundscape changes completely. Geophonic and biophonic sounds are eliminated and what is heard is human activity in the current bazaar activity. Talking people to each other and the commotion of footsteps is the dominant sound that spreads like air throughout the Sarrajan Rasteh-Bazaar. The regular and repetitive geometry of the body of the Sarrajan Rasteh-Bazaar causes the amount of heard echo to

be almost the same in different places. The amount of SPL is such that it is physiologically suitable for humans and does not cause harm. But in the meantime, sometimes the sound of carts being accompanied by their users telling "Ya Allah", or the sound of moving goods, which is sometimes accompanied by dropping them, suddenly disturbs the calm and stable conditions of hearing in space. This disturbance of tranquility is more severe when a motorcycle suddenly appears in the Rasteh-bazaar. In fact, the uniform hum of the Sarrajan Rasteh-Bazaar itself does not in have a high volume; but the sudden appearance of sounds such as motorcycles or carts causes immediate fear in people. Many people are momentarily disturbed when they hear the warning "Ya Allah". On the other hand, there are some sudden sounds that are like signal sounds and create a pleasant feeling. In the middle of the day, the sound of Adhan is heard from the bazaar mosques and subsequently, the food sellers appear in the bazaar and shout loudly, sometimes in the form of songs. On hot summer days, some street vendors usually sell cold drinks, which are accompanied by voice announcements. Sometimes other traveling vendors sell music products and to introduce the products they play it loudly, which creates an interesting contrast with the listening atmosphere of the Rasteh-bazaar. Vendors of music, beverages and food are considered linear sound sources and their sounds are soundmarks.

Sarrajan Rasteh-Bazaar is a longitudinal and transient space that usually has moderate light and is often accompanied by crowds that reduce the possibility of standing and pausing. This reduces the tolerance threshold for noise caused by high population density to some extent. However, changing the direction of movement along with the Rasteh-bazaar order to Mozzafarieh Timcheh, causes the information received by the human senses to change at once. The atmosphere of Mozzafarieh Timcheh is brighter by using more natural light; crowds are significantly reduced; it is easy to stand, pause and wait. Most importantly, the stunning architecture and beauty of the space is very impressive. The Rasteh-bazaar sound is perceived as the wide sound when moving along the bazaar and is the dominant sound. But when the listener is present in Timcheh, the humming of the Rasteh-bazaar is heard as a point sound from Timcheh's entrance and is less intense. The echo phenomenon in Timcheh is due to the large surface area of the glass and the perceived echo is relatively more intense. The calm atmosphere of Mozzafarieh Timcheh and the small number of attendees make the sound of talking more clearly understood. Unlike the Rasteh-bazaar, where the sound of talking is part of the keytones, in Timcheh it is a soundmark that may be unpleasant for some, especially bazaar traders. In fact, by changing the type of space, the role of the same sounds also changes.

The previous lines describe the subjective feeling and perception of people as they move from one type of space in the bazaar to another. The Khan, Rasteh-bazaar and Timcheh are different in nature. Different spatial features in them cause the person to feel the difference and diversity in the spatial experience while moving and walking in them. In fact, what is referred to in the urban design literature as "spatial distinction" is clearly seen in this case. The distinction makes any space different from adjacent spaces and according to many thinkers, creating a series of distinct spaces in the city is one of the basic principles of urban design, which [so far] is the main emphasis on human visual sense and perception. This spatial quality is ultimately created in the series of Tabriz Bazaar spaces. The important point in connection with the subject of this research is that along with "spatial distinction", in the series of Tabriz bazaar spaces, "sonic distinction" is also perceived.

Different types of space in the bazaar, Rasteh-bazaar, Timcheh and the Khan have different geometric and physical characteristics that cause them to show different acoustical behavior. This

makes the sound of each space "as it is heard" different. In addition, the sound sources present in different spaces are diverse, which also makes "what is heard" different. This feeling of difference between "what is heard" and "as heard" is most pronounced when one moves from one spatial species to another. It can be acknowledged that this difference in the auditory sense is due to the quality of "sonic distinction", which specifically refers to the diversity of soundscapes in different spatial types of the bazaar (Fig. 6).

Conclusion

Findings indicate that the physical characteristics of Tabriz Bazaar spaces affect their acoustical behavior. This effect is mainly made through three ways of reflection, scattering and retention of sound waves. Table 9 shows the physical factors affecting the acoustical behavior of Tabriz Bazaar.

