VILNIUS TECH
Vilnius Gediminas Technical University

Journal of Architecture and Urbanism
ISSN 2029-7955 / eISSN 2029-7947
2023 Volume 47 Issue 1: 68–76
https://doi.org/10.3846/jau.2023.17688

THE EFFECT OF PUBLIC FACADE CHARACTERISTICS ON CHANGING PEDESTRIAN BEHAVIORS

Neslişah KESICI *, Nilgün Çolpan ERKAN

Yildiz Technical University, Istanbul, Turkey

Received 11 October 2022; accepted 28 April 2023

Abstract. The facades that define the public open space shape the pedestrian behavior by affecting the visual perception of the pedestrians. In the literature on facade and human interaction, there are pioneering studies in the perspective of environmental perception, but there is a lack and method limitation on the effect of the facade on pedestrian behavior. For this reason, the research aims to evaluate pedestrian behaviors in two areas that are variable in terms of facades, together with video analysis and heat maps. Areas of similar typology in Istanbul's Kadıköy district are compared because of the temporary exterior decoration of the historical candy store in case 1 during the New Year's Eve. According to the research findings, there is a significant difference between the quantity of pedestrians exhibiting stagnant and flowing behaviors and the distribution of these pedestrians in the space. In addition, the subcategories of fluid and static behavior in evening and day conditions also reveal interpretable results regarding the front. The results of the research reveal that the facade features of the public space significantly affect the pedestrian behavior, and therefore this issue should also gain importance in the future of public space design.

Keywords: public space design, building facade, pedestrian behaviors, observation, heat map, environmental perception.

Introduction

The human-oriented public space approach is a major area of interest within the field of not only environmental psychology but also urban design in terms of affecting the environmental perception, orientation, and behavior of pedestrians (Norman, 1999). Carr et al. (2007) describe the needs arising in a human-oriented public space with the concepts of comfort, relaxation, passive-active engagement, and discovery. Active and passive interaction can take place between individuals as well as between building facades and people. Although many studies have been conducted on the effects of facade features of public space on visual perception, its relationship with pedestrian behavior has been neglected in the literature. Therefore, the main research question of this paper is "What are the effects of building facades surrounding the public open space on pedestrian behavior?".

The research on creating an attractive public space for citizens of Jia and Nyström (2008, p. 20) claims that: "if the physical environment is improved a little, a changing of using the city space is noticeable". Determining the impacts of facade features on pedestrian behavior is important for the future of public space design. However, studies dealing with the effects of facades on pedestrian behavior have some limitations in terms of methodological diversity. Another question that the research seeks to answer to bring a new approach to the methodological diversity on this subject is "How can the effect of facade characteristics on pedestrian behaviors be examined?".

The case study focuses on two public spaces located on the same street in the Kadıköy historical bazaar of Istanbul. Kadıköy historical bazaar is very busy day and night, as it is a pedestrianized commercial area at the intersection of many transportation modes (Kürkçüoğlu & Ocakçı, 2015). The exterior decoration of the building facade of historical candy shop in the first observation area causes an observable difference in pedestrian behavior between these two areas with similar typological characteristics. While there is no significant difference in the pedestrian behavior in the first case area except for December, the popularity of the place increases due to the lighting, objects, colors, and patterns in the facade decor in the pre-New Year period and accordingly the pedestrian behavior changes. In this context, when the case areas are considered, the last research question that arises is "How does the pedestrian

*Corresponding author. E-mail: *nkesici@yildiz.edu.tr*

behavior in the two public spaces compared in Kadıköy, Istanbul differ depending on the distinctive exterior of the historical candy store?".

This paper firstly aims to contribute to the existing literature on the relationship between building facades and pedestrian behavior by bringing together different approaches in urban design and environmental behavior disciplines with a focus on public space. Secondly, the aim of this research is to present a new and multi-layered methodological approach on pedestrian behavior and façade characteristics. Finally, it aims to raise awareness on the power of public space facades to shape pedestrian behavior for the future of urban design, based on the findings of the case study on the relationship between facade and pedestrian behavior.

