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URBAN PLANNING AND DESIGN

Assessing the impact of double-skin façades on social activities of people in urban spaces using empirical and syntactical analysis

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ABSTRACT

Despite the fact that previous literature has validated the significant role of urban facades in the initiation of social behaviors, there is still an existing scientific gap regarding the impact of double-skin facades on the establishment of social activities within an urban context. The main objective of the present study is to scrutinize the impact of double-skin facades on the establishment of social activities. A quantitative and qualitative research method was applied using Space Syntax and empirical observations methods. A *t*-test was also used to compare the independent groups using the SPSS software. The results indicated that the establishment of social and behavioral activities in front of double-skin facades were found to be significantly higher than single-skin facades. Meanwhile, the types of observed behaviors in front of double-skin facades were found to be more social and optional compared to those observed in front of single-skin facades. The implication of this study may contribute to urban and landscape designers, planners, and architects, and assist them in creating a more socially sustainable and walkable built environment.

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KEYWORDS
Double-skin façade; informal behavioral setting; social activities; space syntax; urban landscape

1. Introduction

The swift rate of urbanization experienced by many developed countries has escalated awareness regarding the protection, improvement, and diversification of urban landscape (Matsuoka and Kaplan 2008). In many cases, urban facades are considered as the common denominator for enhancing social life (Mehta 2009). Appraisal of a streetscape mainly depends on people's perception of building facades (Asgarzadeh et al. 2012). The physical elements and visual characteristics observed in building facades play a major role in generating attractive streetscapes (Askari and Soltani 2018; Moghtadernejad, Chouinard, and Mirza 2021). Urban façade is mainly described as the most important face of a building elevation that characterizes a preferable access and view from streets (Askarizad and Jafari 2019). Furthermore, a double-skin facade is referred to a double-envelope façade (Yazdi-Bahri, Alier Forment, and Sanchez Riera 2021). This is a multi-layer skin form of architecture consisting of an external skin, an intermediate area, and an internal skin, and can be implemented on the exteriors of buildings (Kim, Kwon, and Yang 2017; Yazdi-Bahri et al. 2022).

Previous studies have confirmed that the degradation of the physical environment may result in abnormal social behaviors (Stedman 2003). The social aspect is highly significant in designing the living environment due to the fact that people are spatially structured by means of their cultural and social values (Carmona 2021). The culture and social value dictate the initial setting of the environment (Zaleckis, Doğan, and Arce 2022). Conforming to Jan Gehl (2010), well-designed facades help to attract visitors, and create public areas that people want to spend their time in (Gehl 2010). Research has uncovered that enhanced façade quality was positively linked to increased walking, and that building height and liveliness had trivial effects (Silvennoinen et al. 2022). Ever-increasing evidence suggests that various features of the built environment are crucial in affecting the behavior of people (Handy et al. 2002).

Social interaction is expounded as a process of reciprocal stimulation and interactivity between a minimum of two persons (Askarizad and He 2022b). It can be evaluated through the amount of time people spend in the place, mirroring their engagement in an open public space, and the intensity of the interaction (Anderson et al. 2017). Additionally, sociological theories set forth by both micro and macro sociology chiefly address the types of social relations among passive (public solitude, people watching) and active (fleeting encounters, chance encounters, and quasi-primary relationships) interactions

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(Aelbrecht 2016). Furthermore, they cover the social behaviors from visual encounters and brief encounters up to longer encounters, and according to these critical components of social interaction, the principles, and attributes of decent public spaces; which are advised as agents for promoting the liveliness and vitality of social spaces and the interactions taking place within these spaces (Chen 2023; Moulay, Ujang, and Said 2017). Human activities bring people together, and observing passion and activity encourages further activity (Gehl 1987). The chance to observe, hear and meet others can be the most significant feature that defines an attractive urban space (Mehta 2019). Generally, social ties are essential for people when it comes to sharing their feelings, sense of belonging, and social solidarity (McMillan and Chavis 1986). This behavioral impact, which is a direct result of the quality of the built environment, is passed on to the people, and ultimately affects the way they behave in their own personal lives (Askarizad and Safari 2020).

Amid the logical systems used for implementing architectural-urban research, the Space Syntax theory is more favorable in the fields of contemporary architecture and urban development (Groat and Wang 2002). Introduced back in 1976 by Bill Hillier and his colleagues at University College London, the Space Syntax Theory is established on the concept that the physical and spatial configuration of the built environment notifies us of how space is experienced, explored, and grasped (Hillier et al. 1976). Through analyzing a series of spatial characteristics, Space Syntax helps designers understand the role of spatial configurations in forming human behavior patterns, and evaluate the social effects of their designs (Hillier and Hanson 1984). This analysis model enables us to study the natural relationships that exist in architectural forms or urban spaces, and their influence on establishing social interactions among inhabitants (Hillier et al. 1993).

The expansion and development of urban spaces, and the resultant increase in the population of cities, has led to noticeable alterations in lifestyle, and even social behaviors among individuals. This matter has also been effective in the evolution of construction patterns thus far. Owing to the fact that human beings need to establish social interaction, informal behavioral settings in urban spaces can outstandingly cover the societal demands of individuals. Yet, urban landscape design and particularly building facades can have a profound impact on attracting different social groups and individuals toward urban spaces. They can also be considered as an influential factor in the formation of informal behavioral settings and attracting people toward sociable environments. The main objective of this study is to provide an outlook towards the formation of informal behavioral settings with the scope of measuring the impact of visual attractiveness of facades in urban landscape design. In fact, the main focus of this study is to investigate the impact of double-skin facades, as a factor influencing the visual appeal of the urban landscape, on the social behaviors and activities of people in Barcelona using empirical analysis. Similarly, the analysis of the spatial configuration of this city, as another effective factor in establishing social behaviors, is measured using syntactic analysis. That being the case, the following questions are posed in order for appropriate answers to be obtained:

- What effects do double-skin facades have on the social activities of people within informal behavioral settings?
- What is the difference between double-skin facades and single-skin facades when it comes to attracting societal activities of people in urban areas?

The hypothesis in this research it is that double-skin facades are positively correlated with the establishment of social activities, and that they provide an opportunity for promoting sidewalks as an informal behavioral setting. In addition, it is postulated that a built environment attributed with highly integrated spatial configurations is strongly associated with intensifying the efficiency of social behaviors within an informal behavioral setting. The implication of this study may assist urban and landscape designers, and architects in creating a more sociable built environment. In the following sections, once the latest existing literature in this field had been concisely reviewed and incidental scientific gaps were identified, a set of theoretical frameworks were conducted in order to facilitate the grasp of notions developed in this study. Afterward, the process of applying different procedures was clarified by describing the implemented methods. Subsequently, the obtained findings are presented and ultimately, discussion and conclusion are conducted.