The acoustical behavior of Tabriz bazaar spaces, which is accompanied by changes in the values of RT and SPL, affects the auditory experience of people during movement along with different types of space. In other words, the difference in the acoustical behavior of the space can be assessed by the amount of echo and intensity of the sound in the space, the difference in which makes the listening mood of the spaces different. Subjective assessments also show that these differences are also perceptually understandable. Thus, different spatial species have different soundscapes, part of which depends on their different acoustical behavior.

Another noteworthy point in this regard is that visual information and spatial qualities affect people's subjective perception of a soundscape. Spatial qualities resulting from the geometry of space, form and numerical proportions among its

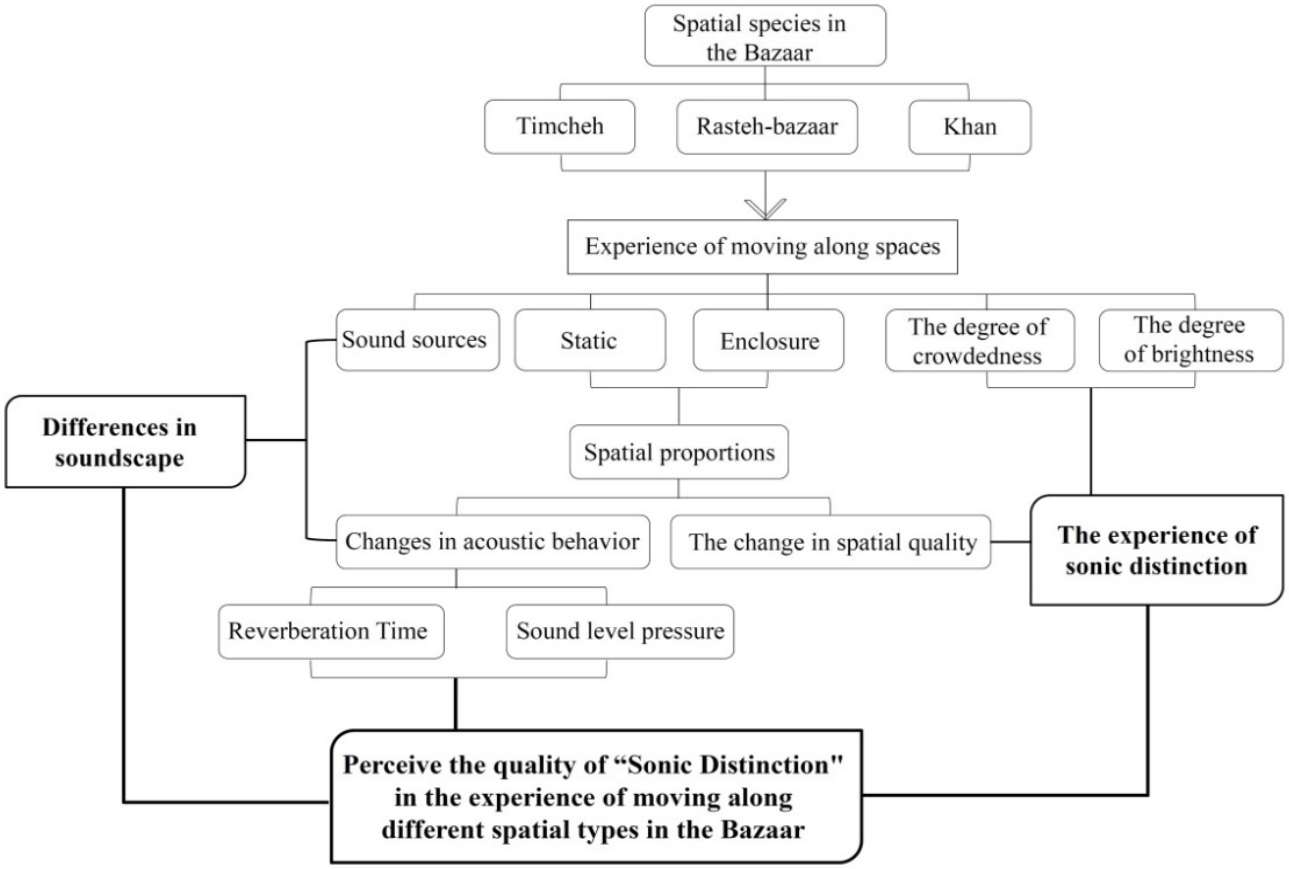


Fig. 6. Factors involved in perceiving the quality of sonic distinction in different spatial species. Source: authors.

Table 9. The most important factors affecting acoustical behavior of Tabriz Bazaar spaces. Source: authors.