1. Literature review

Nasar (1994, p. 381) explains the relationship between building features and human behavior with the "probabilistic model of aesthetic response" scheme as follows: building attributes are perceived by the observer, this perception creates an aesthetic effect, and this effect turns into an environmental behavior. Lynch's (1964) conceptualization of the edge emphasizes the importance of facades, which define the third dimension of urban space, in spatial memory and urban image. The literature research consists of three main parts: research examining the building facade features, research focusing on the observation of pedestrian behavior in the public space, and finally research focusing on the pedestrian interaction with the building facade features.

Nasar (1994) made one of the early studies on evaluation criteria for the aesthetic quality of building exteriors with enclosure, complexity, and order. In addition, Nasar claims that there is a relationship between the knowledge and experience of the individual and the perception created by certain features of the building's exterior, such as the naturalness, upkeep, intensity of use and style. Akalin et al. (2009) examines the perception of the facades under three main headings: preference, complexity, and impressiveness. Yammiyavar and Roy (2019, p. 312), in their study on the perceived effect of visual elements on facades, listed the frequently marked design element/features as: "The entrance door, the visual perspective, size, volume, largeness, display windows, landscape features-vegetation, lighting, symmetry of the entire structure etc.". Mishra and Kolay (2019) deals with the perception of street facades in historical cities by combining facade elements such as columns, cornices, windows with semiotic tools.

Li et al. (2020), in their research on the color harmony of the building facade, drew attention to the importance of the tone, harmony and intensity of the color of the exterior of the building in visual perception. In addition, O'Connor (2006) established the relationship between the aesthetic perception of facade color and urban design and planning. Prieto and Oldenhave (2021) group the parameters they obtained by conducting interviews with architectural experts to investigate the reasons why a facade is perceived as beautiful under two main headings. The first of these are the intrinsic aspects of the facade such as compositional, plastic, detail design and character expression. The second is connections that depend on extrinsic factors, such as humanistic, contextual, and intellectual.

Banerjee (2001, pp. 19–20) highlights two important approaches for the future of public space: "focus on the concept of public life rather than public spaces" and "include conviviality and public life as objectives of street design". The second part of the literature review covers some studies and methodological experiments on the observation of human behavior. Observation studies based on systematically watching people use their environment as individuals, couples, small or large groups (Zeisel, 2006). According to Zeisel (2006), observing behaviors in physical environments gives the researcher an idea about behavioral habits about human activities and the relationships required to maintain them. Observers' points of view can be constructed as hidden strangers, known strangers, marginal participants, or full participants (Zeisel, 2006). There are some methods to record the observation. For example, taking notes with appropriate display technique, pre-coded checklists, maps, photographs, video tapes and films.

Video analysis methods developed by zoologists to record and examine the behavior of animals (Knoblauch et al., 2012). Today, increasing tracking technology of street cameras and wearable devices that provide location data let researchers to make analysis for pedestrian mobility studies and real estate valuation (Schaick & Spek, 2008). In addition, pedestrian counting enables some quantitative data on the observed area. There are several ways to accomplish pedestrian counting manually, such as the use of manual counts with paper, the use of manual counts with clicks, and the use of manual counts with video cameras (Diogenes et al., 2007). The weather conditions, the day and the hour should be selected consciously by the researcher for objective pedestrian counting (Diogenes et al., 2007). The heat map method is another symbolic expression of the pedestrian volume of a place. Wilkinson and Friendly (2009, p. 180) describe the heat map method as, "It is a data visualization technique that shows the change in color can be by hue or intensity, which gives the reader clear visual clues about how the phenomenon is clustered or changed in space".

Whyte's (1980) observation experiment plays a key role in observing human behavior in public spaces. His research, "The Social Life of Small Urban Spaces" introduces many new methods such as time-lapse camera shooting, detection of observations by dividing the space into grid squares, and coding of pedestrian behaviors. Jan Gehl has made significant contributions to the literature at the intersection of environmental psychology and urban design, with observing and categorizing behavior in public life. According to Gehl's (2013) classification, behaviors in public space are examined in three categories: "necessary activities, optional activities, and social activities". Gehl

also examines whether the facades on the ground floors of buildings are active or passive in their relationship with people in street life. For example, Gehl (2013, p. 33) point out the features of unattractive ground floor facades as "Large units with few or no doors, no visible variation in function, closed or passive facades, monotonous facades, lack of detail, nothing interesting to look at". On the other hand, according to Gehl (2013, p. 79). "In front of the open and active facades, there was a noticeable tendency for pedestrian to slow down and turn their heads towards the facade and they stopped frequently".