2. Literature review

Extensive studies have been conducted in recent years, investigating the impact of building facades on urban landscape, and the establishment of social activities; some of which are reviewed below. Hassan, Moustafa, and El-Fiki (2019), scrutinized the ground-floor façade design and activity patterns on the sidewalks in Cairo using behavioral mapping observations. The results suggested that ground-floor façade characteristics play an important role in promoting lingering activities on the sidewalk. Elsadek, Liu, and Lian (2019) assessed the contribution of green facade in terms of stress recovery and well-being in high-density cities. The results elucidated that green façades appear to enhance human physiological and psychological relaxation compared to typical building-wall façades.

Mao, Qi, and He (2020) examined the influence of heritage building façades in small-scale public spaces on human activities. The results showed that human behavior could be influenced by the façade characteristics of historical buildings. Moreover, factors such as architectural style and decoration played a vital role in attracting human attention. Hollander and Anderson (2020) studied the impact of urban façade quality on affective feelings using empirical studies. Their findings indicated that high quality façades led to people feeling more pleasant compared to low quality facades. Serra et al. (2021) investigated the analysis of facade solutions as an alternative to demolition for architectures with a visual impact in historical urban scenes. Results indicated that local citizens are in favor of preserving historical urban scenes. However, people unfamiliar with the area were found to be more inclined towards demolition. Yuan and Chen (2021) investigated the factors influencing street vitality in high-density residential areas. Their findings indicated that the density of entrances and exits of residential properties, the proportion of walkable areas, and the density of retail and service facilities were correlated with the vitality of street segments. Silvennoinen et al. (2022), examined the effects of walkability on three key features including *liveliness*, *high-quality façades*, and *low buildings* using a virtual reality experiment. The exploratory analyses suggested that improved façade quality was positively correlated with the walking activity. Balasubramanian, Irulappan, and Kitchley (2022), examined the influence of aesthetical attributes over activity patterns and user behavioral responses in commercial street landscapes. The findings supported that the diversity and perceived pleasantness of the environment, which include elements such as façades, colors, aspect ratios, maintenance, and vegetation, has a significant correlation with walking preferences. Reviewing the existing literature indicated that despite considerable approaches towards examining the effect of visual attractiveness of urban façades on the social behaviors of people, no studies have been carried out on the impact of double-skin façades in the establishment of social activities. Hence, the present research aims to bridge the identified scientific gap as its contribution to the body of existing literature in this field.

3. Theoretical framework

3.1. The role of urban façade on the establishment of social activities

In order to create urban open spaces that respond to the social demands of humans, people's experience of the urban environment should be taken into consideration. An evolutionary biology perspective sets forth four major characteristics of spaces, that have been derived from the findings of empirical research in the psychological and cognitive sciences, to explain why people intuitively are attracted to certain streetscapes over others (Byrne 2009). These four properties include *edges*, *shapes*, p*atterns*, and *narrative*: (1) Edges, as shown in the scale of a path or street corridors, are most often articulated by facades; (2) Shapes, such as the bilateral symmetry of faces and its presentation on façade design; (3) Patterns; the repetition of patterns; (4) Narrative, which emphasizes historical significance and enhances a sense of place within a space (Byrne 2009). Previous studies approved that elements of vernacular architecture, including elaborate façades as well as bilateral symmetry, bring about a significant influence on the mental image ability (Hollander et al. 2020) and affective atmosphere (Abusaada and Elshater 2021) that citizens have. Thereafter, this process can lead to achieving a more social urban environment (Larson 1995).

Complexity and architectural character is one of the key features found in ground-floor façades, and these features can ultimately affect people's activities. This includes façade articulation, scale and rhythm, and human scale that may be noted through the richness of details and articulation of façades incorporating *texture*, *size*, *color*, *façade irregularity*, and *shape* (Bassily, Abufarag, and Goubran 2022). When façade articulation matches human size and proportions, building details can provide a more noticeable human scale (Zordan, Talamini, and Villani 2019). Façade details are to be scaled to human proportions and human use in order to represent a space that is proportioned appropriately to respond to human feelings and social requirements (Hassan, Moustafa, and El-Fiki 2019). The existence of scale and rhythm involves having narrow units and many doors on the street-level, which keeps passers-by engaged and encourages them to decelerate their pace (Elsadek, Liu, and Lian 2019). Furthermore, vertical and horizontal façade lines and articulation break down the scale of a building to human scale, and direct the focus of attention to the ground-floor level (Mao, Qi, and He 2020).

Scholars have also assessed the exteriors of buildings and their role in affecting emotional responses. Nasar (1994) designed a practical framework by suggesting three major categories of building exterior qualities: enclosure, complexity, and order – a non-evolutionary approach on how people experience places grounded instead of the empirical observations of psychologists. Ewing et al. (2016) intended to quantify the most ideal streetscapes by counting pedestrian activity, and discovered that the busiest places also had more active uses, street furniture, and permeable edges (windows on the ground floor level). Studies suggested that there are three features that affect the overall quality of an urban edge; mainly around

facades: (1) permeable walls (doors, windows, and arches); (2) wide-ranging materials, and (3) awnings. A high-quality edge environment leads to people feeling more pleasant compared to low-quality edges (Hollander and Anderson 2020).

The ground-floor façade is a significant aspect of sidewalk design that clarifies the urban space and acts as an area of exchange between people and place (Mehta 2009). Conforming to Joyce and Guaralda (2013), ground-floor façades can affect people's social behaviors and activity patterns in the street; providing further opportunities for activity, play, and interaction. When a connection between a public space and its edge or ground-floor façades is present, the confines of indoor and outdoor space is blurred, and indoor activities extend to the outdoors, and various activities take place directly in front of the building (Hassan, Moustafa, and El-Fiki 2019). Despite the fact that to this day, little research has questioned the relationship between ground-floor façade design and activity patterns on the sidewalk, the existing literature does suggest a number of design characteristics that can enhance staying and social activities on sidewalks (Zordan, Talamini, and Villani 2019).

3.2. The role of urban morphology on social activities

Urban morphology is interpreted as a branch of science that evaluates the generation process of ideas and tendencies that base the form of cities in contemplation of scrutinizing the tangible impacts of social, economic, and environmental forces (Boeing 2021). While buildings, gardens, streets, parks, and statues are consistently exposed to change and evolution over time, they are considered as the key elements of morphological analyses (Castro et al. 2019). In other words, the physics of the city mirrors the impact and footprint of human inclinations and activities (Benguigui, Czamanski, and Marinov 2001; Fathi, et al., 2020). In his approach towards urban forms, Lynch (1960) declared that a street is actually a path that has been enhanced by a series of nodes where other paths meet it, or where activities are boosted. Gehl (1987) suggests that these high quality edge conditions, well-designed façades in particular, help attract visitors and create more desirable public spaces. Despite their agreements, none of these authors possess verifiable evidence indicating that façade design influences people in effect. Psychology researchers have gathered and analyzed proof in support of the significance of various elements of the built environment in terms of their impacts on people (Dunstan et al. 2005).

