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THE RELATIONSHIP BETWEEN SPATIAL CONFIGURATION
OF RESIDENTIAL QUARTERS AND CHILDREN'S OUTDOOR ACTIVITY

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FIG. 1 SOME ILLUSTRATIONS DEMONSTRATING THE DIFFERENT OPEN SPACES OF THE NEIGHBORHOOD



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THE RELATIONSHIP BETWEEN SPATIAL CONFIGURATION OF RESIDENTIAL QUARTERS AND CHILDREN'S OUTDOOR ACTIVITY

CHILDREN
OUTDOOR ACTIVITY
RESIDENTIAL QUARTER
SPACE SYNTAX
SPATIAL CONFIGURATION

Open spaces in neighborhoods are children's main living spaces, closely related to their daily activities. There is an increasing awareness that the physical form of the neighborhood plays a critical role in children's activity, by offering opportunities for exploration and interaction. The aim of this paper is to explore the impact of the spatial configuration of buildings on children's activity on the example of a residential area in the city of Oum El Bouaghi (Algeria) as the research object. The hypothesis of this work indicates that spatial configuration and the location of the buildings, in particular, the way in which the site is embedded are important variables in children's outdoor

activity. Based on this hypothesis, both quantitative and qualitative methods are used together through Space Syntax and Snapshot Observations. Findings indicate that the extent and character of children's outdoor activities are greatly influenced by the physical characteristics of the neighborhood environment in residential areas through the degree of space enclosure interpreted by visibility and accessibility. By uncovering the impact of spatial configuration, this research offers an approach to designers for rethinking and considering new insights into managing and designing current and future spaces in light of children's preferences and behavior patterns.

INTRODUCTION

The housing sector in Algeria, as a developing country, has been facing a serious crisis (Madani, 2012; Merzag, 2015). The fast growth of the Algerian population in the past years has resulted in rapid urbanization, whereby almost all Algerian cities have been going through an increased mass housing production (Mebirouk, Zeghiche & Boukhemis, 2005; Hima, Tacherift & Abdellaoui, 2018; Zerouati & Bellal, 2020). By putting an emphasis on a quantitative dimension, the state has made dwellings a priority without considering the importance of outdoor open spaces (Madani & Tacherifte, 2010).

However, outdoor open spaces are recognized as highly important to children's development (Jansson, 2010; Carson & Predy, 2019), they are especially associated with children in terms of outdoor play as a fundamental part of their daily life (Bao et al., 2021). According to Bagattini (2019), children are the most vulnerable social group, they are also the most present category in public open spaces within the residential neighborhoods. The Algerian residential neighborhoods are composed of various units of buildings in different shapes and arrangements, generating several voids and different spatial configuration types.

The topic discussing the impact of spatial characteristics of outdoor space in residential quarters on children in the Algerian context is still unexplored. In response to this

research gap, the purpose of this work is to investigate the actual use of outdoor spaces, by analyzing the spatial configuration and demonstrating children's recreational preferences and behavior patterns in residential neighborhoods. The research centres on how spatial configuration affects the ways in which spaces are occupied by children. In other words, how does spatial configuration shape children's outdoor interactions?

The hypothesis of this work indicates that spatial configuration and the location of buildings, in particular, the way in which the site is embedded, are important variables in children's outdoor activity. Based on this hypothesis, both quantitative and qualitative methods are used together via Space Syntax and Snapshot Observations. Therefore, by uncovering the impact of spatial configuration, the research offers an approach to designers for rethinking and considering new insights into managing and designing current and future spaces in the light of children's preferences and behavior patterns.

RELATED STUDIES

In the last few years, the number of studies exploring the impact of environmental factors on children's physical activity has grown rapidly. In a recent study, Bao et al. (2021) investigated the physical activities of children in neighborhood space, more specifically, they were interested in the influence of the urban neighbourhood space on the duration of physical activity. In a similar context, Sallis, Prochaska & Taylor (2000), Popkin, Duffey & Gordon-Larsen (2005), Davison & Lawson (2006), highlighted factors such as accessibility, safety and area deprivation to be important influence factors for play activity. As the most essential space that has also become the most critical factor affecting children's physical activity, other researchers also agree that the outdoor activity of children is influenced by environmental factors (Chawla, 2001; Romeo, 2004; De Vries et al., 2007; Aarts et al., 2010; Henderson et al., 2015).