Research conducted by Joyce and Guaralda (2013) using the observation method in three different public spaces is one of the studies that forms the basis of this research, since it examines the relationship between the "shelter, open, support and share" features of the public space facade and the behaviors of pedestrians. Mao et al. (2020) examined the effects of historical facades in public spaces on human behavior with various spatial analysis methods. Mao et al.'s (2020) research focuses on the frequency of preference of building facades by people with certain demographic characteristics, but no evaluation of spatial behavior categories was made in this study. In line with the findings obtained from the literature review, the main components of the research such as the evaluation criteria for the facade features and the method of observing pedestrian behavior emerged. Hollander and Anderson's (2020) research based on statistical data examining the effect of façade quality on affective feelings proves the importance of façade in human perception. The criteria for examining the façade quality of this research are the number of elements such as windows and doors, colors and textures, architectural details, materials, and visually permeable surfaces. On the other hand, researchers define frontal-affected emotions as pleasant, aroused, and likely.

2. Case area and methodology

The independent variable of this research is defined as facade characteristics and the dependent variable is pedestrian behavior. The case study in Kadıköy, Istanbul aims to understand the changing pedestrian behaviors due to the façade factor in two public spaces where physical and functional other variables are considered constant. Two public spaces with similar typology are compared because, during the New Year period, a noticeable difference in pedestrian behavior was observed in the first case area compared to the second case area, due to the attractiveness of the exterior decoration of the historic candy shop. The case areas are in the historical bazaar area of Kadıköy, on one of the lively streets in a grid layout (Kürkçüoğlu & Ocakçı, 2015). As can be seen in Figure 1, analyses were made at two nodes on Mühürdar Street, which is suitable for pedestrian observation at street scale.

The location, approximate areal size (400 square meters), ground slopes, street widths and depths are examples of similar spatial features of these two public spaces. Case areas shaped in the X-junction typology at the intersection of two pedestrian streets are defined by four corner facades in the third dimension. The physical and functional features of these corner facades also bear some similarities. The buildings surrounding the open area have similar facade features as they have functions such as retail trade, cafe, and restaurant. In both areas, one of the corner façades is defined by the high walls bordering the churchyard and the entrance gate. The other three of the corner facades are similar in terms of building height, architectural details on the facade and materials. On the other hand, the New Year decoration on the exterior of the historical candy store in the first case area becomes the main distinguishing element in the facade features of the two squares in terms of color, material, and detail.

The methodological approach of this study is a mixed methodology based on two main stages. The first part consists of descriptive spatial analyzes of the building facades by 360-degree panoramic photographs of each case area to reveal the facade features. The second part includes an evaluation of the heat map to determine the fluid and static areas of the public space and to analyze pedestrian behaviors by digitizing behavior categories in video records.