Urban space is the foremost core of socio-cultural events. However, owing to the fact that space is in turn shaped through social, cultural, and economic processes, it is usually regarded to be invisible, and its form is not considered (Hillier 2002). In the early 1980s, some reflections led to an attempt to turn some questions around and re-establish the theoretical links between the spatial and social worlds that had been so dominant in establishing the foundations of the modern social theory (Hillier and Hanson 1984). The society – space relation "space first" was introduced by examining the patterns of real space found in the built environment, and asking in what sense could these be seen to be the outcome of social and economic processes (Hillier 2008). In an attempt to emphasize its initial focus on real space, this approach was named Space Syntax (Hillier et al. 1987). Based on the graph theory, Space Syntax, is mainly employed to analyze spatial configurations (Hillier et al. 1976). This theory was expanded by Hillier and Hanson (1984) in London. Hillier and Hanson then published *The Social Logic of Space*, in which they defined a syntactic theory for the organization of spaces in buildings and settlements (Hillier and Hanson 1984). In the Space Syntax theory, spatial and social forms are in such close relationship that a certain spatial configuration may define a number of social patterns, including the distribution pattern of land use, movement, urban crimes, and location of immigrants (Vaughan 2007).

The term Space Syntax comprises of a set of theories and techniques for the analysis of spatial configurations (Hillier and Hanson 1984). The main objective of this technique was to denote an instrument to assist architects and urban designers to simulate the possible societal influences of their designs, and understand the relationship between human societies and spatial configurations (Karimi 2012). The main purpose of this theory is to shed light on the impact of spatial layouts on sociability; specifically, Space Syntax proposes a relationship between built environments and social activities (Hillier et al. 1976). Additionally, research has indicated that there is an appreciable relationship between spatial configurations and the behavioral patterns of individual (Bafna 2003). Space Syntax primarily focuses on patterns of pedestrian movement within a built environment, which in turn provides beneficial feedback for designers and researchers (Penn 2003). Figure 1

4. Material and methods

The research method has been applied quantitatively and qualitatively. In this way, the Space Syntax method has been adopted in the present study, which is considered to be a predictor of the social aspects of architectural and urban spaces. This technique is one of the most useful methods for assessing urban spaces in order to understand the social logic latent in the spatial configuration of cities. This technique can be applied to properly examine and measure the

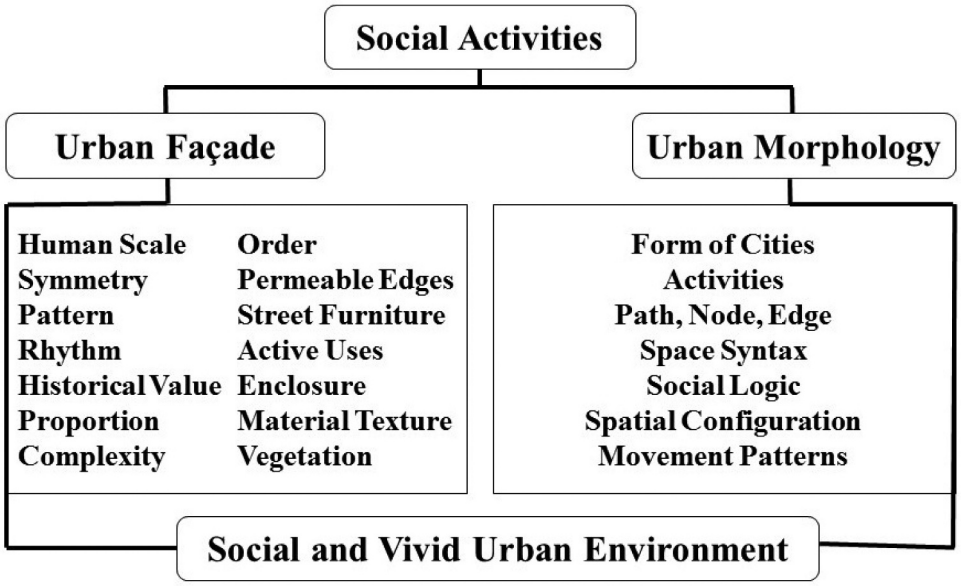


Figure 1. Conceptual framework of the research.

relationships between physical and spatial elements, activities, and social processes. This technique was first developed by Bill Hillier and Julien Henson at the University College London. In the next phase, gathering qualitative data was accomplished through conducting a set of empirical observations with respect to the societal activities of individuals to explain the results efficiently. In this regard, gate counting, along with static snapshot observational methods were accomplished in order to gauge the visual impact of double-skin and single-skin façades on the social activities of people in Barcelona (Figure 2).

The method of implementing this research is that in the first stage, the positions of double-skin and single-skin façades were identified. Then, their syntactical values, as well as their correspondence with established social activities were discerned. Ultimately, the findings were compared with one another and discussed. It should be noted that the obtained

Figure 2. Functional procedure of the research.

quantitative data from the frequency of observed social activities in front of each type of urban façade were compared using the *Statistical Package for Social Science (SPSS)* software. Hence, the t-test was used to compare the independent groups with parametric data in order to identify whether there is a significant difference between double-skin and single-skin façade. In the following, each of these segments were categorized and described in detail to explain the implementation procedure of each mentioned method meticulously.

4.1. Empirical analyses by space syntax

Space Syntax analysis quantifies the relationships between social life and the built environment based on the spatial configuration approach to explore the relationships between the social, behavioral patterns of the people (Penn 2003). According to the fundamental theoretical notion of Space Syntax, space is shaped in ways that reflect the direct interaction between space and people, and through this, the space we create or the built environment is humanized (Karimi 2012). The contributor instrument for conducting syntactical analysis is UCL Depthmap developed by Alasdair Turner. Depthmap is a specialized software package that contributes to the syntactical identification and evaluation of spaces in order to estimate the sociability potential of architectural/urban spaces through simulation. The axial line map was implemented in this research in order to assess the social logic of the spatial configuration.

The variables used in this research to evaluate the sociability potential of the spatial configuration and estimate the behavioral and movement patterns of the people include *Integration*, *Connectivity*, *Choice*, and *Intelligibility*. This study focuses on spatial configuration and subsequent attempts to recognize the effects of double skin façades on the social activities of people in Barcelona. In other words, the societal impact of utilizing urban facade attributes in urban landscape has been scrutinized in both double-skin and single-skin façades. The method for gathering data in this research was that after drawing the urban plan of the case study using the AutoCAD 2010 software, the acquired DXF file was transferred to Depthmap. Afterward, using required variables, the spaces were analyzed and outputs were extracted in the form of graphs and quantitative numbers.

4.2. Empirical space syntax observations

Space Syntax Observations are a set of techniques to observe movement flows and patterns of space usage in urban contexts. Field observations have also been used to enrich and strengthen the research implementation method, and to create a link between the adopted procedures. Accordingly, the outcomes of syntactical analysis have been compared with empirical observations in order to evaluate the degree of consistency between simulation and observations (Al_sayed et al. 2014). In order to determine the social activities of people, and to obtain a detailed image regarding the behavioral patterns of people in Barcelona, a couple of empirical observations have been employed, namely *gate count* and *static snapshot*. Observations have mainly taken place on regular weekdays, and at a specific predefined time. The main objective of using the gate count method is to identify the consistency between the findings of the syntactical simulation and the reality in order to validate the acquired data. In the meantime, the main objective of using the static snapshot method is to gather a set of empirical data to obtain the established behavioral patterns of citizens in front of identified urban façades, and their possible transformations within the spatial configurations.

