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Space Syntax and Disability: Can Space Syntax Predict Users with Disabilities' Movement?

A case study from Algiers' historical city of *Casbah*

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ABSTRACT

Previous studies on urban space have shown that space syntax can be predictive of users' movement in the urban space. These users are standardized and their mobility is studied according to the configuration and geometry of the urban fabric. But how can other variables related to users' socio-economic status and body conditions be included in these studies? Space syntax deals with social phenomena through a spatial configuration approach, this study seeks to explore how space syntax can integrate the body conditions' variable by studying a social phenomenon which is the mobility of people with disabilities. This paper aims at investigating the mobility of people with disabilities through their wayfinding, itinerary choice, and spatial perception, with the purpose of seeing if the spatial configuration through space syntax can predict their movement. Context is important in this research, whether it be the socio-spatial context or users' body conditions. The Algerian socio-spatial context was chosen. The first case study is Algiers' *Casbah*, the old city, a UNESCO World Heritage Site. It is characterized by a very uneven morphology with winding streets. The second case study is a recently built strolling park, which is directly overlooking the sea and was built in a flat area. It is a large area developed in open spaces. The case studies were investigated by comparing the in-situ studies and the space syntax modelling to see if the results match and if space syntax can predict the movement of people with disabilities in various urban configurations. The paper first starts a qualitative analysis with an in-situ survey conducted in both case studies, which investigates disabled spatial use. The second part of the paper focuses on the syntactic description through axiality and isovist's proprieties. This analysis allows to appreciate the elements influencing the movement of people with disabilities. This leads to the conclusion that when studying the mobility of people with disabilities, it is necessary to consider the spatial configuration on a macro scale, but also the urban pattern on a micro-scale. This study will bring new knowledge and useful adjustments by taking into account the body conditions of all users in space syntax studies.

KEYWORDS

Disability, Historical cities, Urban Audit, Accessibility, Algeria

1 INTRODUCTION

Public space is at the heart of all concerns and different planning policies, with accessibility and mobility as fundamental elements for its attractiveness and durability over time, so it forms the main core and urban "armature" to create space that will encourage people to use and experience the city in a specific way (Hillier 1996). Mobility in the public space is an essential stake of social integration, the increase of its potential allows social and economic progress as well as the emancipation of the individuals by proposing new possibilities to them (Cadestin et al 2013). This increase can be accomplished by better accessibility to the public space, which corresponds to the possibility of crossing a space to reach a destination (Church and Marston 2003). This mobility can be difficult to achieve for vulnerable populations, creating exclusions for these populations. This is even more obvious in historical cities. These cities were built at a time when the diversity of the population was not taken into account in planning, the city was usually built on a military defence basis or/and on religious and sociocultural bases.

These traditional institutions and structures erected historical Islamic cities by insisting on the production of visible spatial entities such as mosques (*Djamaa*) and schools (*Madrassa*), autonomous neighbourhoods (*Houma*), bazaars (*Suq*), semi-transitory spaces private houses and introverts (Rashid and Bindajam 2015, Abu-Lughod, 1993, Zubaida 1989). These entities have shaped the urbanity of these cities. Without adapting the physical structure of these cities to modernity, the balance of their traditional urbanity will be compromised. Rashid and Bindajam (2015) state that "How to deal with these changes of the historical cities in Islamic societies, therefore, is a major concern for all those interested in preserving urban heritage and identity." The building of these historical cities dates back to the ancient and medieval periods, during which time people with disabilities were not taken into account in planning. Defensive and religious concerns were considered more important than this vulnerable and minority population. The basic construction methods did not allow for accessibility. There was no reflection on accessibility, as the model of the city user was standardized on the basis of the model of the young man with no disability or vulnerability. Without knowledge and technology and without the will to design a city which is accessible to all, the physical structure of the city becomes an obstacle to a user with a motor impairment, greatly reducing his mobility.

Nowadays, science and mentalities have evolved. Taking into account all users in their diversified and not standardized form has become an obligation. Disability has become a variable to be taken into account in planning like other types of vulnerability. The obligation to make public space accessible has become an obligation. However, in addition to their particular urban configuration and physical structure, historic cities have the particularity of being listed as

UNESCO-protected built heritage, which makes their accessibility a very complex process. Secondly, the urban configuration of these cities has been carefully designed in a very old period, with old materials in particular morphologies, which makes their accessibility even more problematic. Finally, these historical cities have a typology with a great defensive or religious character, which means that they have a spatial configuration and morphology that is not necessarily favourable to people with mobility difficulties.