Spatial configuration as an important environmental factor also has an impact on the quality of life and space use. Whyte (1980) and Gehl (1987) have considered the physical features of public spaces and their impact on residents' behavior and their main findings indicated that the use of places was correlated with space characteristics, mainly visibility created by the buildings arrangement as an important factor in space frequency. By using the space syntax approach, many other recent research studies (Campos, 1997; Ferguson, 2007; Bada, 2012; Can & Heath, 2015;

Bendjedidi, Bada, & Meziani, 2018; Zerouati & Bellal, 2020;) have also confirmed the impact of spatial characteristics on the use patterns of public spaces and neighborhood spaces. However, these studies have not address spatial configuration impact on children in particular.

The use of space syntax in the context of children is relatively unexplored. Only a few research studies have used the space syntax method in investigating children. Özgece et al. (2015) investigated the perceptions and children's experiences with regard to outdoor spaces in order to discover children's landmark recognition and preferences of outdoor spaces. Their main results confirm the impact of city proprieties on the spatial perceptions of children. Meinert et al. (2019) investigated the relationship between children's use of urban spaces and the quality level of living environments (in two different neighborhoods in Bergen, Norway) using segment analysis and the urban microscale tool. The findings indicate the importance of children's use of urban spaces as the main factor in choosing living environments. Loit (2021) too has explored children's access to playgrounds in Stockholm using space syntax, and his findings reveal the existing conflicts between creating a safe play environment and the ambition of designing accessible areas.

MATERIAL AND METHOD

- Study area – Oum El Bouaghi is a small-sized city, its total population is around 80 thousand inhabitants. Located in the eastern part of Algeria (Fig. 2), Oum El Bouaghi, as almost all Algerian cities, has its own mass housing neighborhood extension area situated in the south western part of the city. The neighborhood in question includes about 2100 inhabitants belonging to an intermediate occupations category (clerical, sales, service) with a total number of children of 1260. (This study is interested in the age range of school children 6-14 years old). The neighborhood space is composed of 420 housing units and some public and administrative buildings (high school, bank, clinic, group of individual houses, courthouse, office and gym). It also contains a considerable surface of open spaces exposed as leftover plots, with poor physical conditions and a lack of furniture (Fig. 1).

- Materials and design – The analytical approach used in this study case is based on the combination of two methods according to the objectives to be achieved. The first one is space syntax, using Visibility Graph Analysis VGA and Agent-Based Modelling while the second is observation, using static snap-