4.2.1. Gate count observations

The Gate Count method refers to a procedure that normally gauges the level of density in pedestrian movement flow within an urban space. It allows researchers to collect a great deal of data in relation to mobility level in the form of a quantitative analysis. The location of gates can normally be specified based on a wide variety of low-integrated, integrated, and high-integrated spots spread around an urban environment (Mohamed 2016). The collected data ought to be acquired based on the provision of the utmost visual field in order to count the individuals who cross the imaginary gate lines (Khotbehsara et al. 2023). In this study, to validate the results obtained from syntactical analysis, 20 gates have been determined based on the variety of integration values in the urban plan of Barcelona.

4.2.2. Static snapshot

Normally, static snapshots are conducted to record use patterns within urban spaces. The method is useful for comparing static and dynamic activities, which is a combination of quantitative and qualitative sorts. By tracking and mapping the ongoing activities in the identified locations, it would be possible to outline spatial behavioral patterns within the study area, and identify the places where more potential interactions take place (Al_sayed et al. 2014). The obtained behavioral cognitive maps have been applied in the large-scale plans to note categories and activities. The acquired behavioral patterns in this research consist of *sitting*, *standing*, *walking*, *talking*, *eating*, *shopping*, *working*, *cycling*, *playing*, *smoking*, *photographing*, *teaching*, and

running. The conducted observations have been made for 5-minute periods over regular intervals throughout the day.

4.3. Study area

Barcelona is a city on the coast of northeastern Spain. It is the capital and largest city of the autonomous community of Catalonia, as well as the second most populous municipality of Spain (Figure 3). With a population of 1.6 million within city limits, its urban area extends to numerous neighboring municipalities within the Province of Barcelona, and altogether, is home to approximately 4.8 million people; making it the fifth most populous urban area in the European Union after Paris, the Ruhr area, Madrid, and Milan. It is one of the largest metropolises adjacent to the Mediterranean Sea. Barcelona is known for its rich cultural heritage, and today, it is recognized as an important cultural center and a major tourist destination. Barcelona is a significant cultural, economic, and financial center in southwestern Europe, as well as the main biotech hub in Spain. As a leading world city, Barcelona's influence in global socio-economic affairs qualifies it for global city status. Barcelona is a transport hub, with the Port of Barcelona being one of Europe's principal seaports and the busiest European passenger port, and an international airport, Barcelona – El Prat Airport, which handles over 50 million passengers per year.

Barcelona's urban planning has been developed in accordance with the historical and territorial changes of the city, and is in line with other defining factors of public space, such as architecture, urban infrastructure, and the adaptation and maintenance of natural spaces, parks and gardens. The process of urban regeneration has been rapid in Barcelona and accompanied by the greatly increasing international reputation of the city as a tourist destination. The increased cost of housing led to a decline (−16.6%) in its population over the last two decades of the 20th century. This is mainly due to the fact that many families have move out to the suburbs. This decline has been reversed since 2001, as a new wave of immigration has gathered pace. Due to the geographical conditions of Barcelona and the Mediterranean climate, this city has the potential to attract utmost tourists and social activities to all parts of the city. In previous studies, the influence of the urban landscape and architectural façades on people's social activities were accentuated, which were concentrated on classical façades. Whereas the effect of modern double-skin façades on social activities has not been investigated sufficiently; specifically, in a context which possesses rich potential for tourist hub and architectural attributes. This is the main reason for selecting Barcelona as the case study for the research at hand.

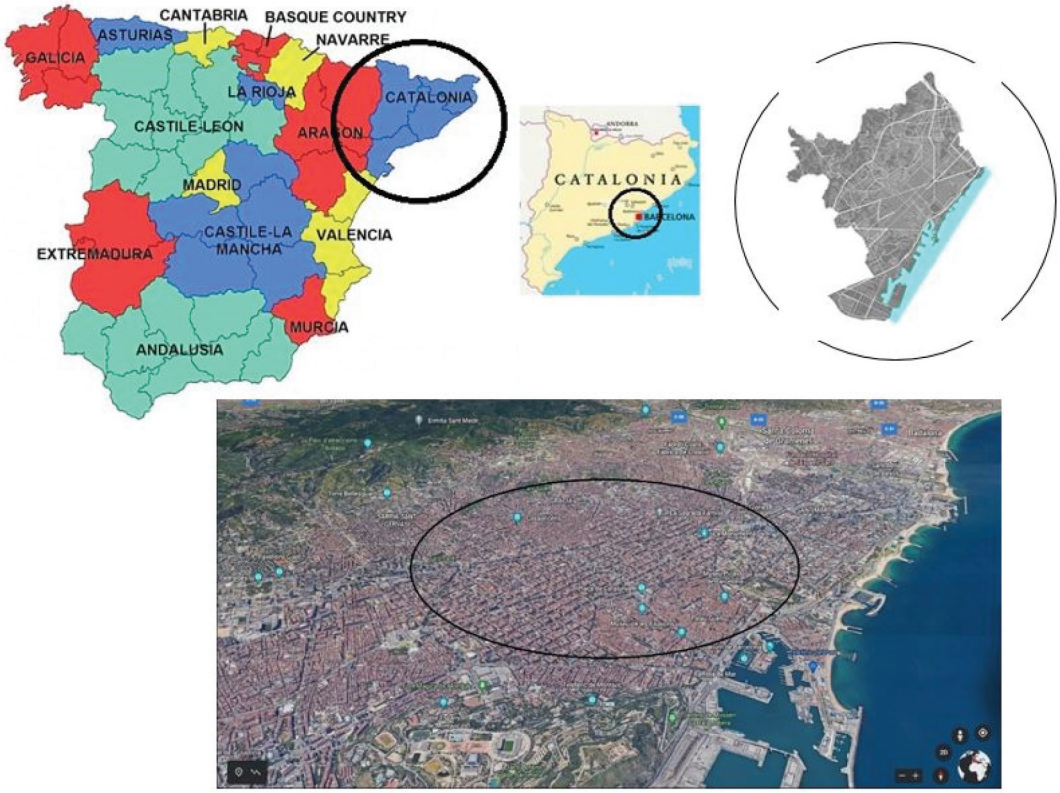


Figure 3. The geographical position of the study area on the map (Spain, Catalonia, Barcelona).

5. Research findings

This section presents the obtained data from gate counts, static snapshots, along with data obtained from the Space Syntax method. In this regard, static observations, location of urban façades, as well as the level of their consistency with the axial map analyses of the streets in Barcelona were performed. The computational simulations were carried out using the UCL Depthmap software. Afterward, a general comparison was made between the output of the simulated software and what has been observed in reality in order to figure out their possible correspondence with the location of urban façades.

5.1. Empirical simulation of space syntax using gate count observations

This section presents the results based on the collected data for gate count observations during a specific weekday in some of the streets of Barcelona. The figures in this section demonstrate the density and frequency of pedestrian movement patterns in the streets. Table 1 lists the total number of pedestrians, along with the axial map analyses in the specified gates. The data is also presented in the form of graphs and charts for better comprehension in Figure 5. It should be noted that one of the main aims of using gate count observations is to substantiate the validity

Table 1. Comparing the syntactical values of each gate with the density of people; obtained from gate count observations.