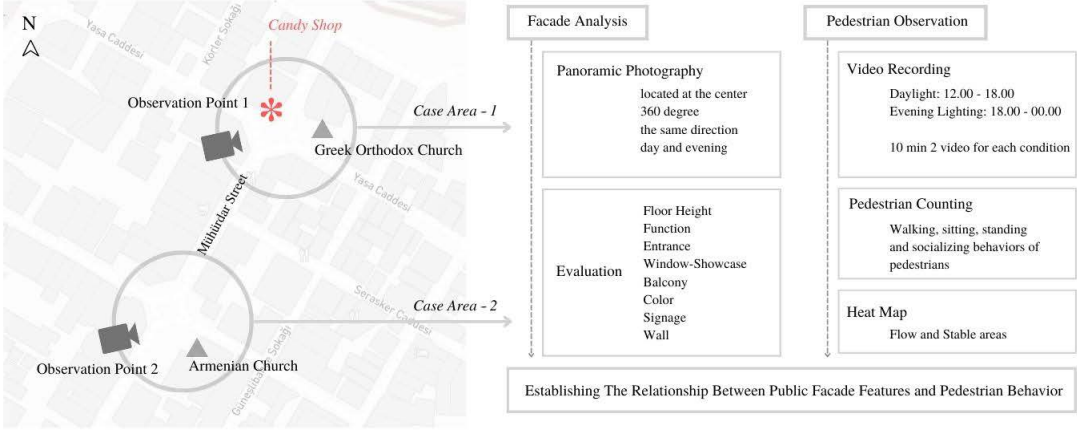


Figure 1. Case areas and the methodological framework

The researcher made 10-minute video recordings from the balconies that can see both squares from a wide angle and in the same direction. Video records under daylight (12:00–18:00) and evening lighting conditions (between 18:00–00:00) belong to the weekday of December with 17 degrees air temperature and no precipitation.

The videos recorded with the 13 MP resolution rear camera of the Samsung Galaxy Tab S7 model tablet was converted into heat maps by being processed in the Cam Heat Map program produced by GeeBee Apps (2019) company for Android devices. As Class Activation Mapping (CAM) is a technique for generating heat maps to highlight the class-specific regions of the images, it was designed by the software manufacturer to detect areas with intense street activity in security cameras or to determine the movement areas of pets (Draelos, 2019). The program used for the heatmap prepares the heatmap by taking 1 slice every 10 minutes from a 1-hour video recording slowed down to 30% sensitivity and neutral color scale. Heatmaps help to correlate the features of the facades according to the shape and size of the flow areas (red and yellow areas) and stationary areas (green and blue areas) at both nodes. The final section discusses the significant findings of the relation between facade features and pedestrian behaviors. This study makes a methodological contribution to the literature in terms of investigating spatial analysis and pedestrian behavior analysis with an experimental method design.

3. Public space facade analysis

The facade analysis of the photograph taken in the first case area; it is remarkable that the floor heights are similar (see Figure 2). Three facades are surrounded by 2–3 story buildings and one facade is surrounded by 1–2 story buildings. Cafe and restaurants are the dominant functions, so most of the facades are visually permeable with open surfaces such as shop windows and balconies. The facade of the Greek Orthodox Church, which has the church wall and the church entrance door, is a distinctive feature of the public space and the facade function. Although it is an area defined by facades with similar historical periods and architectural features, there is no diversity in terms of color, visual composition, geometric form, and lighting, except for the facade of the historical candy shop. There is no element of design value on the facades other than this facade, except for the signboards of cafes and restaurants, which mostly use two colors and text as a visual element. The exterior of the candy store, located in the northwest corner of the area, contains many details, harmonious colors, and objects of different sizes.

The tree in the second area and the high-visibility bell tower of the Armenian Church are two important elements that can be noticed in this area (see Figure 3). Three-quarters of the facades have a similar floor height to the other area. On the other hand, the second case area is separated from the first by the 4-story building on the