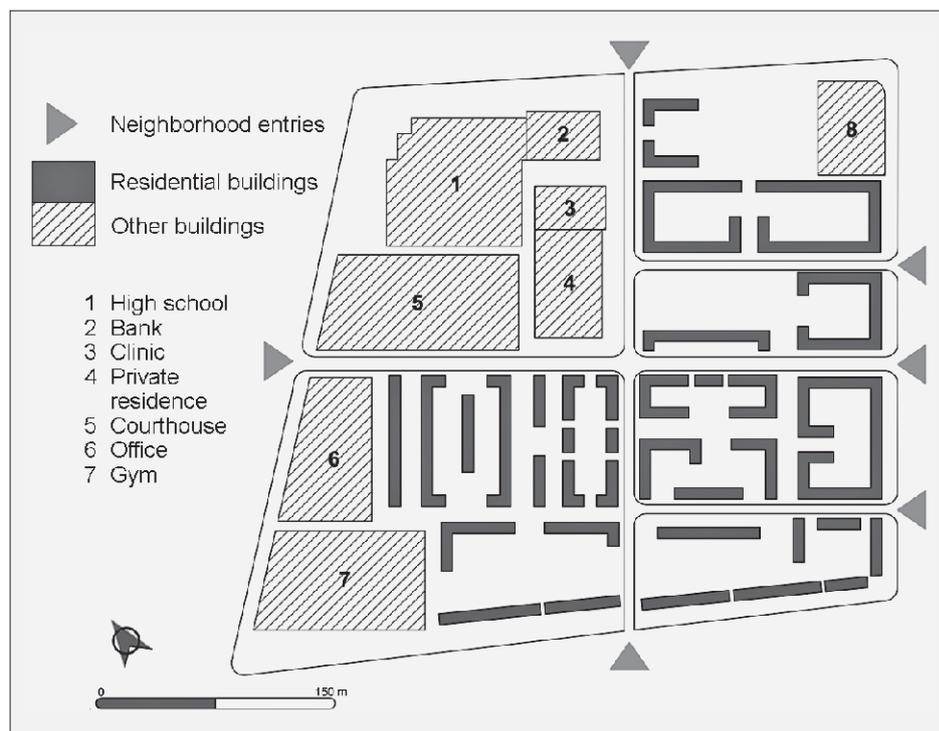


FIG. 2 LOCATION OF THE STUDY AREA

shots. As a third step, an overlapping of the two mentioned methods is used in order to verify the hypothesis that refers to the relationship between the children's use of open space in mass housing, and the characteristics produced by spatial configuration.

Space syntax was used in the analysis of the physical residential environment. It provides an effective quantitative indicator of spatial configuration in order to understand children's space use and behaviors. Among the space syntax analysis methods, the visibility graph analysis is used for analyzing open

FIG. 3 SPATIAL COMPOSITION OF THE NEIGHBORHOOD



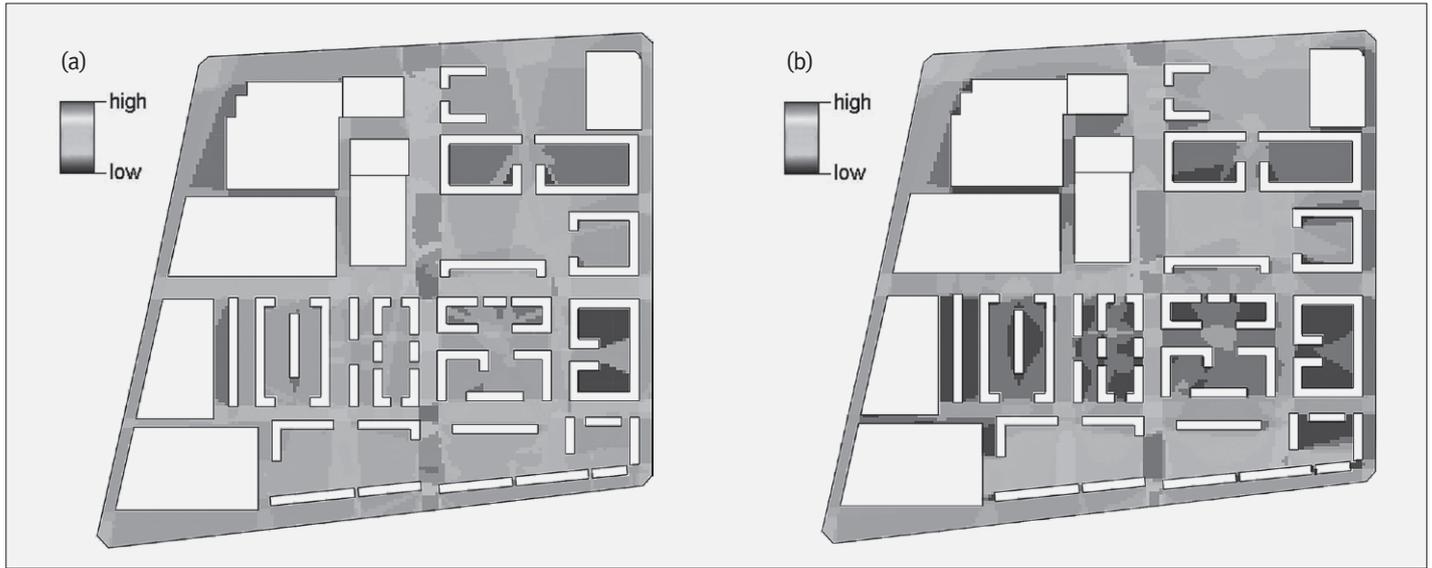


FIG. 4 (A) VISUAL GLOBAL INTEGRATION MAP (VGA);
(B) VISUAL CONNECTIVITY MAP (VGA)

