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# Daylight, View-Out, and Windows: The Sensorial-Based Design of Ottoman-Era Mosques.

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**Abstract:** Daylighting and outside view, as window design parameters, are often the main ambience-generating design factors that connect the users' sensorial relationship to their external environment. These relationships and their resulting ambiances vary by building type and carry a heightened value in some specific typologies of which, religious buildings hold a paramount place. Indeed, the sophistication of openings' design strategies applied throughout centuries in religious buildings, are good learning grounds on the use of daylighting and its resulting sensorial impact on users. In addition to a literature review related to Ottoman religious architecture, this paper reports on an in-situ field investigation that explored these relationships in a corpus of forty-five (45) mosques in Bursa, Edirne, and Istanbul, dating back to the Ottoman era (1299-1923). Breaking with past schemes, the new design paradigm introduced drastic changes in plans, openings, windows, views, and daylight, which resulted in unique ambiances. The variables investigated in this study include: i) the window location within the mosque envelope (zenithal and/or lateral), ii) the window location concerning the conventional prayer direction referred to as "Qibla" wall, and iii) the window transparency that permits or stops/blocks the outside view. In addition, the view content encompasses the identification and categorization of the objects, as seen by the worshipers while performing their prayers, through the ground-level windows. The collected information was converted into a database for statistical analysis. By focusing on the human sensorial-based design in the Ottoman mosques, the results revealed the daylighting design specificities of the building envelope and the windows as well as the nature of the view out content. Both of them attested to the human-centered design by Ottoman builders offering worshipers a strong connection to the external environment, thus creating ambiances conducive to spiritual fervor and beatitude.

**Keywords:** Daylighting; Window design; View out; Heritage Ambience; Ottoman Mosques.

## 1. Introduction

Environmental design could not be undertaken without considering the users [1, 2]. Significant research substantiates the inadequacy of building design as a result of failure to meet users' needs, resulting in discomfort, energy performance gap, alteration of buildings, and/or reduced productivity [3-5]. Hence, several approaches have been established by researchers to set up ways that would allow the consideration of the users during the architectural design process. Going beyond the functional aspects, researchers are increasingly focusing on the psychological and behavioral effects including emotions and feelings.

In the architectural research field, "Ambiances" or "Atmospheres" is a widely known theme highlighting the human sensorial relationships towards urban and architectural environments [6].



Such relationships are limited to what the built environment transmits, through the most common human senses, to its users. This research work belongs to the same thematic context of scientific research. It investigates the luminous ambience in the Turkish Ottoman mosques through the study of window openings design strategies, with a focus on daylight admission and the provision of a view out. Both parameters are considered as important factors for human physical and psychological well-being within the built environment realm.

The investigation of such aspects within historical buildings remains inherent to the fact that these ambiances constitute an intangible heritage needing to be studied, advertised, and preserved [7, 8]. Additionally, contemporary users' needs, as well as building techniques development, must be carefully adapted to the specific constraints of such historical buildings. This will also allow the constitution of a set of architectural daylighting design references for the contemporary restoration of Ottoman architectural religious buildings. It must be reminded here, that the design order in question is present in most of the Muslim and non-Muslim parts of the former Ottoman Empire and is an inherent part of the local architectural heritage [9].

## **2. Ambience, natural light, view out, and Islamic architecture**

From the conceptual point of view, ambience is modeled as a temporally evolving condition that expresses the interaction between four components: i) the Context (climatic, cultural, and social), where the investigated built environment is located (building and/or urban space), ii) the Architectural space (shape and usage), iii) the Sensorial stimulus-related physical environment previously enumerated, and iv) the Users through perceptual and behavioral conducts towards the spaces [10,11].

Equally valorized by Islamic builders and writers, while enjoying a manifest presence in several Quran verses, natural and artificial lighting are epitomized as an inherent component of 'Beautiful' [12]. From an artistic point of view, artificial lighting artifacts such as chandeliers are considered a unique craft field of a high caliber. Besides, and similarly to geometry and rhythm, light is one of the artistic tools expressing the 'unity of existence' or 'unity of the real' in the architectural composition.

Natural light is a critical stimulus historically recognized as the main design component in Islamic architecture. The Islamic art and architectural historian Oleg Grabar indicated that the contrast between light and shadow in the first Islamic palace architecture was different than the one inherited from Roman classical buildings [13]. Moreover, the archeologist J. Bonnéric also attested that in medieval Islamic architecture, the light created an intangible architecture that comes to be superimposed to the material one [14]. Beyond the mosque's roofs, walls, and finish materials, natural light plays a major topological-based functionality in addition to the divine symbol it represents [15]. Respectively, natural light indicates distinct areas inside the prayer hall such as: i) the Mihrab and Minbar zone from which the Imam leads the community prayer and the Friday sermon, and ii) the other parts of this space reserved for the regular prayers. Moreover, as it is the case for any sacred space, Muslim worshippers are also not insensitive to the divine symbolic effect of light [12, 16, 17]. Inside the mosque, the perceiving process has been revealed as a sensing function type involving the five senses (vision, touch, smell, taste and hearing). These senses are driven by the details and people focus first on them before defining an impression. In addition, it has been pointed out that the mosque's physical environment provides that outer physical and social stimuli in favor of the worshippers' extraversion, preferred orientation in terms of spiritual relationships with God [18]. Therefore, natural light constitutes one of the most powerful external physical environments that: i) are sensorially perceived by means of human vision, ii) make worshippers focus on the mosque envelope's details, in particular its various openings and the views contents they provide, and iii) offer that extraverbed environment linking spiritually the worshippers to their creator.