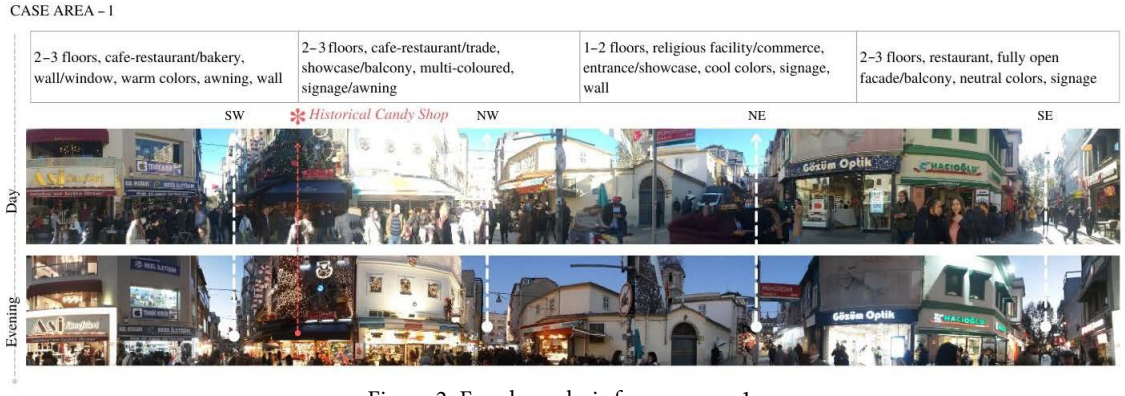


Figure 2. Facade analysis for case area 1

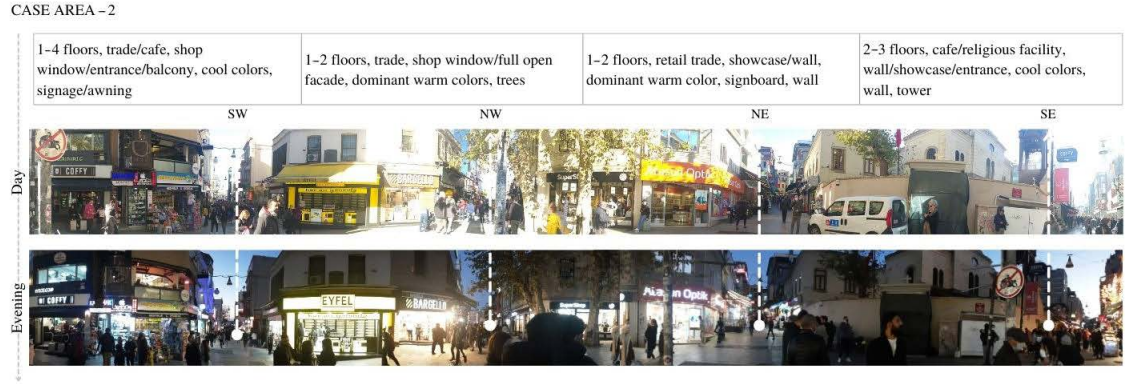


Figure 3. Facade analysis for case area 2

southwestern direction. This may cause some differentiation in the shading of the space and the feeling of the enclosure. Although the facades here are visually permeable, the interaction with the street and the pedestrian is passive as the open surfaces serve as commercial showcases. Only the northwest facade has balconies and interactive facades facing the street. While the dominant warm colors such as yellow and orange dominate the signboards and awnings on the three facades, neutral colors take place on the facade of the church wall.

In addition to the findings in daylight, the characteristic of the facade is highly influenced by the variety, intensity, and quality of the facade lighting in the evening hours. Facades where the lighting is very strong, but the diversity is weak and unqualified cannot create a visual effect in the space. In line with all these findings, the inference that can be made for both focuses is that the effect of permanent facade features on spatial perception is weaker than temporary facade decoration, despite the presence of historical buildings. In addition, differences in pedestrian behavior are inevitable because of the differentiation of space perception in daylight and evening lighting conditions.

4. Observation of pedestrian behaviors

Observation of pedestrian behavior takes place in three stages: video recording, pedestrian counting by encoding videos, and heat map showing flow and stagnant areas. Pedestrians exhibiting stable behavior are shown with white points in Figure 4 and Figure 5. In addition, the numbers at the ends of the arrows placed at the exit points from the video frame of the streets represent pedestrians exhibiting walking behavior in four directions. The total number of pedestrians observed in both areas (n = 493 in the first region, n = 485 in the second region) is quantitatively similar. However, the differentiation in the two case areas is remarkable in terms of the variation in pedestrian behaviors and their spatial distribution. In addition, depending on the changing lighting conditions, the behavior tendencies of the pedestrians in the evening and during the day also cause some differences in the two areas.

As can be seen from the distribution of warm colors such as red and yellow in the heat maps, the areas where pedestrian activity increased in the two observation nodes differ. In case area 1, there is a linear focus along Mühürdar street to the northeast and southwest. On the other hand, there is an organic distribution in case area 2 that cannot be expressed with a specific form. According to the daytime heatmap, pedestrian activity in case area 2 is slightly less than double that in case area 1. On the other hand, when we look at the heat map in evening conditions, case area 1 is more intense than case area 2 in terms of pedestrian mobility. In heat maps, pedestrian movements are stationary in areas expressed with cold colors in blue and green tones. Considering the distribution of cold colors in the heat map in the space, it is observed that stationary behaviors are clustered in the west and east directions in case area 1. On the other hand, in case area 2, stationary behaviors focus on the south of the area. According to the