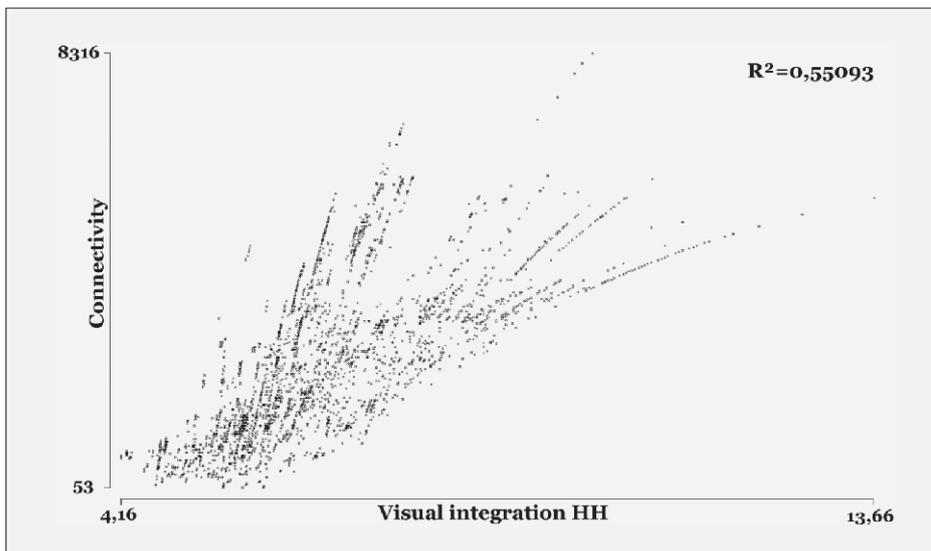
spaces. Connectivity, integration, and intelligibility were measured for the data analysis.

The visibility graph analysis (VGA) is a method for analyzing the inter-visibility connections of urban space, it is used to evaluate the design of outdoor areas, parks and gardens (Van Nes & Yamu, 2021). This approach promotes a quantitative analysis of visual properties in the built environment (Ostwald, 2011). In terms of visual analysis, VGA is used to study the visibility in the neighborhood's open spaces in order to understand the relationship between visibility and children's use of space. Two syntactic measures will be obtained; the integration which identifies the most visible and accessible spaces besides the local measure of connectivity which indicates visual connections between different

spaces of the neighborhood using the "DepthmapX" software. The visibility analysis radius used is (n) in the global analysis and (3) in the local one.

Agent-based modeling is a relatively new technique for modeling accessibility and interactions between people and spaces based on visual fields and syntactic steps. Using "DepthmapX" software, the agent-based modeling is applied to the neighborhood for the purpose of understanding the relationship between spatial configuration and children's movement patterns. With a sight field angle of seven degrees (7°) and a number of five (5) syntactic steps, a certain number of agents is equally distributed in the investigated space for a certain time frame, aggregating their movement in order to comprehend the ways children orient themselves and navigate outdoor spaces departing from different locations in the neighborhood.

FIG. 5 INTELLIGIBILITY OF THE NEIGHBORHOOD



Static Snapshots represent an effective observation technique for the registration of various people's stationary activities, moving activities, and social interactions in public spaces, by recording the use patterns from specific moments (Van Nes & Yamu, 2021), in order to consider in detail, the open spaces of the neighborhood such as a plaza, playgrounds, green spaces and also the leftover plots. The method is used for recording both stationary and moving activities to make a direct comparison and demonstrate the existing relationships between different types of space. For each part of the neighborhood, 15 to 20 min of observations and activity records were executed. This technique provides an understanding of how children use and interact within a particular space according to its characteristics. The method supplies an

effective tool for understanding the spatial configuration impact of a neighborhood on children and evaluating the results of design decisions.

FINDINGS

- Spatial Configuration Analysis – Visibility Graph Analysis results (Fig. 4) illustrate both global integration (a) and connectivity (b) measures of the neighborhood under investigation. Values range according to different colors, from red for the highest values to dark blue for the lowest ones (or shades of grey). The global integration values ranged from a maximum of 13.6695 to a minimum of 4.16427 and an average of 7.99001, while the connectivity values ranged from a maximum of 8316 to a minimum of 53, and an average of 2950.97.

Results show a high similarity in the distribution of values between integration and connectivity. Compared to different space configuration types the most integrated and connected areas of the neighborhood are located in the spaces representing an open configuration. These spaces are more accessible and well-connected compared to other spaces. On the other hand, moderate integration and connectivity values are located in semi-open spaces while the lowest integration and connectivity values are located in semi-closed spaces.