Natural light, as an immaterial stimulus, was at the basis of the creation of numerous and rich Islamic architectural components varying from the larger urban scale to the minute construction detail [19, 20]. For the special case of Ottoman religious architecture, a previous study by one of this study's authors highlighted such daylighting design-related architectural variety in the case of Ottoman mosques in Tunisia and Algeria [21]. In and closely associated with natural lighting, the

provision of a view outside the prayer hall seems to be a supplementary character distinguishing Ottoman religious architecture from other preceding sacred buildings including Islamic ones. The lower windows in the Ottoman mosques' prayer hall provide a view to the outside. This is not; however, the case of the mosques built during the Ottoman's earlier dynasties. Additionally, these windows are unscreened and differ from the upper ones in the same wall. For, the view content is considered as sources of latent signals including skylight, sunlight, gardens' colors and odors as well as the carved tombstones' shapes. These latter participate powerfully in the prayer hall's inner ambience.

This study aims to explore, identify and survey window openings design in the Ottoman mosques in Turkey. These ambient components are considered as the architectural devices transmitting the luminous and other latent signals towards the mosque's users (worshippers and travelers as well). Users receive these various signals sensorially. Describing the inner luminous ambience of Istanbul's Fatih Mosque, F. Babinger said:

*"The interior of the mosque is of almost overpowering puritanical simplicity. The unobscured light enters through numerous windows ordered in superimposed rows" [22, p. 177].*

The windows' provision of an outside view seems to be another important function as it was cited by the traveler Stratten:

*"The eye, from inside or from out, sees clear through the building. ...He (Sinan) glazed those at floor level with clear glass and grilled with the Ottoman rectilinear iron bars..." [22, p. 187].*

It must be pointed out that using such sensorial signals to affect the worshippers is a key design strategy for Ottoman architects; for, art is a means to bring humans closer to their Creator. Rather than a geometric shape order, the designed dynamic, changing, and unexpected visual qualities of spatial experiences are based on distinct and/or associated effects of color and light among others. Such sensorial-based relationships between the mosque's inner spaces and its natural and/or urban exterior environment are treated from the most general to the smallest of conceptual details [23].

In order to undertake this investigation, an extensive literature review and a large in-situ fieldwork were carried out. Additionally, an analytical protocol was developed.

### 3. Study Corpus

In his book entitled "Mosques of Istanbul including the mosques of Bursa and Edirne", Matthews [24] sets chronological groupings of Ottoman mosques as they historically evolved from the early to the latest stages of the Ottoman Empire. Hence, the architectural historian defined six main eras; i) Period before the conquest of Constantinople (mosques in Bursa and Edirne), ii) Early period after the conquest of Constantinople, iii) Classical period (Sinan's mosques), iv) Late classical period, v) Baroque period, and vi) Late Nineteenth-century period.

In addition to three Christian churches converted into mosques, Matthews enumerates forty-six (46) mosques constructed during these periods and located in Bursa, Edirne, and Istanbul. Among this collection, forty-one (41) mosques were visited and selected as the study corpus of this investigation. In addition, four (4) mosques located in Istanbul and not cited by H. Matthews [24] were visited and added to the study corpus; i) Firuz Aga Mosque (Early period after the conquest of Constantinople), ii) Seb Sefa Hatun Mosque (Baroque period), iii) Pertevniyal Valide Sultan Mosque, (Late Nineteenth-century period), and iv) Ertuğrul Tekke Mosque, (Late Nineteenth-century period)

As a result, forty-five (45) mosques constituted the study corpus, spanning though the various eras as defined by H. Matthews [24], and located in the three most important Ottoman cities of Bursa, Edirne, and Istanbul (Table 1).

**Table 1.** The in-situ investigated study corpus mosques in Bursa, Edirne and Istanbul.

N°	Name	City	Era	Style -Matthews's Classification
1	Alâeddin Mosque	Bursa	1335	Bef. Constan. Conq.
2	Orhan Gazi Mosque	Bursa	1339	Bef. Constan. Conq.
3	Yildirim Beyazit Mosque	Bursa	1391-95	Bef. Constan. Conq.
4	Ulu (Great Mosque)	Bursa	1396-1400	Bef. Constan. Conq.
5	Yeşil (Green Mosque)	Bursa	1412-22	Bef. Constan. Conq.
6	Muradiye Mosque	Bursa	1424-26	Bef. Constan. Conq.
7	Eski (Old Mosque)	Edirne	1403	Bef. Constan. Conq.
8	Muradiye Mosque	Edirne	1435	Bef. Constan. Conq.
9	Üç Şerefeli Mosque	Edirne	1438-47	Bef. Constan. Conq.
10	Murat Paşa	Istanbul	1469	Early M. Aft. Conq.
11	Beyazit II	Edirne	1484-88	Early M. Aft. Conq.
12	Firuz Aga	Istanbul	1491	Early M. Aft. Conq.
13	Gazi Atik Ali Paşa	Istanbul	1496	Early M. Aft. Conq.
14	Sultan Selim	Istanbul	1522	Early M. Aft. Conq.
15	Haseki	Istanbul	1550-51	Classical Sinan
16	Mihirmah Sultan Iskele	Istanbul	1543/44-48	Classical Sinan
17	Şehzade	Istanbul	1543-48	Classical Sinan
18	Süleymaniye	Istanbul	1550-57	Classical Sinan
19	Kara Ahmet Paşa	Istanbul	1565-71	Classical Sinan
20	Sinan Paşa	Istanbul	1554-55/56	Classical Sinan
21	Rüstem Paşa	Istanbul	1561-63	Classical Sinan
22	Mihirmah Sultan	Istanbul	1563-70	Classical Sinan
23	Molla Çelebi	Istanbul	1570-84	Classical Sinan
24	Selimiye	Edirne	1568-75	Classical Sinan
25	Sokollu Mehmet Paşa and Ismahan Sultan	Istanbul	1567/68-71-72	Classical Sinan
26	Piyale Paşa	Istanbul	1565-73	Classical Sinan
27	Zal Mahmut Paşa and Şahsultan	Istanbul	1577-90	Classical Sinan
28	Sokollu Mehmet Paşa	Istanbul	1573-77/78	Classical Sinan
29	Atik Valid Sultan	Istanbul	1571-83	Classical Sinan
30	Kiliç Ali Paşa	Istanbul	1578-81	Classical Sinan
31	Şemsi Ahmet Paşa	Istanbul	1580-81	Classical Sinan
32	Nişancı Mehmet Paşa	Istanbul	1584/85-88/89	Classical Sinan
33	Yeni Valid Emi	Istanbul	1597-1663	Late Classical
34	Sultan Ahmet (also called Blue Mosque)	Istanbul	1609-16	Late Classical
35	Yeni Valid Usk	Istanbul	1708-10	Baroque
36	Nuruosmaniye	Istanbul	1748-55	Baroque
37	Laleli	Istanbul	1759-63	Baroque
38	Fatih	Istanbul	1767	Baroque
39	Seb Sefa Hatun	Istanbul	1787-88	Baroque
40	Eyüp Sultan	Istanbul	1798-1800	Baroque
41	Dolombahçe	Istanbul	1853	Late 19 <sup>th</sup> Century
42	Mecidiye	Istanbul	1854	Late 19 <sup>th</sup> Century
43	Pertevniyal Valide Sultan	Istanbul	1871	Late 19 <sup>th</sup> Century
44	Hamidiye	Istanbul	1880	Late 19 <sup>th</sup> Century
45	Ertuğrul Tekke	Istanbul	1887	Late 19 <sup>th</sup> Century