Gate	Location	Mean Depth	Control	Choice	Connectivity	Integration	Density of People
1	Carrer del Comte d'Urgell	4.79	0.39	55546	830	3.76	122
2	Pg. de Gràcia	4.60	1.64	583029	4743	4.04	322
3	Gran Via de les Corts Catalanes	4.89	1.29	116840	2019	3.42	192
4	C/d'Ausiàs Marc	4.50	1.47	162540	8373	4.00	108
5	Avinguda Meridiana	4.64	0.71	145552	1643	3.92	102
6	C. de Pere IV	5.28	1.19	131702	1088	3.39	94
7	Pl. de Dolors Piera	4.37	2.64	91965	3209	3.98	41
8	C/de Mallorca	4.38	2.69	153896	8430	4.02	64
9	Avinguda Diagonal	4.87	1.32	218567	1348	3.91	189
10	Avinguda Diagonal	5.03	2.11	491667	1560	3.99	213
11	Ronda del General Mitre	5.34	1.49	70607	1099	3.28	78
12	Via Augusta	5.36	1.81	49223	1017	3.24	71
13	Carrer de Johann Sebastian Bach	5.95	1.18	102581	120	2.88	56
14	Travessera de Gràcia	5.27	1.64	128044	2478	3.62	74
15	Avinguda Diagonal	5.01	3.29	152205	10857	4.31	104
16	Carrer de Còrsega	4.39	2.53	366930	4331	4.28	200
17	Carrer de Sardenya	4.99	1.72	559247	951	3.65	104
18	C. de Josep Estivill	4.84	0.93	262137	1269	3.72	74
19	de la Mare de Déu de Montserra	5.29	0.97	189073	917	3.33	69
20	Carrer de cartella	4.73	1.42	208316	302	3.83	91

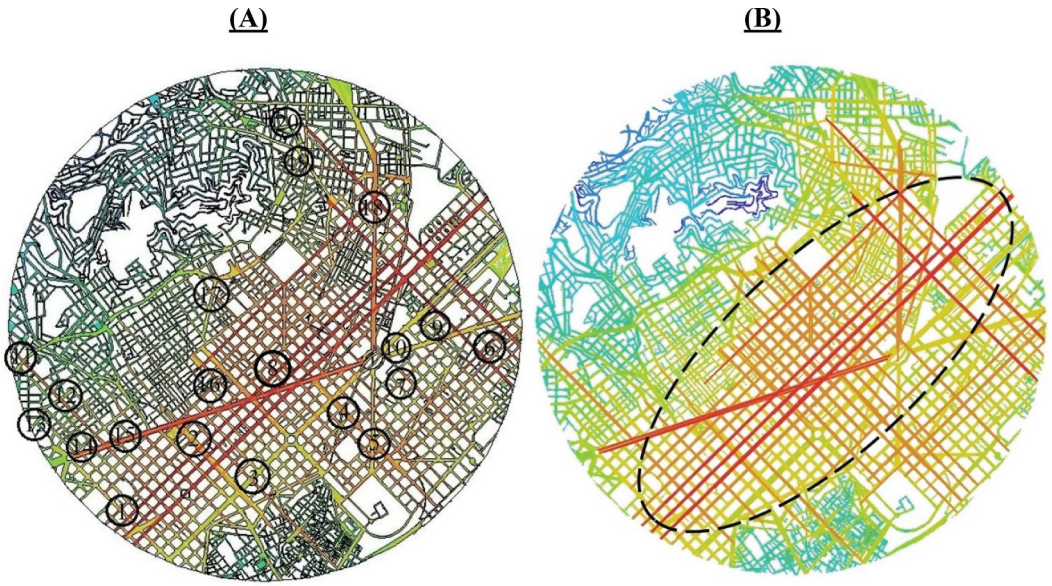


Figure 4. (A) Gates specified on the map to estimate the population density in the studied area; (B) axial map analysis based on the spatial integration obtained by the space syntax method.

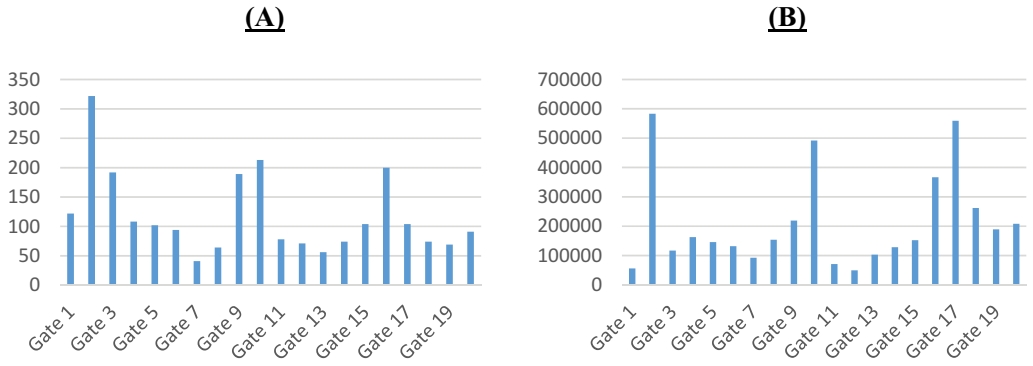


Figure 5. (A) Density (number of persons) at each gate; (B) syntactical value of choice at each gate.

of Space Syntax analysis in order to spot spaces with the most potential for establishing social activities. With regard to the analyses of the axial map test in the simulator software and its degree of integration, spaces that are most commonly used by people are determined (Figure 4B).

Accordingly, these spaces are compared with the location of the marked gates; which are experimented as field observations in this research. Therefore, according to the results of the axial map test and the integration degree of spaces in the streets, 20 gates were selected for the field observation test; which determines the total number of people passing through that gate (Figure 4A). Then, the results are compared with the findings obtained from the software, so that if there is a conflict in the findings, the reasons are identified and possible solutions may be proposed. The findings obtained from the Space Syntax analysis determined the highly integrated spaces which possess the highest potential for the establishment of social activities (Figure 4B). Hence, it is intended to use the spotted areas in order to determine the double-skin façades for further investigations. In the following, an analysis of the gate count method was carried out in an attempt to discern the validity of the syntactical analysis.

The locations of the gates were determined based on the density of the pedestrians in that area and their degree of integration, and observations were made at a predefined time. In all gates, a time interval of 3 minutes was considered to gauge the number of people crossing the gates. According to the results, gates 2, 10, and 16 feature the highest pedestrian traffic, followed by gate number 3. By contrast, gates 7, 13, 8, followed by gate 19 have the lowest frequency of pedestrian use. Based on the findings, there is a relative conformity between the obtained data from the empirical observations of gate counts and the numerical values of integration and choice in the syntactical analysis (Table 1, Figure 5). Therefore, it can be declared that there is a general consistency between the empirical and simulation studies in this research.