Intelligibility is the most commonly used correlation in space syntax, it is calculated as the correlation between visible global integration and visible connectivity. This syntactic measure is based on the correlation coefficient (R^2) where the closer the correlation coefficient is to one (1), the more orientable and thus intelligible the built environment under scrutiny is. In our findings, the coefficient (R^2) was moderate ($R^2 = 0.55 / 0.5 < R^2 < 0.7$; Fig. 5), meaning that the area is vital, relatively easy to orientate in and navigate through and the spatial hierarchy of space is clear. This stands for how easy it is for children in a local position to infer the structure of the whole neighborhood setting from one situated point of observation.

The agent-based modeling of children’s behavior in space (Fig. 6) demonstrates the ways agents as children tend to orient themselves in the built environment. Agents are released from all locations in the simulation, however, they gather mainly in the extremes of the neighborhood. Also, the highest levels of agents’ clustering are registered in spaces with open configurations while the agents’ clustering tends to progressively decrease in the closed ones. The clustering degree of agents follows a stepwise spatial hierarchy correlated to the syntactic characteristics (in-

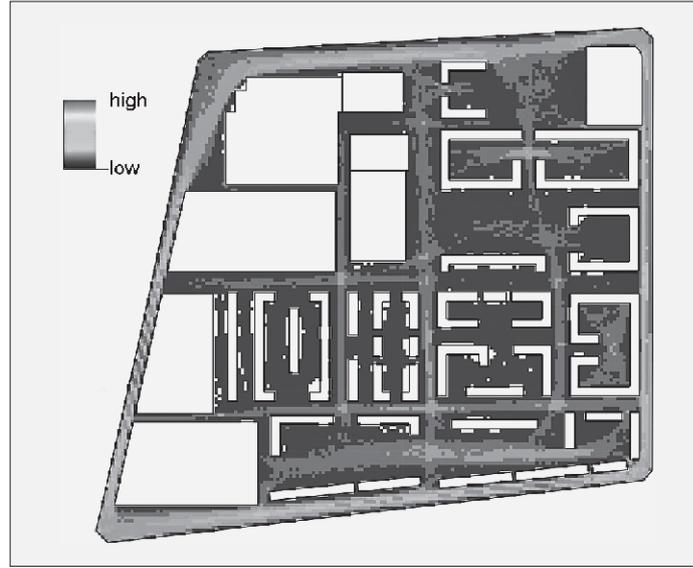
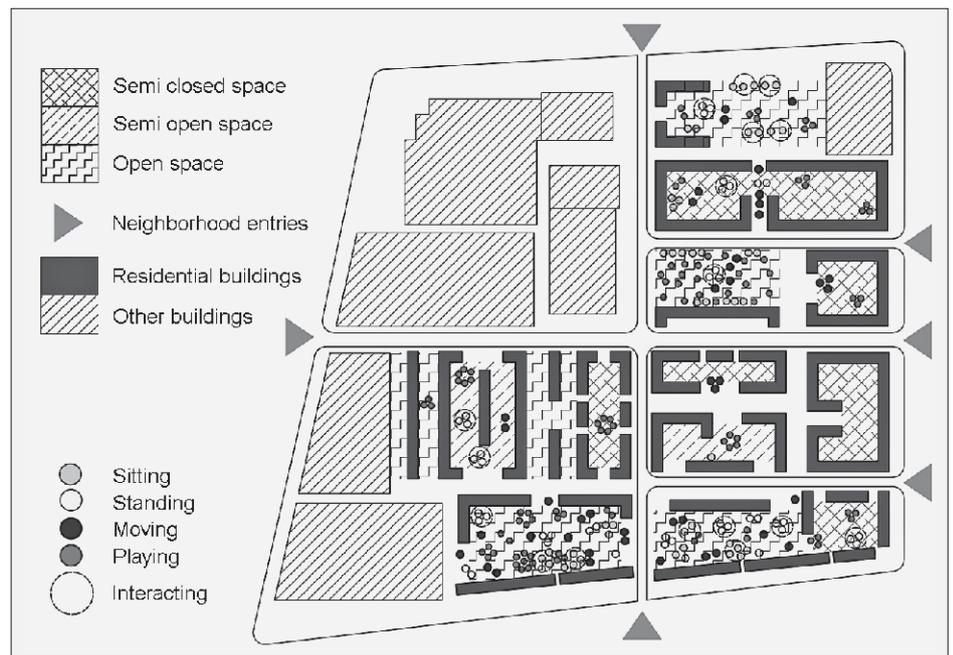


FIG. 6 AGENT-BASED MODEL

tegration and connectivity) of space, along with its spatial configuration types.