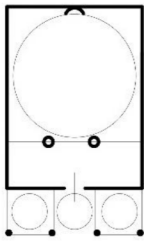
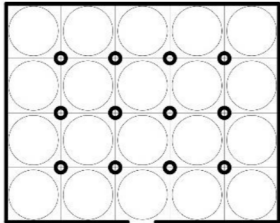
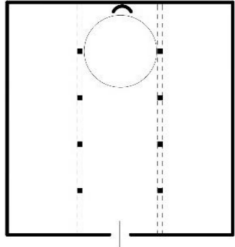
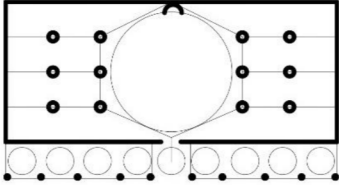
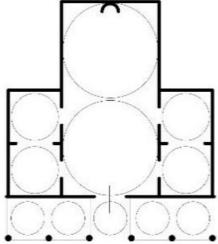
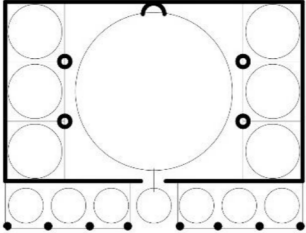
## 4. Methodology

From an architectural point of view, daylighting is primarily provided in a lateral and/or zenithal way, regardless of the used means [25]. Hence, this research considers openings located in roofs and walls. This study presents specifically the investigation of the Qibla wall's openings and its resulting ambiances. The Qibla wall, always oriented towards the Kaaba in Mecca, is the wall faced by all worshippers during their prayers. However, the space characteristics are still crucial parameters in terms of daylighting design [26]. Thus, the mosque's prayer hall is examined to set up a series of daylighting-related morphological indicators. The methodological approach is; therefore, based on an in-situ detailed survey of the parameters and characteristics of the daylighting strategies in each considered component, roof and wall, followed by a statically analysis of the data collected.

### 4.1. Ottoman mosques' prayer hall characteristics

The Ottoman Mosque has been and remains an attractive architectural research topic and several publications, as well as scientific events, are devoted to it. For this investigation, the Ottoman mosque typology is based on an adaptation of Oney's classification, who divided the XIV<sup>th</sup>-XV<sup>th</sup> century era of Ottoman mosques into seven types [27]. This investigation; however, considers six types instead of seven with type 5 and type 6 being combined to form the inverted T-shape mosque type (also called mosque with "Tabbanes/Zaouias" which are two additional prayer areas located laterally and set back from the main prayer hall). The six resulting types are: i) The cubical buildings with a unique cupola, ii) the hypostyle mosques, iii) the basilica-style mosque, iv) the mosque with a transept, v) the inverted T shape mosque, vi) the mosque with a central dome (Table 2). In addition, the location of a mosque within a religious urban complex and the resulting landscaped setting remains into consideration due to its link to the view-out content.

**Table 2.** The six types of mosques' prayer halls (Variants' examples).


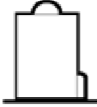






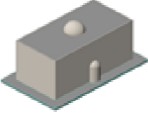

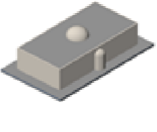

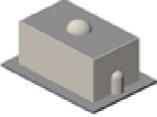
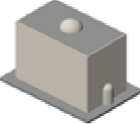

	
The cubical building with a unique cupola	The hypostyle mosque
	
The cubical building with a unique cupola	The hypostyle mosque
	
The inverted T shape mosque	The mosque with a central dome



In addition to this architectural-historical classification, the prayer hall size needs to be considered in daylighting design. Hence, the width, length, and height of the prayer hall are considered in this study. They are distinctively divided in categories per their width/length ratio and include: i) square (width = length), ii) large (width > length), and iii) deep (width < length). The categories defined in respect to the prayer room height are: i) regular (height = length), ii) high (height > length), and iii) low (height < length).

To set up a more daylight-related classification that is independent of the effective (metric) area of the prayer hall, the inner volume of this latter has been categorized in respect of its height, length, and width. This synthetically inner volume-based classification emerges from the crossing of the previous categories and results in three kinds of prayer hall inner volumes: i) cubical, ii) slender, and iii) flattened (Table 3).

Table 3: Categories of the Ottoman mosque's inner prayer hall volume.