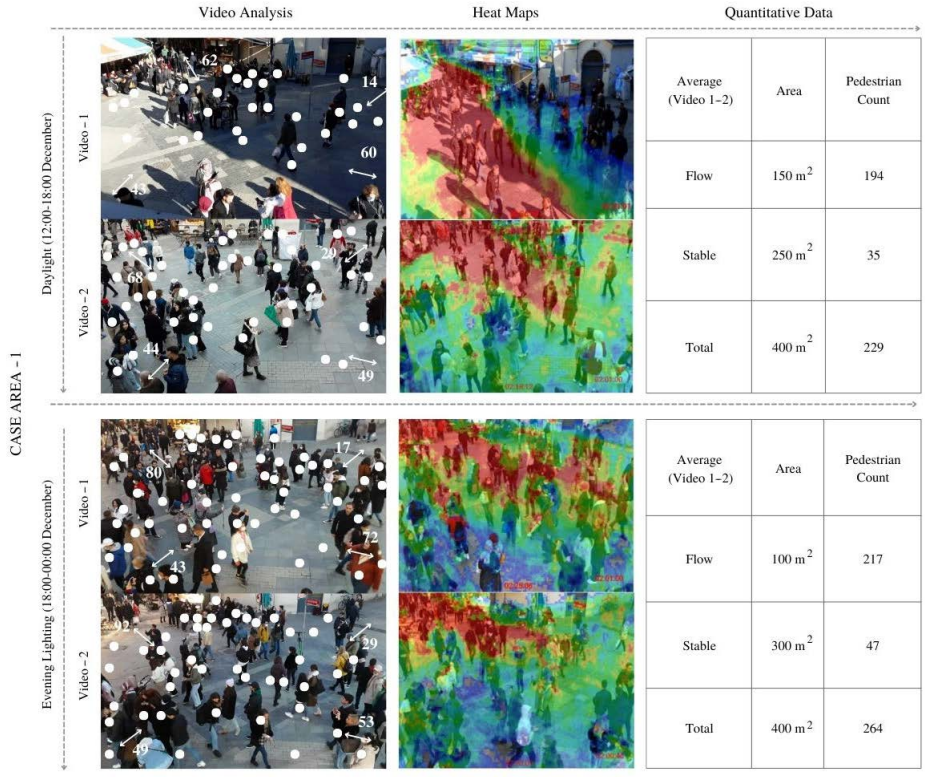


Figure 4. Video-analysis, pedestrian counting and heat map of case area 1

Figure 5. Video-analysis, pedestrian counting and heat map of case area 2

daytime heat maps, the stationary areas in case area 1 are exactly twice the stationary areas in case 2. In addition, according to the heat maps in the evening conditions, the stable behavior areas in case area 2 are similar with the stable behavior areas in case area 1.

As shown in Figure 6, of the 229 pedestrians observed in the first area during the day, those exhibiting fluid behavior were approximately six times more likely than pedestrians exhibiting stationary behavior. A total of 264 pedestrians observed in the same area in the evening consist of standing pedestrians and five times as many walking pedestrians. In the daytime video of the second area, almost all the 211 pedestrians in total exhibit flowing behavior because pedestrians exhibiting standing behavior are negligible. Similarly, a total of 274 pedestrians observed in the evening consists of a negligible minority of standing pedestrians and a large majority of flowing pedestrians. According to these data, the total number of pedestrians in both areas is similar during the daytime and evening hours. The number of stable pedestrians is considerably less than the number of pedestrians in flow. There is no significant change in the proportional distribution of stagnant and flowing pedestrians during evening and daytime hours.