In this contribution, in order to illustrate the problem of accessibility of historical cities, we will analyse the case study of the old city (*Medina*) of Algiers, which is the *Casbah*. This city, with its very uneven morphology and sanitary streets, is a city with Phoenician foundations, fortified by the Ottoman occupation of Algeria, which means that it has an urban fabric of Arab-Muslim style. Despite its classification in the UNESCO World Heritage List, it suffers from a very advanced state of deterioration. Its public space has several obstacles to the mobility of people with disabilities. This situation makes the public space of the *Casbah* of Algiers exclusive for people with disabilities and the elderly. From the point of view of the obligation of universal accessibility, the public space of the *Casbah* must be made accessible to respect the rights of people with reduced mobility. The *Casbah* has a heritage character which makes it a site with strong tourist potential, with its atypical architecture and its stepped site opening the doors of the Mediterranean, situated on a hill overlooking the city and the bay of Algiers.

In this contribution we will study the degree of accessibility of the *Casbah* of Algiers for people with disabilities. This is in order to answer the question: how can a protected historical city accessible for all? The main hypothesis for this research question is: in order to provide solutions for accessibility, the study of the urban configuration of the historical cities on a micro and macro scale could be a first step to decipher the complexity of the morphology and the spatial configuration of these cities. In order to verify this hypothesis, we will compare the degree of accessibility of the *Casbah* with the degree of its frequentation. It will be a question of confronting an urban survey of accessibility with the syntactic study of the use of the urban space of the *Casbah*.

The objective of this contribution firstly is to study the characteristics of the *Casbah* of Algiers from it accessibility of people with disabilities in order to improve the mobility and the attractiveness of this historical city for all. Secondly, we will verify if space syntax, a method presented as a predictor of movement, can predict movement when there are two variables specific to the user and to the urban space. Indeed, in this case, the physical situation of the user is specific since we are studying the movements of people with disabilities. The morphology of the public space is also specific since the case study is located on a very hilly site and it is classified as a protected world heritage. Finally, this contribution will make recommendations to make these historical sites with a high tourist potential accessible to all, which will contribute to their attractiveness.

2 THEORY

2.1 The impact of urban environment on people with disabilities' mobility

More than one billion people, which is 15% of the world's population, live with disabilities, it constitutes the largest minority in the world (WHO 2011). The World Health Organization defines "disability" as "a generic term for impairments, activity limitations or participation restrictions. It refers to the negative consequences of the interaction between an individual (having a health problem) and the contextual factors in which he/she evolves (personal and environmental factors)" (WHO 2001). Having a disability means facing challenges and complications when performing daily tasks; these difficulties are a result of combined personal and environmental factors (Victor et al 2016). This situation defines the problem of accessibility, which happens when there is a mismatch between the individual characteristics of the users and the specificities of the environment (Goodley 2016).

Indeed, the obstacles related to accessibility, and to the physical barriers of the urban environment causes restrictions on accessibility that negatively impact the quality of life of people with physical disability, since it prevents them from carrying out their tasks, pleasing to their lives, move freely and plan to stroll in attractive places and recreation to relax and change air, which contributes to the problems of social segregation (Imrie and Hall 2001). These restrictions on accessibility have been classified into two types in the literature:

a. Barriers considered as obstacles stopping the progression of people with disabilities in their pathways.
b. Path with different types of obstacles, some of which are impassable, but other passable with additional effort.

Marshall (Marshall 2004) argues that these accessibility restrictions created by the built environment affect the connectivity and permeability of urban space, and their effects are felt on the mobility of people with disabilities. Vale (Vale et al 2017) illustrates this theory at the micro and physical scale of the public space, for example, an annoying element on a path will reduce the permeability of the path since it will reduce its width, even for the connectivity that will diminish and force the person with a disability to look for an alternative trajectory.

Accessibility studies from the perspective of permeability and connectivity have been done by Vale (Vale et al 2017) by measuring accessibility across specific pedestrian networks. Other studies have focused on the relationship between public space and accessibility such as Rimmer (Rimmer et al 2004) with a study that analyses the ease of travel and quantifies the impact of the

built environment on the accessibility of people with disability compared to that of able-bodied people by introducing a concept called "accessibility disparity" coming up with the conclusion that the degree of participation of physical activity among people with disabilities is affected by a multifactorial set of obstacles and factors specific to this population.

Public space is of great importance in the development of cities and the quality of life of these users (Chiesura 2004). In theory, public space is considered as a space with strong integration and spatial continuity, where all spaces are connected to each other (Monokrousou and Giannopoulou 2016) but this is not the case for all public spaces in reality. As a matter of fact, there may be certain dysfunctions in the public space, which affects the behaviour and movements of users. This theory supports the fact that the syntactic properties of space determine their level of accessibility to other destinations, thus the urban configuration of spaces and its impact on the movement and behaviour of users can be studied by the space syntax (Monokrousou and Giannopoulou 2016).