			Section		
			Regular	High	Low
Plan					
	Square		 <i>Cubical</i>	 <i>Slender</i>	 <i>Flattened</i>
	Large		 <i>Flattened</i>	 <i>Slender</i>	 <i>Flattened</i>
	Deep		 <i>Flattened</i>	 <i>Slender</i>	 <i>Flattened</i>

#### 4.2. Domes and cupolas openings

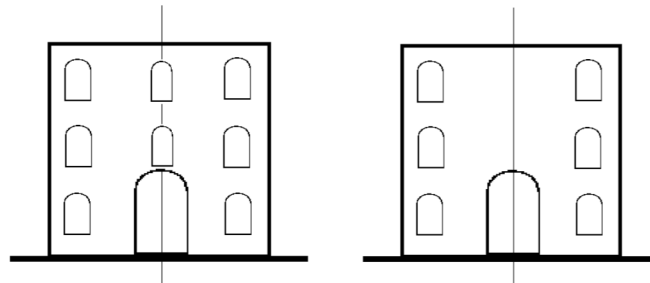
Typically, in an Ottoman mosque design, zenithal daylighting occurs through apertures in cupolas and domes. These openings vary in number and location according to the building construction era. This research refers to the classification established in R. Günay's book entitled "*Sinan. The architect and his works*" which identified five base types of Ottoman mosques [28]: i) square-based single-domed mosques, ii) square-based semi-domed mosques, iii) hexagon-based mosques, iv) octagon-based mosques, v) multi-based multi-domed mosques. This typology was extended to the entire corpus' mosques and applied to those built before and after Sinan's era as well as by other builders.



#### 4.3. Qibla wall openings

The characteristics of both vertical and horizontal distributions of windows within the Qibla wall may be analyzed as follows [28]. Horizontally, the windows are divided into series depending on their openness/closeness as they relate to the absence/presence of a screen. The screens are also distinguished as inside, outside, or double (inside and outside screens). The absence of a screen provides the prayers with a view out through the window. Its presence allows sunlight and/or daylight admission as well as a play of a mixture of colored sunrays. This division of window screens is quantified as a quotient defining the number of screened windows' rows per the total number of rows of windows in the whole Qibla wall.

Vertically, attention is paid to the presence/absence of windows in the Mihrab's axis (Figure 1). This axis is prominent in all mosque designs as it indicates the direction of the Qibla inside the prayer hall, and consequently, the location of the windows highlights such importance. Additionally, it is argued that the location of windows on both sides of the Mihrab will have a similar but less expressed importance. The number of window stacks (or vertical series) within the Qibla wall is considered. However, this division is quantitatively limited to the number of those located on either side of the Mihrab's axis.



**Figure 1.** Presence or Absence of the Qibla wall's windows in the Mihrab's axis (Respectively on the left and right).

### 5. Results and Analysis

The surveyed characteristics of the investigated Ottoman mosques formed a database which was then examined through a statistical descriptive and multivariate analysis using the "Statistica" 7.1 version program [30]. This constituted corpus indicates that mosques with a central dome are predominant (76%). The cubical mosques with a unique cupola, the hypostyle mosques, and the mosques with "tabbanes / Zaouias" (inverted T) are less present; respectively accounting for 9%, 9%, and 7%. The results and analysis that follows addresses each component (prayer hall, roofing system and Qibla wall).

#### 5.1. Prayer hall characteristics

The prayer hall characteristics highlighted predominant categories. The inner volume-based classification of the prayer hall allows the identification of the most dominant categories as the flattened (49%) and slender (40%) prayer halls, while the cubic one was less frequent (11%) (Figure 2).

#### 5.2. Prayer hall's roofing system characteristics

As an integral part of the roof design, most of the principal domes (84%) include windows. They are distributed as follows: i) the square-based single-domed mosques (24%), ii) the square-based semi-domed mosques (18%), and iii) the octagon-based mosques (18%) (Figure 3). The double in-depth square-based domed mosques, the hexagon-based mosques, and the multi-based multi-domed mosques are less present (respectively 13%, 13%, and 7%). Besides, few cases (representing 2%) are:

i) double in large square-based domed mosques, ii) single eccentric-based mosques, and iii) windowless octagonal-based domed mosques.

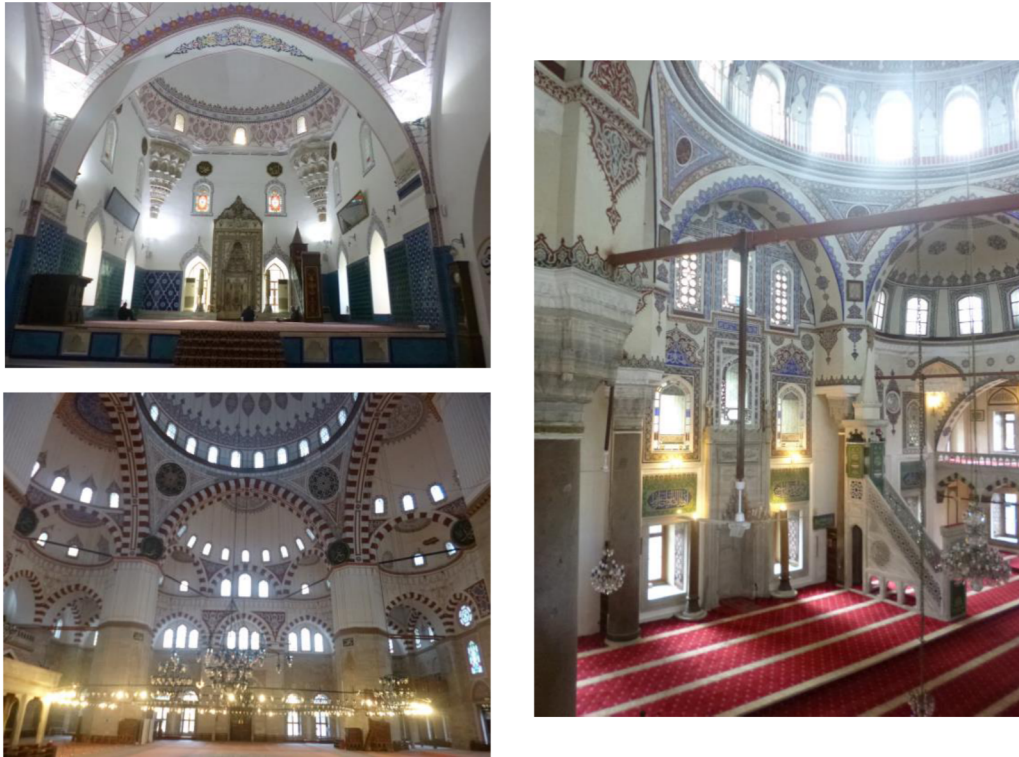


Figure 2. The presence degree of the studied mosques' prayer hall inner volume categories: i) Left top: Flattened (49 %), ii) Right: Slender (40 %), and iii) Left down: Cubical (11 %).