5.2. Observing people's social activities using static snapshots

This section presents the data collected from observing the behavioral patterns of activities in front of identified façades. Observations were performed after dividing the streets into ten zones. In fact, these zones were mainly identified based on two reasons. Initially, the potential sociable spaces which were displayed through the syntactical analysis; latter, the location of spaces which possess double-skin and single-skin façades. In the following, an evaluation of people's behavioral patterns including walking, talking, sitting, standing, eating, shopping, working, cycling, playing, smoking, taking photos, teaching, and running were considered using field observations and by taking snapshots. Subsequently, the correlation between these behaviors and the location of the identified façades have been further explored and scrutinized in order to discern whether these specific façades influence social activities or not.

In this regard, zone 1 is located in the vicinity of a hospital; so that at some hours of the day, people can visit physicians in this area; which can lead people to constituting some behavioral patterns. Zone 2 is located in one of the most popular streets of the city, which is home to a wide variety of shops and restaurants. In addition, the presence of elements that are in accordance with the culture of the city has led to the creation of sociable spaces among citizens. In zone 3, there are lines for walking and sitting, and it also allows convenient access to *Plaça de Tetuan* and *Plaça de Catalunya*, which are the main squares of the city. Zones 4 and 6 have also played a significant role in social activities due to their easy access to shopping centers and the beach of Barcelona, which have been equipped with a wide variety of street furniture.

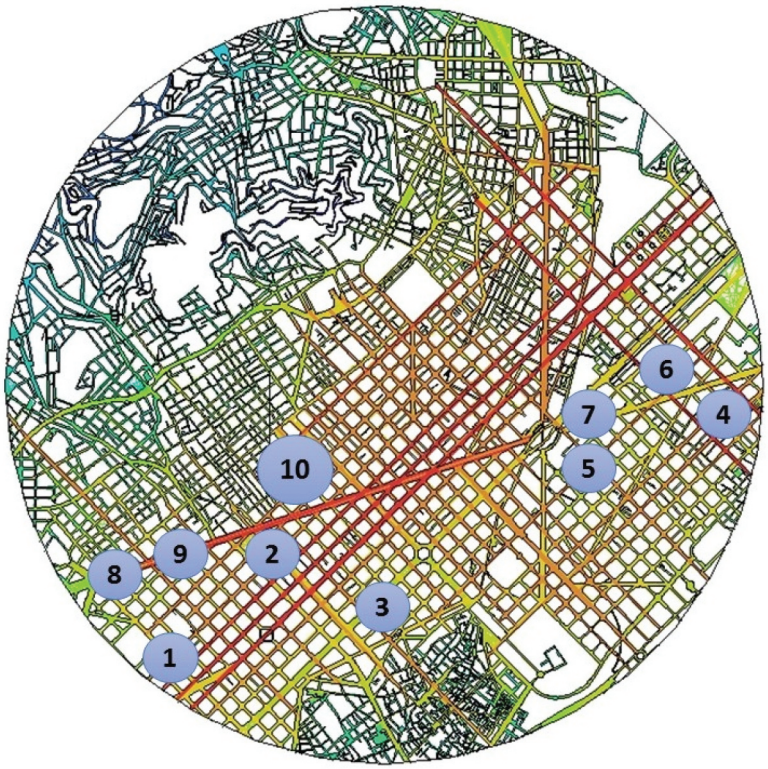


Figure 6. Location of the identified zones on the map for capturing social activities.

In zone 5, one of the most outstanding double-skin façades is set in placed, which attracts many visitors. Furthermore, the impact of street furniture on the establishment of social activities is conspicuously evident, which can be defined by the spatial layout of the urban context in this zone. The tallest skyscraper in the city, *Torre Glòries*, is located in zone 7, and is adjacent to the *Glories Shopping Center*. This structure is considered to be one of the most important landmarks of the city. In zone 8, the presence of miscellaneous forms of street furniture has led to social interactions among the people in this area. In zone 9, there are cycling lanes, as well as a wide walkway for running and walking. This is also one of the widest streets in the city. There are multiple restaurants and hotels in zone 10, and public transportation ensures easy access. Moreover, there is access to the tram, and a place for children to play, run, and cycle in this zone (Figure 6).

In the analysis process of people's social and behavioral activities in each zone, attempts have been made to follow-up the individuals' prevalent activities for time intervals of 5 minutes. In general, observations have indicated that the establishment of social and behavioral activities in front of double-skin façades are more prevalent compared to single-skin ones (Figure 7).

In the first zone, the most frequently observed behaviors in front of double-skin façades include walking, talking, and standing; while the most observed