- Effect of space configuration on children’s use and interaction – The next step was to analyze the correlation between children’s use patterns and the frequency of interaction on the one hand and the space configuration of the neighborhood on the other, in order to identify the related factors. The results from the static snapshots technique (Fig. 7) show an unequal distribution and imbalance of the frequency of children within the different open spaces of the neighborhood. Some spaces tend to be more used compared to

FIG. 7 STATIC SNAPSHOTS DATA FOR THE NEIGHBORHOOD



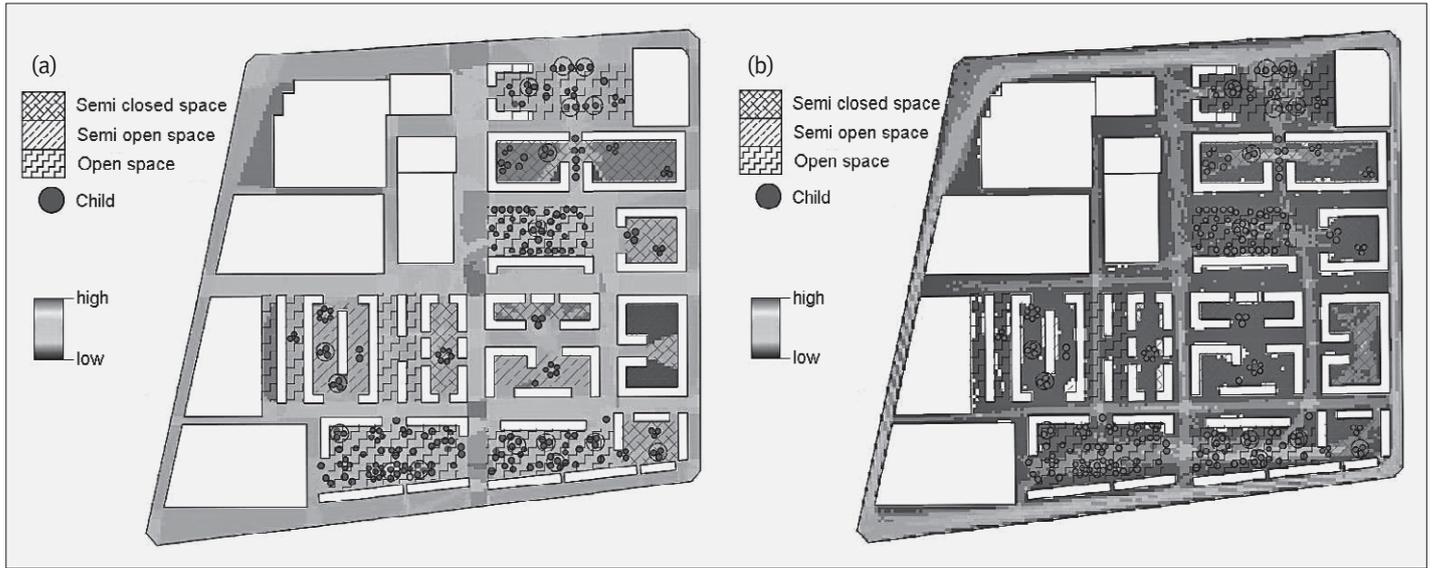


FIG. 8 CORRELATION OF STATIC SNAPSHOTS WITH (A) VISUAL GLOBAL INTEGRATION (VGA) AND (B) AGENT-BASED MODEL

others. The highest presence of children was concentrated in spaces with open configurations while it tends to decrease progressively in the closed ones.