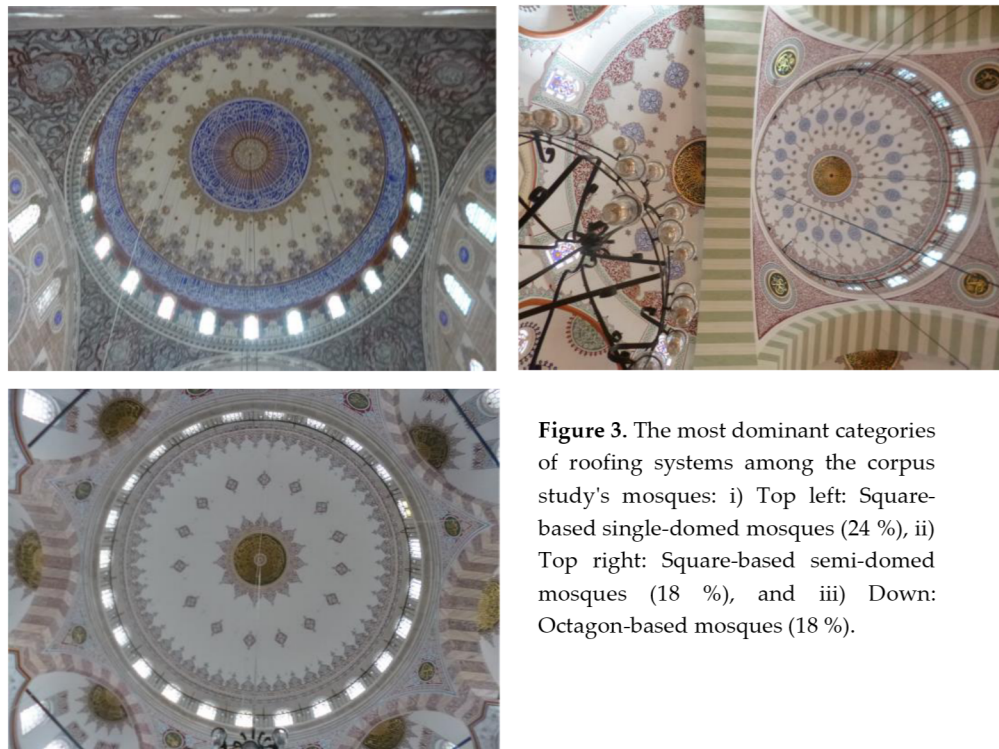


Figure 3. The most dominant categories of roofing systems among the corpus study's mosques: i) Top left: Square-based single-domed mosques (24 %), ii) Top right: Square-based semi-domed mosques (18 %), and iii) Down: Octagon-based mosques (18 %).

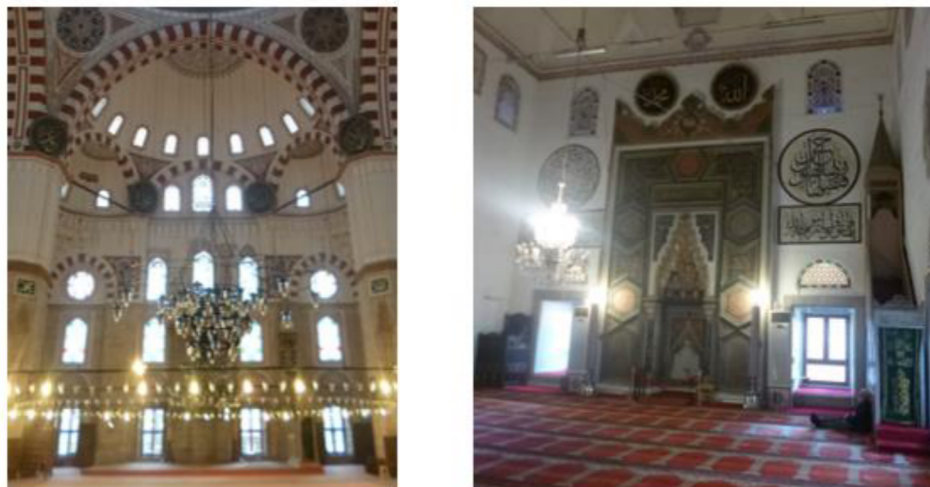
### 5.3. Characteristics of the Qibla wall windows

The Ottoman mosques' Qibla wall is largely windowed as identified by the statistical analysis. In the studied mosques, the window horizontal distribution varies greatly from 2 to 5 rows (31%, 20%, 24%, and 18%). Nearly all the mosques have a low-level row of unscreened windows (96 %) whilst only five mosques (11%) have no screened windows rows altogether (Figure 4).



**Figure 4.** Example of a mosque with a unique unscreened ground level windows' row (Left) and another with all unscreened windows' rows (Right), respectively Mourad Pacha Mosque and Dolmabahce Mosque, Istanbul.

In the Qibla wall, the Mihrab constitutes a focal point for the prayers that gave it a topological character inside the prayer hall [20]. Utilizing daylighting design, the Ottoman mosque highlights such a character through various daylighting-based architectural compositions: i) windows located along the Mihrab axis/span in more than three quarters of the mosques (78%), ii) from one to four columns of windows positioned on both lateral sides of the Mihrab (respectively 29%, 13%, 16%, and 22%) (Figure 5). Moreover, the Mihrab span is designed as a specifically windowed cantilevered volume in more than three-quarters (78%) of the mosques (Figure 6).



**Figure 5.** The Mihrab's luminous topology by means of: i) Windows' columns located on the its axix and/or span (Left), and ii) Windows' columns located only on its both lateral (Right), respectively, Sehazade Mosque, Istanbul and Yildirim Beyazit mosque, Bursa.