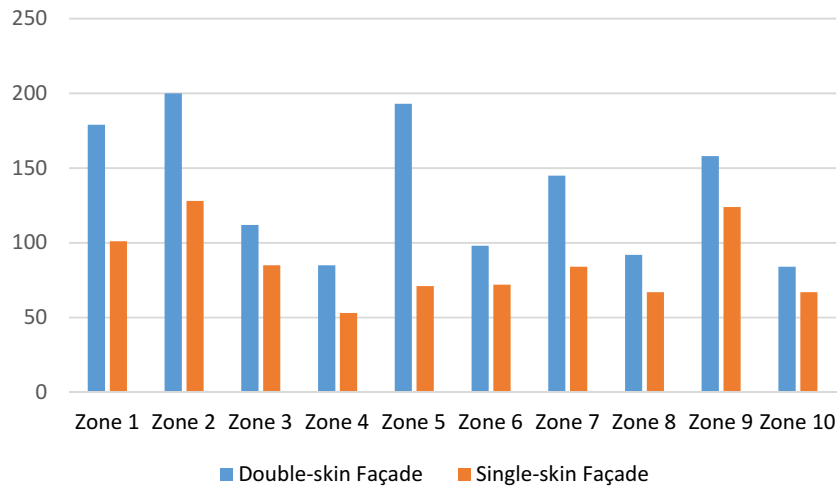
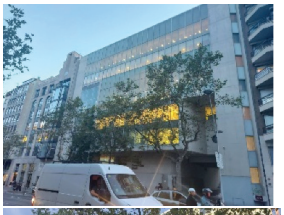
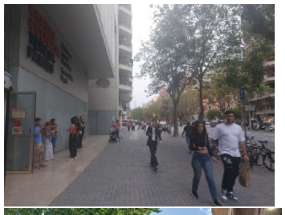
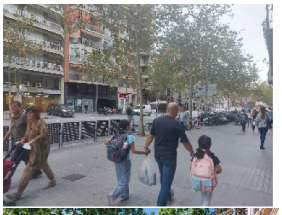
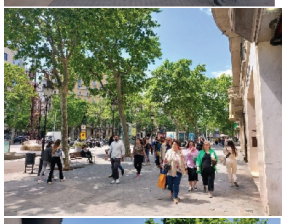
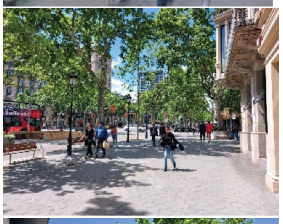
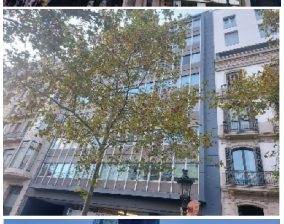
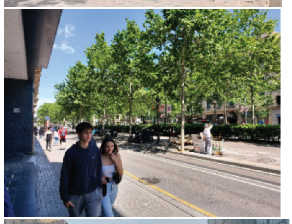
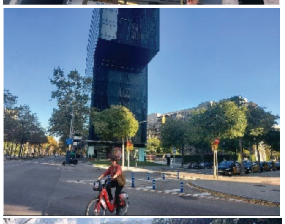
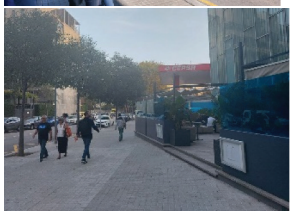
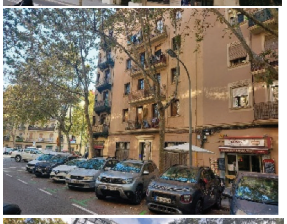
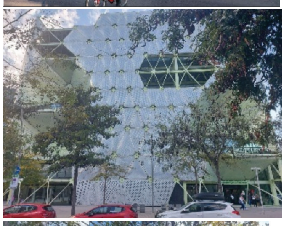
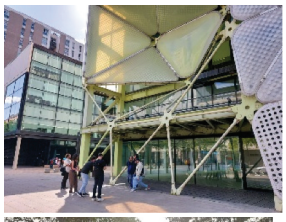
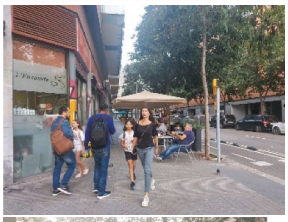
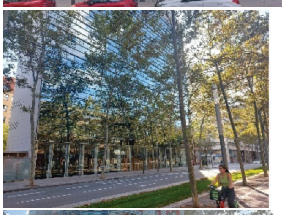
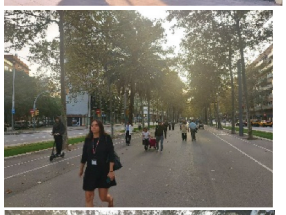
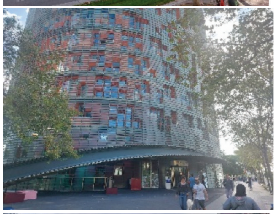
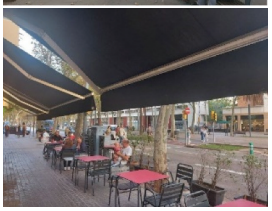
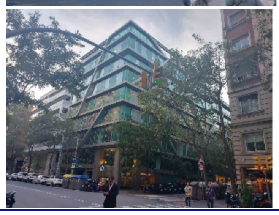
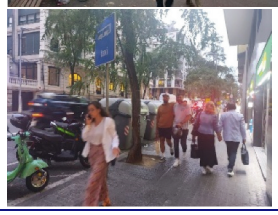
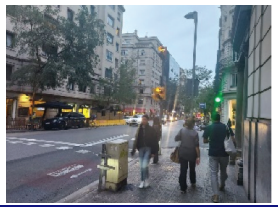


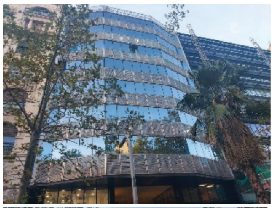
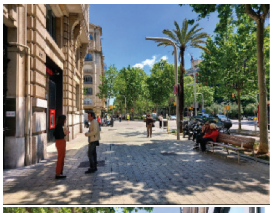
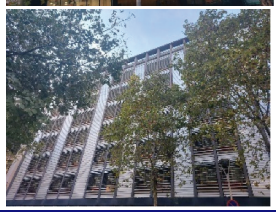
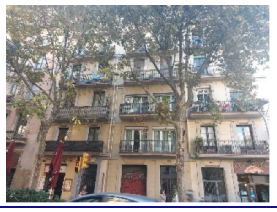
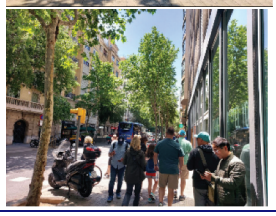
Figure 7. Total observed activities in each zone in front of identified façades.

Table 2. The identified double-skin and single-skin façades, and social activities associated with them in ten zones using the snapshot method.

Zone	Façade (double-skin)	Social activities (double-skin)	Façade (single-skin)	Social activities (single-skin)
1				
2				
3				
4				
5				
6				
7				
8				

(*Continued*)

Table 2. (Continued).

Zone	Façade (double-skin)	Social activities (double-skin)	Façade (single-skin)	Social activities (single-skin)
9				
10				

activities for this zone in front of the identified single-skin façade were walking, talking, and cycling, respectively. In zone 2, walking, talking, and cycling are the most common behaviors in front of both types of façades, respectively. In front of the double-skin façade in zone 3, the most common activities include walking, talking, and standing; while in front of the single-skin façade, the most prevalent types of activities include walking, talking, and sitting. In zone 4, walking, talking, and eating are the most common behaviors in front of both types of façades. In front of the double-skin façade in zone 5, the most common activities include talking, walking, and standing; whereas in front of the identified single-skin façade, the most common types of activities include walking, talking, and eating.

In zones 6 and 7, walking, talking, and cycling are the most prevalent behaviors in front of both types of façades. In front of the double-skin façade in zone 8, the most rampant activities include walking, talking, and standing; but in front of the identified single-skin façade, the most common types of activities include walking, talking, and cycling, respectively. In zone 9, walking, talking, and cycling are the most prevalent behaviors in front of both types of façades. In zone 10, the most frequent activities in front of both types of façades include walking, talking, and working, respectively (Figure 8, Table 2).

In order to complete the analysis process in this section, the findings obtained from the frequency of established social activities in front of each type of urban façade were compared with one another using the SPSS software and the independent sample t-test. The results of the analysis obtained from Levene's test for equality of variances indicate that the P-value is 0.009. Since the obtained value is lower than 0.05, this indicates that the variances of the two data are unequal and heterogeneous. The value of 2-tailed significance is equal to 0.01, which indicates that the mean of the groups is statistically unequal with one another, and there is a significant difference between the obtained data from constituted social activities in

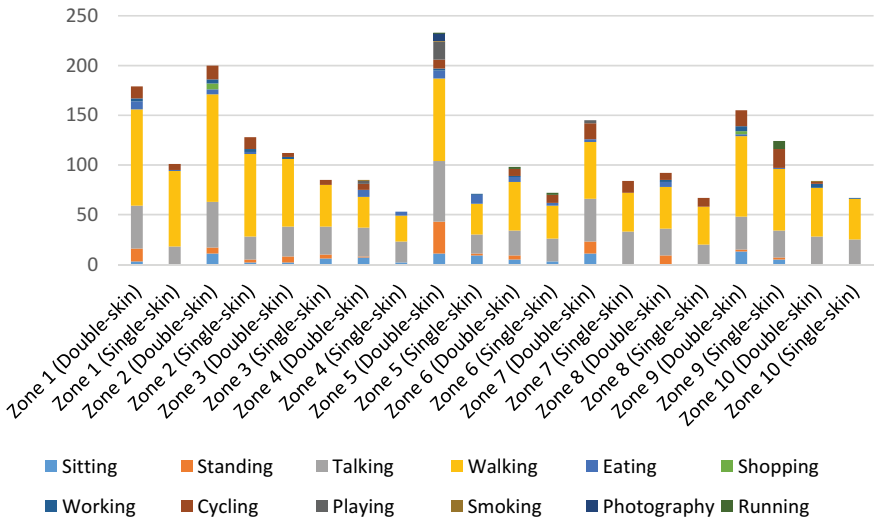


Figure 8. The frequency distribution of people's social activities in Barcelona in front of identified façades.