While counting the physical sub-behaviors of pedestrians, firstly the seated pedestrians, then the standing pedestrians and finally the pedestrians in motion were counted. According to Manual on Uniform Traffic Control Devices (MUTCD), under normal conditions, the average walking speed of a pedestrian is 1.2 m/s (Montufar et al., 2002). The longest distance measured by the researcher between the distances of the entrance and exit points to the video frame on the plan plane was measured as 40 meters. In normal walking conditions, this distance is completed in an average of 33 seconds. However, the time elapsed between entering and exiting the video frame of pedestrians

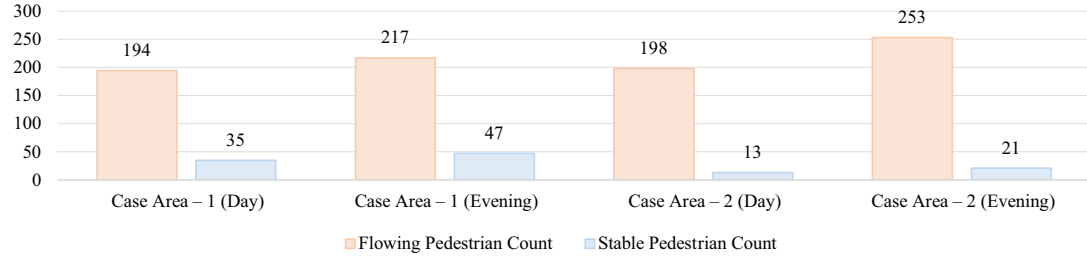
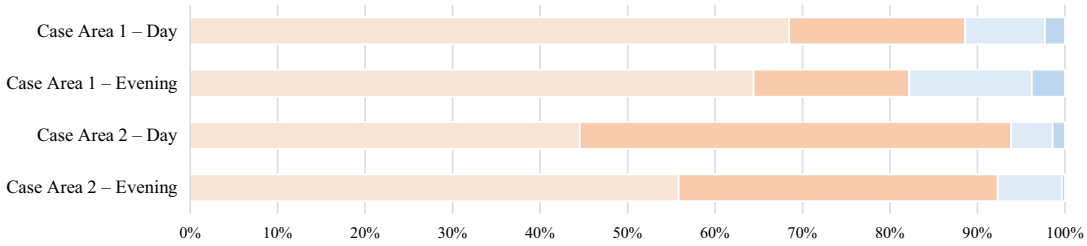


Figure 6. Proportional distribution of pedestrians exhibiting static and fluid behaviors



	Case Area 2 – Evening	Case Area 2 – Day	Case Area 1 – Evening	Case Area 1 – Day
Slow Walking	153	94	170	150
Fast Walking	100	104	47	44
Standing	20	10	37	20
Sitting	1	3	10	5

Figure 7. Subcategories of pedestrian behavior frequencies

who stop or walk while looking around can be longer than 33 seconds. On the other hand, the longest walking time observed in the video recordings was 160 seconds. For this reason, the behavior of pedestrians who exhibit stagnant behavior in the space for longer than the longest walking time was evaluated as standing. Considering these conditions, pedestrians who completed their walk in 33 seconds or less were evaluated under the "fast walking" behavior category, and pedestrians who completed their walk between 33 and 160 seconds were evaluated under the "slow walking" behavior category. Pedestrians who continue to stand for 160 seconds or longer throughout the video are included in the standing behavior category.

As shown in Figure 7, the dominant behavior in both areas during the daytime and evening hours is primarily fluent behaviors (red) and secondly static behaviors (blue). The first of the behavior types that differ in the two areas is related to subcategories of flowing behaviors. There is a remarkable difference between the two cases related to walking speed. It is seen that pedestrian walking speeds in case area 2 during day and night are much higher than in case area 1. On the other hand, the rate of stationary behaviors in the first area is higher than in the second area. Case area 1 is significantly higher than case area 2 in almost all subcategories of stationary behaviors.

Heat maps as the first part of pedestrian behavior analysis, do not provide data on the number of pedestrians, as they show the intensity of pedestrian movement. In addition, the pedestrian count does not provide data on the distribution of pedestrians in the space. Finally, subcategories will be overlooked if pedestrian behaviors are evaluated under two very basic headings, such as standing and flowing. Therefore, in this study, a three-stage method experiment is conducted for the analysis of pedestrian behavior. In the conclusion and evaluation part of the research, these three stages are evaluated by relating them.