**Figure 6.** The Mihrab's luminous topology by means of semi-domed cantilevered volume. Example: Molla Çelebi Mosque, Istanbul.

## 6. Discussion

### 6.1. Daylighting design-based correspondences between the multiple characteristics of the prayer hall

Three multivariate statistical analyses were undertaken to identify the daylighting-based features that should correspond to the prayer hall characteristics. The first Multiple Correspondences Analysis (MCA) informed that each category of the prayer hall inner volumes is related to specific roof design and a precise total number of the Qibla wall windows' rows (Table 4).

The second MCA revealed that the absence of windows at the principal dome base occurs for the case of the square-based single-domed mosques with a single row of windows and mostly characterized by a slender inner volume and less by a cubic one (Figure 7). By contrast, the presence of windows in this zenithal daylighting component is common to the mosques with the other characteristics.

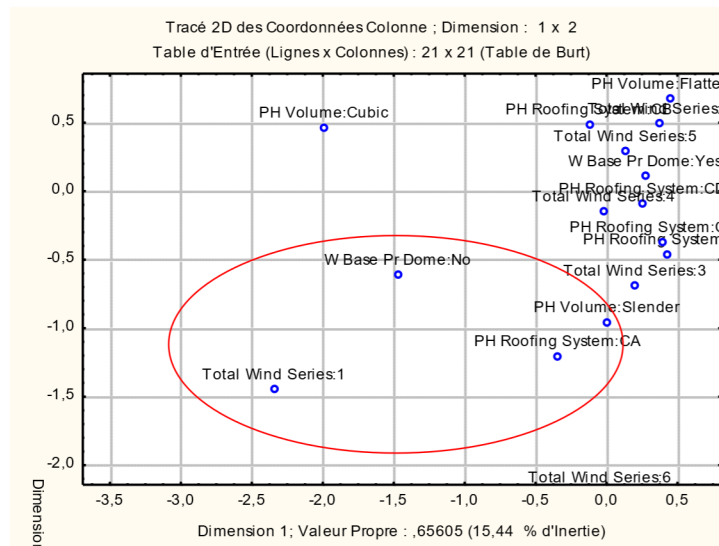
The corresponding relationships between the type of mosque and the prayer hall's inner volume as well as its roof design were also investigated. The third MCA showed that each type of mosque, as categorized by G. Oney [27], has specific characteristics (Table 5). However, it must be noted that the hypostyle mosque is not specifically characterized by any prayer hall inner volume or a precise number of window rows. Similarly, the mosques with a central dome are not associated with a unique kind of prayer hall inner volume. Additionally, the cubic prayer hall inner volume is not limited to any mosque architectural type.

### 6.2. Window, Daylight and View out

The Ottoman mosque's openness towards the outside contrasts with the previous mosque examples and, for that matter with Christian sacred buildings as well [31]. Whilst the first opposition could be related to the different climatic conditions between Anatolia and the other hot arid regions of the Muslim world, the second one could be considered from the divergence of meanings of the whole sacred space and light, particularly from the Christianity and Islam points of view.

**Table 4.** Correspondences between Prayer hall's inner volume categorizes and its characteristics as resulted from the first Multiple Correspondences Analysis.

N°	Prayer hall inner volume category	Variant	Prayer hall characteristics
01	Slender	1	<u>Total windows number series :</u> <ul style="list-style-type: none"> <li>Three (3)</li> </ul> <u>Prayer hall roofing systems:</u> <ul style="list-style-type: none"> <li>Double square-based domed Large mosque</li> <li>Hexagon-based mosque</li> <li>Octagon-based mosque</li> </ul>
		2	<u>Total windows number series :</u> <ul style="list-style-type: none"> <li>Six (6)</li> </ul> <u>Prayer hall roofing systems:</u> <ul style="list-style-type: none"> <li>Square-based Single-domed mosque</li> </ul>
02	Flattened	1	<u>Total windows number series :</u> <ul style="list-style-type: none"> <li>Two (2)</li> </ul> <u>Prayer hall roofing systems:</u> <ul style="list-style-type: none"> <li>Double square-based domed Deep mosque</li> <li>Single Eccentric domed mosque</li> <li>Multi-based Multi-domed mosque</li> </ul>
03	Cubical	1	<u>Total windows number series :</u> <ul style="list-style-type: none"> <li>Four (4)</li> <li>Five (5)</li> </ul> <u>Prayer hall roofing systems:</u> <ul style="list-style-type: none"> <li>Square-based Semi-domed mosque</li> </ul>



**Figure 7.** The graphical outcome of the second multiple correspondences analysis revealing the prayer hall's characteristics associated to the case of central dome without windows at its base (Statistica 7.1 program).



**Table 5.** Correspondences between Prayer hall's inner volume categorizes and its characteristics as resulted from the first Multiple Correspondences Analysis.

N°	Mosque Type in respect to G. Oney's categorization [27]	Prayer hall characteristics
01	<u>Type i:</u> The cubical mosque with a single cupola	<u>Total windows number series :</u> ▪ Three (3) or Six (6) <u>Prayer hall roofing systems:</u> ▪ Square-based single-domed mosque <u>Prayer hall inner volume:</u> Slender
02	<u>Type ii:</u> The hypostyle mosque	<u>Prayer hall roofing systems:</u> ▪ Double square-based domed Large mosque ▪ Multi-based Multi-domed mosque
03	<u>Type v:</u> Mosque wiith 'Tabbanes' (Inverted T)	<u>Total windows number series :</u> ▪ Two (2) <u>Prayer hall roofing systems:</u> ▪ Double Square-based Single-domed Deep mosque <u>Prayer hall inner volume:</u> Flattened
04	<u>Type vi:</u> Mosque with a central dome	<u>Total windows number series :</u> ▪ Four (4) or Five (5) <u>Prayer hall roofing systems:</u> ▪ Octagon-based mosque

Moreover, this character illustrated by the row of a low-level window, which is largely present in the Ottoman mosques, influences powerfully the worshippers inside the mosque and then, the general ambience of the prayer hall. In addition to the travelers, architectural historians and writers also described the luminous ambience within the Ottoman mosques and used a rich poetical vocabulary in their narratives. Inside the prayer hall, the Qibla, right and left walls' ground level unscreened windows are mainly oriented towards green intermediary spaces and/or cemetery gardens [23, 32]. By intended contrast, the ground level windows located in the wall behind the prior provide views on the open-to-sky courtyard.