Table 3. The obtained attributes of the investigated urban façades according to the theoretical framework (S: Single-skin façade; D: Double-skin façade).

	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5		Zone 6		Zone 7		Zone 8		Zone 9		Zone 10	
Urban Façade attributes	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Human Scale	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Symmetry	✗	✓	✗	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✓	✓	✓
Pattern	✗	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓
Rhythm	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Historical Value	✓	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗
Proportion	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓
Complexity	✗	✗	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗
Order	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓
Permeable Edge	✗	✓	✗	✓	✗	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗	✓	✗	✓	✗	✗
Street Furniture	✗	✗	✓	✓	✗	✗	✗	✓	✓	✗	✓	✗	✓	✓	✗	✗	✓	✓	✗	✗
Active Uses	✗	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
Enclosure	✓	✗	✗	✗	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Material Texture	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Vegetation	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗

front of each type of urban façade. Thus, based on the statistical calculation of the independent sample t-test, the establishment of social activities in front of double-skin façades is significantly higher than single-skin façades.

In the next part of the analysis process, it has been endeavored to investigate the urban façade attributes of the identified zones in order to understand what the influential characteristics of urban façades are that may contribute to the attraction of social activities within urban spaces. According to the obtained theoretical framework (Figure 1), fourteen urban façade attributes including *human scale*, *symmetry*, *pattern*, *rhythm*, *historical value*, *proportion*, *complexity*, *order*, *permeable edges*, *street furniture*, *active uses*, *enclosure*, *material texture*, and *vegetation* were adopted for this part of the analysis. The obtained results indicated that the double-skin façades in zones 5, 2, 1, 9, and 7, which are laden with social activities, were considered as the most agglomerated urban spaces. Also, the acquired findings demonstrated that the single-skin façades in zones 2, 9, 1, 3, and 7 were identified as the most densified urban areas, which are laden with social activities (Figure 7). In general, the results revealed that double-skin façades with the attributes of possessing *human scale*, *pattern*, *rhythm*, *permeable edges*, *active uses*, *material texture*, and *street furniture* are more influential on stimulating pedestrians to establish social and behavioral activities within urban spaces (Table 3). Hence, implementing such artistic procedures and principles in designing double-skin façades may contribute to the creation of informal behavioral settings and stimulating social activities in urban spaces.

6. Discussion and conclusion

The main objective pursued by the present study was to explore the influence of double-skin façades on the establishment of social activities among Barcelonians. The process of urban development has led to remarkable changes in people's lifestyles and social behaviors. Therefore, living in densely occupied apartments has diminished the opportunity for the establishment of social interactions among people within indoor spaces. Consequently, creating informal behavioral settings in urban spaces may substantially cover the social requirements of individuals within outdoor public spaces. Hence, urban landscape design, particularly building façades, may play a striking role in drawing the attention of different social groups and individuals with regard to the creation of informal behavioral settings. Quantities of people opt for the sidewalks along the main streets as places for establishing their social activities. Thus, the necessity for striving to achieve visual attractiveness in the urban façades in urban landscape design, and its subsequent impact on people's social activities has become manifested.

The findings obtained from the present study indicated that there is a relative consistency between the obtained data from empirical gate count observations and numerical values in the syntactical analysis. Hence, the highly integrated spaces in the spatial configuration analysis were chosen for identifying potential double-skin and single-skin façades in order to understand what influences each type of façade has on establishing social activities. The subsequent results obtained from the statistical calculation of *t*-test for observing people's social activities revealed that the establishment of social and behavioral activities in front of double-skin façades was found to be significantly higher than that of single-skin façades. In the interim, the types of observed behaviors in front of double-skin façades were found to be more social and optional compared to the ones taking place in front of single-skin façades. Overall, the findings indicated that double-skin façades, with the attributes of featuring *human scale*, *pattern*, *rhythm*, *permeable*

edges, *active uses*, *material texture*, and *street furniture* are more influential on stimulating pedestrians to establish social activities in urban spaces.

In respect to comparing the findings of the present study to previously conducted literature in this field, it can be declared that prior studies have particularly been concerned with the impact of ground-floor façade design (Hassan, Moustafa, and El-Fiki 2019), green façades (Elsadek, Liu, and Lian 2019), heritage building façades (Askarizad and He 2022a; Hollander et al. 2020; Mao, Qi, and He 2020; Serra et al. 2021; Zhang, Zhang, and Yin 2021), digital interactive façades (Abdel-Aziz, Abdel-Salam, and El-Sayad 2016), urban façade color (Zhong et al. 2021), urban façade quality (Hollander and Anderson 2020; Silvennoinen et al. 2022), and aesthetics aspects of urban façades (Balasubramanian, Irulappan, and Kitchley 2022; El-Darwish 2019; Ghomeishi 2021) on sociable and walkable urban areas. However, the present study mainly concentrated on the impact of double-skin façades on the establishment of social activities as its contribution to the body of existing literature in this field. Besides, in line with previous studies regarding the positive effect of visually pleasing urban façades on fostering walkable urban areas (Abdel-Aziz, Abdel-Salam, and El-Sayad 2016; Elsadek, Liu, and Lian 2019; Hassan, Moustafa, and El-Fiki 2019; Hollander et al. 2020; Mao, Qi, and He 2020; Serra et al. 2021; Silvennoinen et al. 2022; Zhang, Zhang, and Yin 2021), this research presents a set of artistic procedures and principles for designing double-skin façades that may contribute to higher levels of sociability and walkability in urban areas.

In conclusion, implementing double-skin façades in urban landscapes has a substantial impact on the constitution of social and behavioral activities, which can ultimately contribute to a socially sustainable urban environment. Certain limitations of selecting Barcelona as the present case study, with a primary focus on its double-skin façades, can be can be complemented by scrutinizing other elements of urban landscapes in future studies. Likewise, other case studies characterized with distinct contextual attributes can be evaluated using the present research design in order to generalize the subject matter as widely as possible. In addition, the present research design can be intermingled with virtual reality simulations in order to make a comparison between virtual and real environments as a novel attitude for future research agenda. The implication of this research may contribute to urban and landscape designers, planners, and architects, and assist them in creating more socially sustainable and walkable built environments.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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