5. Results and evaluation

This research aims to reveal the differences in the pedestrian behaviors, which can be caused by the changing facade characteristics of the public space because, researchers interested in the relationship between urban design and environmental psychology have focused on a human-centered spatial approach (Rapoport, 1977). "This paper was developed in line with the pioneering research of Nasar (1994), which examined what facade features evoke in human perception. The contribution of the research to the literature is that it brings together studies on facade perception (Li et al., 2020; O'Connor, 2006; Yammiyavar & Roy, 2019; Prieto & Oldenhave, 2021) with studies based on pedestrian behavior (Whyte, 1980; Gehl, 2013). The methodological principles of the research are based on Zeisel's (2006) pedestrian census study and Diogenes' (2007) heatmap research. This research brings an alternative perspective to the statistical approach of Mao et al. (2020) as it looks at the relationship between facade and pedestrian behavior with a mixed method such as video analysis, pedestrian counting and heat mapping. In addition to the research of Joyce and Guaralda (2013) and Hollander and Anderson (2020), this study emphasizes the importance of this issue in the future of urban design by addressing the effect of facade perception on pedestrian behavior categories in the public open space".

A few meaningful implications regarding the relationship between static and flowing pedestrian behavior areas in heat maps and facade features. When we look at the form of the mobility areas defined by the warm color in the heat maps, the fact that there is an organic mobility distribution in the other area, although a linear mobility area is detected in the area showing the distinctive facade feature, proves the effect of the facade features on the shaping of pedestrian behaviors. Although the number of pedestrians exhibiting fluid movement in daytime conditions is almost equal in both areas, since case area 2 is almost twice that of case area 1 in the distribution of heat maps, it can be inferred that case area 2 assumes a transition space function. However, according to the heat map in the evening conditions, this situation is reversed in the late hours of the day. This may affect the sense of security of the place here, depending on the liveliness of the street life in the first node. Considering the walking speeds in the two areas, the fact that the pedestrian walking speed in case area 1 is much lower than in case area 2

may be due to the remarkable exterior decoration of the historical candy shop, which is the distinguishing factor between the two areas. Looking at the areas focused by pedestrians exhibiting stagnant behavior, there is a similarity between the two areas in terms of the facades defined by the church walls. When pedestrian counts and heat maps in the two areas are compared, the stagnant behavior in the early hours of the day is considerably higher in case area 1 than in case area 2. This situation shows that pedestrians prefer to spend more time in the first area where the distinctive facade is located, and therefore this area, which is a pedestrian node, assumes the function of a square. In addition, heat maps and pedestrian counts in the evening show that although the pedestrian density with stagnant behavior increases in case area 2, it continues to focus in case area 1.

Conclusions

There are some potentials and limitations of this research, which consists of three main parts: evaluation of facade perception through photographs, pedestrian behavior analysis through videos, and correlation of these two. First, the research focuses only on the visual perception of facades, so some other factors that affect pedestrian behavior are not covered in this research. Secondly, behaviors in details that the observer cannot notice due to the shooting distance of the videos are not included in the pedestrian behavior categories. Finally, this research, which takes a descriptive approach to facade features, is not based on a direct correlation, but is based on facade features associated with behavioral tendencies through pedestrian observation and heat maps. As a result of the findings in the case area, it is possible that this area occupies an important place in the spatial memory of the Candy Store, in parallel with the variety of time and experience the pedestrians spend due to the attractiveness of the facade. This situation shows that it is possible to build an urban identity and publicity with the design of the facades in the public space. The results of this behavioral study, which focuses on facade features in public open spaces, will lead to studies and regulations on issues such as the design and management of public open spaces, pedestrian flow rate, and crowd control. Beyond perceiving the production of public space as "building new spaces open to the use of the society in public ownership", today's urbanism approaches are evolving to use it as a "tactical" tool that can shape social dynamics and keep street life alive. However, the opinion that formally designed public spaces are better than informally designed public spaces in terms of keeping public life alive is not clear. This article proves that the unplanned and temporarily produced New Year's facade of the candy store has a greater impact on pedestrian behavior in the public space than the other planned and permanently produced facades. While it is possible to create such an effect in public life with facades that define public spaces, in today's practice, facades built without considering the effects of facade design features on pedestrian behaviors are discussed with this paper. This discussion also raises the question regarding the future of public spaces: Is it possible to design public life with public space facades?

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