In terms of view out through the low-level windows, the points of view diverge in terms of the influence they have on the user's behavior during prayer. For C. E. Arseven [33], the worshipper is entertained and focuses less on religious duty when looking outside through windows. In contrast, H. Matthews [24] considers the content of view to the outside and sees that the worshipper will be reminded of human mortality when seeing the garden cemetery located near the prayer hall. When observing on-site, the very high degree of decoration and sculpture of these tombstones, it is inevitable that the contemplation of the divine imposes itself on the human being and affects his or her piety (Figure 8).

Moreover, these windows are designed in such a way that they provide a specific place for devotion. Following an ancestral tradition and until the present time, the worshippers still use mosques to read the Muslim holy book, the Koran, while being in visual contact with the outside (Figure 9). It must be noted here that this location is the most comfortable in the Mosque from the daylighting point of view. However, the magnificence of the outside landscape is not to be ignored.



**Figure 8.** Various views through low level row windows as well as outside the prayer hall showing the cemetery gardens decorated with sculptural tombstones.

The Ottoman designers included this aspect by the creation of an urban complex which encompassed the mosque and allowed the creation of various outdoor greenery scenes (Figure 10). Both cemeteries and gardens belong to paradise. So, rather than just admitting light inside the prayer hall, the introduction of greenery through unscreened ground-level windows meant death and paradise, in opposition to the open-to-sky courtyard which provided social communion and represented the earth [24, 32].

### *6.3. The users' point of view: From the inherited luminous ambience to the daylight-based contemporary architectural design.*

At the present time, Ottoman mosques in Turkey are used by worshippers and visitors. The impact of natural lighting on both groups is manifestly contained within the mosques' description by old travelers and/or renowned architectural experts. In this respect, the traveler E. Celebi described the ambience of a religious event (the Ashura night during August 1630) inside a mosque in Istanbul:

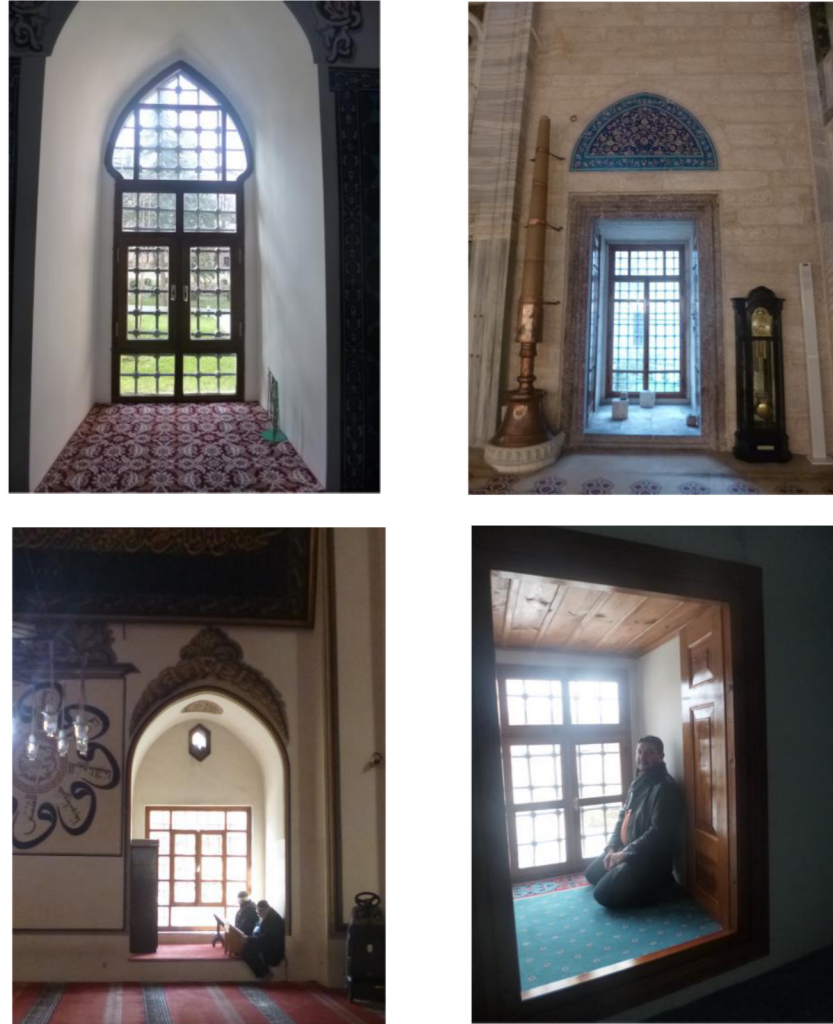
*"...the door was opened, and the light-filled mosque was crowded with a luminous congregation, who were busy performing the dawn prayer" [34, p.4].*

A similar encounter involved one of the Modern Masters, Le Corbusier who in 1911, marveled about the Suleymanie Mosque in Istanbul:

*"It must be a silent place facing toward Mecca. It needs to be spacious so that the heart may feel at ease, and so high that the prayers may breathe here. There must be ample diffused light as to have no shadows; the whole should be perfectly simple; and a kind of immensity must be encompassed by these forms...At a glance*

*one sees the four corners, distinctively feels their presence and then construes the great cube perforated by small windows...overhead is a vast space whose size one cannot grasp, for the half sphere has the charm of eluding measurement... All these things are clothed by a majestic coat of whitewash. The forms stand out clearly, the impeccable construction displays all its boldness" [35, p. 363].*

An in-progress research work investigates such textual data with the aim to identify the most cited daylighting devices by travelers and their associated effects as they described them. Further, a morphological study will focus on those dominant apertures.



**Figure 9.** The devotional use of the human scale designed ground level windows by the priors for the reading of the Koran and worship using the rosary.