The spatial-configuration data analyzed in the previous section were used to represent the correlation between the spatial configuration of the residential area and children's use and interaction within outdoor spaces. All the registrations from the Static Snapshot technique are overlapped and compared with results from the Visibility Graph Analysis and the Agent-Based Modelling (Fig. 8). Accordingly, the highest concentration of children exists in the most integrated and connected areas. On the other hand, in the highly segregated and unconnected areas of the whole, mainly spaces with semi-closed configurations, children's concentration tends to be low and the spaces are mostly abandoned. Similar to the agents, children gather mainly in the spaces with open configurations and avoid closed ones. Thus, the children's clustering tends to decrease progressively from open configurational spaces to the closed ones.

DISCUSSION

The purpose of this paper was to investigate the relationship between the spatial configuration of residential quarters and children's outdoor activity in order to assess planning decisions. The correlation between the spatial configuration of residential neighborhoods and the frequency of use of outdoor spaces by children was analyzed. As was shown, space syntax seeks to objectively understand the ways in which the urban form influences the collective use of spaces.

Therefore, the main finding of this study indicates that children living in the residential quarters and mass housing neighborhoods are directly affected by the spatial configuration that emerged from buildings arrangements.

On the one hand, the application of visibility analysis and agent-based model in our previous findings shows that syntactical measures vary considerably within the same neighborhood depending on the type of building arrangement. Spaces with open configuration are well-connected and integrated, they have adequate accessibility and openness, oppositely to spaces with closed configurations which possess low-connectivity and low integration, they have poor accessibility and openness. In association with the intelligibility analysis, areas with high integration present high intelligibility values and thus a better interaction with space. This was also confirmed by Kim (1999) in his research discussing space intelligibility and space usage.

On the other hand, the application of snapshots demonstrates that children are aware of their surrounding environment and can identify the places where they prefer to spend their time. They occupy the most integrated and inter-connected space with open configuration, seeking more opportunities for free play, or due to some preferences for particular play or games, group activities and social interactions that open spaces can provide. This is contrary to the least integrated and inter-connected spaces with semi-open and semi-closed configurations, which remain almost abandoned. According to children's perception, these kinds of spaces provide physical restrictions and make them leave their close environment avoiding vari-

ous obstacles. This is confirmed by the research discussed by Özgece (2015).

The results indicate a strong correlation between “space visibility”, “space accessibility” and “space use”. Outdoor spaces with a well-connected and integrated value are those which are highly used by children for their daily play activity. Young children felt freer to move, play and interact in spaces demonstrating accessibility and openness. Thus, this type of open spatial configuration supposedly encourages children to use the space more fully, and allows them to explore the physical environment freely. A similar result was obtained in the works of Ferguson (2007) and Bada (2012), where a common feature of those studies is that places with high accessibility in their spatial configuration are potential spaces, in which interaction between people occurs frequently. However, their research is mainly concerned with adult users.

CONCLUSION

The urban neighborhood space has an important impact on residents’ activity and interaction, including children. This study was carried out with the main objective of revealing the existing relationship between spatial configuration and the use of outdoor spaces by children. Space syntax analysis through different syntactical measures has uncovered some hidden aspects of open spaces within housing neighborhoods. Therefore, the extent and character of children’s outdoor activities are greatly influenced by physical characteristics of the neighborhood environment in residential areas. As a result, the building arrangements and site organization in mass housing affect outdoor activities of children through the degree of space enclosure interpreted by visibility and accessibility.

From a spatial point of view, the built environment is defined as an area for interaction. It can provide opportunities or form obstacles for physical and social use. Findings stand to confirm our hypothesis that the space use patterns and children’s frequency are strongly correlated with the spatial configuration of residential buildings. Overall, the spatial configuration itself is the primary piece that influences the physical and social well-being in housing neighborhoods. Ultimately, this work provides an aid for urban planners and designers in exploring the spatial configuration of buildings in line with children’s use preferences, offering an approach for rethinking outdoor space design adapted to children.

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Conceptualization, O.C. and A.H.; methodology, O.C.; software, O.C.; validation, O.C. and A.H.; formal analysis, O.C.; investigation, O.C.; resources, O.C.; data curation, O.C.; writing – original draft preparation, O.C.; writing – review and editing, O.C.; visualization, O.C.; supervision, A.H.; project administration, A.H.; funding acquisition, O.C.

Both authors have read and agreed to the published version of the manuscript.

ILLUSTRATION SOURCES

FIG. 1, 3-8 Authors, 2021

FIG. 2 Google Earth and authors' adjustment, 2021