	The type of behavior versus sound waves		
	Retention (Decrease of the RT)	**Scattering (Decrease of the RT)**	**Reflection (Increase of the RT)**
Influential factor	- Small-scale cavities; roof - covering domes and space entrance hemispheres	- Fine fractures in the shell of the walls -Fine fractures caused by wall materials (bricks with plaster pointing) - Trees [in the Khan]	- Glass surfaces - Metal surfaces

dimensions, the distance of the components from each other that can lead to a special feeling in the space attendees. On the other hand, the same physical characteristics specifically affect the acoustical behavior of spaces, which in turn affect the quality of heard sound. Therefore, it can be acknowledged that the body of different spatial species affects the subjective perception of the soundscapes of spaces in two ways; direct effect on acoustical behavior and sound quality and an indirect effect through qualities and spatial feeling and its effect on subjective perception from the soundscape. Therefore, when people experience movement along different types of space, the physical properties of the spaces affect both the quality of what they see and the quality of what they hear. In fact, while moving along with different spatial types, one experiences “spatial distinction” as well as “sonic distinction”. This subjective experience and perception of spatial and sonic distinction along the three spatial types of Tabriz Bazaar can be examined in the form of Table 10.

As can be seen, the special spatial features of Tabriz Bazaar cause a spatial distinction in terms of the feeling of being in space and the quality of the sounds heard while moving along different types of spaces. The physical characteristics of

Table 10. Components involved in the perception of acoustic distinction in the experience of motion along spatial species of Tabriz Bazaar. Source: authors.

	The Components of heard sound quality				**Spatial qualities**				
	Sound slowness	**Spatial echo**	**The acceptance of heard sounds**	**Dominant sound**	**Stagnation or dynamism**	**Enclosure**	**Pause possibility**	**Crowdedness**	**Brightness**
From Khan to Rasteh-bazaar	Almost slowly to slightly slowly	Slightly echoes to normal	Relatively desirable to Normal	Natural to the Rasteh-Bazaar humming	Static to dynamic	Open to completely closed	Possibility of standing, sitting, watching, eating and drinking to impossibility of pausing	Ascending	Descending
From Rasteh-bazaar to Timcheh	Slightly slow to normal	Normal to echoes	Normal to almost desirable	Rasteh-bazaar humming to talking	Dynamic to relatively dynamic	Completely closed to closed	Impossibility to pause to the possibility of standing, sitting, watching, eating and drinking	Descending	Relatively ascending

Tabriz Bazaar have caused that depending on various components, sound morality is different in several places. This difference has created a variety of auditory moods in the spatial species of Tabriz Bazaar, which, along with the visual components, plays a significant role in creating a sense of dynamism and movement, vitality and performing various activities. Thus, the perception of sonic distinction along the different spaces of Tabriz Bazaar is very useful in the role of this valuable and historical place. Though the "sound of the bazaar" has created a greater sense of belonging in the citizens of Tabriz, has provided the ground for the presence of more people from different social classes, so it is possible to preserve its body and its place in the collective memory. Also, the special listening experience of "sound of Tabriz Bazaar", a memorable experience for tourists, can become a component for the development of tourism in this unique place. In this regard, the design pattern of Tabriz Bazaar can be a way for the design of commercial and multi-purpose complexes in the contemporary era.

In general, due to the study done on the acoustical behavior of three samples of the three spatial species of Tabriz Bazaar, it is concluded that depending on the spatial characteristics, the quality of sound heard in the Khan, Rasteh-bazaar and Timcheh is different. The differences between the three different spatial types in the geometric ratios, the degree of enclosure, the stagnation and dynamism and the materials of the shells, cause the acoustical behavior of each space to be different from the other and to be perceived differently.

Thus, different types of space in the city have different geometric and physical characteristics that cause the exhibition of different acoustical behavior. This, along with the variety of sound sources in each place, causes the soundscapes of the spaces to be different. When a person moves from one type of space to another, this diversity and difference is more pronounced in the soundscapes of different urban spaces. In fact, it can be acknowledged that this difference in auditory sense is due to the quality of "sonic distinction", which specifically refers to the diversity of soundscapes in different urban spatial species with different spatial-local characteristics. In the vast majority of urban soundscape studies, the emphasis is on the quality of the heard sound in a particular urban space. Therefore, it has been overlooked that the consecutive experience of various soundscapes, along a range of different urban spaces, can play a perceptually effective role in people's feelings. Therefore, it seems necessary to examine the citizens' listening experience not only in a specific space, but also in a series of consecutive urban spaces. In this regard, paying attention to the quality of "sonic distinction" can be helpful. Because the smart design of the body of urban spaces, along with a variety of sound events, can create a collection of "distinctive soundscapes" and create pleasant experiences for urban passers-by.

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