The users' point of view about this sensory experience is still important nowadays, and for several reasons. Besides the current life within the historical mosque and its luminous ambience impact on the worshippers, the restoration of these heritage buildings requires a careful undertaking in the preservation of such human based environmental and authentic character while responding to the current requirements for indoor comfort. Effectively, the users of some of Bursa historical mosques attest that the noticeable visual discomfort is due to the new but inappropriate artificial lighting used [36]. Among these mosques, two were restored, mainly after the numerous earthquakes, and the inadequate artificial lighting features could have been adopted as part of these restoration projects.



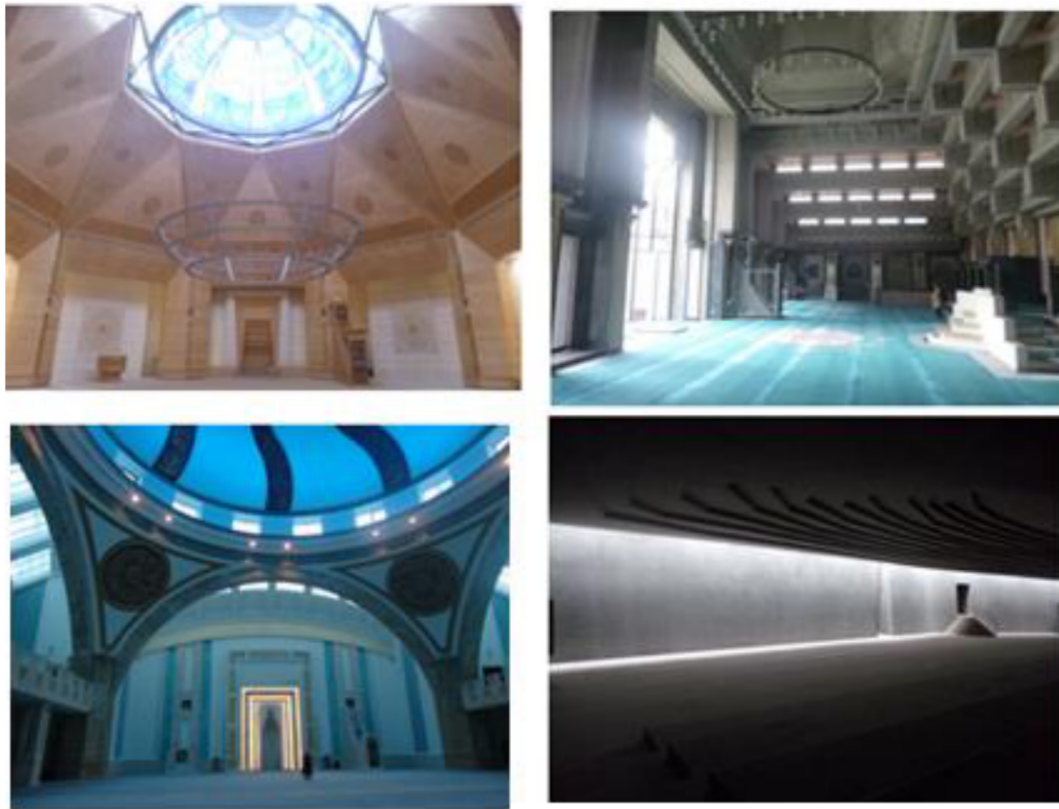


**Figure 10.** The mosque's outside garden and cemetery landscaping as well as the scenes perceived from inside through the prayer hall's low level windows.

In addition, the specificity of this sensory design related legacy induces its scientific overall and detailed knowledge in order to take a new look towards the still undisclosed Ottoman architecture [35]. Finally, such investigations will allow identify the degree this heritage ambience has been and/or could be used as a reference for the contemporary mosque design and, thus, constitute a permanent architectural identity feature [37]. Effectively, the recent built Turkish mosques' designers used widely the natural light as a main creative tool in reference/or not to the Ottoman architectural heritage [38-41] (Figure 11).

## 7. Conclusions

This research aimed to investigate the sensorial-based environmental relationships inside the Ottoman mosques in three main Turkish cities, Bursa, Edirne, and Istanbul. The data collected during the extensive fieldwork as well as from an extensive literature review were statistically analyzed to satisfy a large degree of objectivity.



**Figure 11.** Examples of natural lighting architectural components in the Turkish contemporary mosques revealing the reference (left) or not (right) to the Ottoman old daylighting design.

The preliminary outcomes of this analysis revealed that slender and flattened inner volumes of the prayer hall are more present among the mosques' study corpus than the cubic ones. These most prominent volumes are generally covered by a windowed central dome to which could be added semi-domes and smaller cupolas.

In the history of the Ottoman Empire, the mosques' Qibla wall is progressively windowed. In the later structures, it became almost transparent with large rows of fully unscreened windows. Further, this wall attests to a particular luminous spatial topology. The Mihrab itself is a blind focal point that is brought to light by the windows located above and/or on either side of it. This specific important and symbolic area was elevated as a cantilevered volume added to the general envelope of the mosque. Both lateral and zenithal daylighting are used to enhance the luminosity of the place by respectively employing rows of windows and a windowed semi-dome.

The mosques' inner volume daylighting design attests to a development that is respectful of the architectural style evolution, whilst some characters occurred throughout the various Ottoman eras. In addition to the daylight admission inside the prayer hall, the view out through ground-level windows constitutes a specific Ottoman attribute for the sacred space. The view orientation and contents include several signals that powerfully impact the worshippers' perceptions and behaviors while they distinctively characterize the Ottoman mosques' ambiances.

This research work will be extended in the future to include more case studies representing the production of all the Ottoman Empire's eras. On the other hand, the ambient-based architectural design will be investigated at both the designer's intentions and the levels of users' perceptions and behaviors. It is intended that content analysis will be applied to historical narrative sources and contemporary literary productions. Finally, an exhaustive analysis will be undertaken to define the morphological characters of the windows-envelope relationships in terms of lateral (walls) and zenithal (roof design) daylighting design.



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