The urban configuration was studied by space syntax. Several studies have shown it can predict the use of space. This by its main measures that are integration (Hillier and Hanson 1984; Hillier et al 1993, Lawand et al 2012), connectivity (Hillier et al 1986; Choi and Sayyar 2012) and visibility (Bada 2012). It assumes that the most integrated and connected spaces will necessarily be the most frequented spaces, which possess a strong urban attractiveness (Hillier et al 1993, Hillier 1996, Hillier and Iida 2005; Major et al 1998, Penn et al 2016). It is based on the principle that urban configuration has an impact on movement by the concept of natural movement; it also has an impact on land use, the distribution of activities and other social phenomena (Hillier et al 1993; Hillier and Iida 2005). The more attractive spaces are, the more the concept of natural movement applies to them. The more attractive these spaces are, the more 'magnet' effect applies to these spaces attracting more and more movement (Khorsheed et al 2018).

This method has also been studied in the use of space by so-called "vulnerable" populations. The study by Heitor et al. (2014) deals with the accessibility of the university campus for people with disabilities. It combined syntactic measures with commented walks and the level of effort. Results showed that the low connected spaces created barriers to accessibility and "black spots" that hindered the movement of people with disabilities. Belir and Onder (2013) did a study on the spatial cognition of visually impaired people in malls. They explored the impact of location features on their navigation in a study which combined cognitive map methods and observations with the space syntax method. The results have shown the importance of sensory and structural landmarks on navigation in spaces by people with disabilities.

In the different definitions of accessibility, two stand out. The first is geographical or spatial accessibility (Litman 2003), which is the ease of reaching a space or activity, and the spaces which are connected and integrated into the urban network (Bocarejo and Oviedo 2012, Chaloux

et al., 2019, Geurs and Halden 2015). These accessibility approaches can be studied by space syntax method. The second definition concerns physical accessibility, which is defined by the facilitators or barriers to access a place, focusing on barriers in the built environment (Castrodale and Crooks 2010, Heylighen et al 2013). This definition relates directly to people with mobility limitations, such as people with disabilities. It looks at the impact that the built environment can have on their mobility (Grosbois 2008, Imrie 1996). The previous studies on accessibility have made a distinction between reaching a space, access to the opportunities, and the ease of mobility, as well as the physical limitations of a place. This study adopts the definition of accessibility in its universal form with the concept of universal design, which seeks harmony in human-environment interaction and advocates the idea that the environment must be adapted to all users regardless of their physical and socio-economic situation (Iwarsson and Ståhl 2003).

2.2 The need of accessibility in the historical cities' design

The expansion of UNESCO World Heritage sites over the last two decades has made necessity of the development of these historical cities (Pendlebury et.al. 2009). Considering these listed cities as places of socio-cultural interaction, several principles for historical and urban beautification have been established in the framework of the Vienna Memorandum (UNESCO, 2005). Among these principles, the urban dimension has an important place with its landscape, morphology and functionality, while for the historical principles, the emphasis is on the authenticity and integrity of the cities and the enhancement of their intangible heritage (Alberts and Hazen 2010, Pendlebury et al 2009; Rodwell 2007).

These principles emphasize that a historical city should not be but should exist as an integral part of the multifunctional city. The criticism that could be made of these principles is the omission of the human and social character in general. Long before the Vienna Memorandum, however, some authors highlighted the importance of humans in creating appropriate economic opportunities to maintain the viability and vitality of the historical cities (Ashworth 1993, Ford 1985, Baer 1995). These authors have shown that conservation alone is not sufficient for the beautification of historical cities, and that other urban qualities such as historical atmosphere, accessibility and density of people and activities must be taken into account. The lack of consideration of mobility and travel in heritage planning studies in historic cities needs to be addressed. This is even more obvious for studies on the mobility of disabled people or elderly people with a loss of independence. Few studies deal with the accessibility of disabled people in historical cities. Most of these studies have a universal tourism approach. This is the case of the Piopel study (2014) on the accessibility of the historical centre of Krakow for people with disabilities. Although the respondents appreciate the attractiveness of the city, most of them point the lack of accessibility to take advantage of this attractiveness, it concludes that accessibility is an important factor in exploiting the tourism potential.

While historical cities represent important elements of history and culture, some people with reduced mobility have limited access to this heritage with high tourism potential. The

inaccessibility of public space and services such as transport, accommodation and shopping restricts the freedom of movement of disabled and elderly people, which severely limits their ability to enjoy the attractiveness of these destinations (Deichmann 2004). In their study on the accessibility of European historical cities, Ambrose et al (2013) explain in relation to the elderly and disabled populations that "those responsible for the management and preservation of historical cities face the challenge of improving the accessibility of city streets, monuments and buildings while safeguarding their cultural heritage" (Ambrose et al 2013).

3 DATASETS AND METHODS

3.1 Case of study: The Algiers's old city, the *Casbah*

The *Casbah* of Algiers is a city (*Medina*) that has existed for more than 2000 years. It was the nucleus of the city of Algiers from antiquity, then a Phoenician trading post in the 4th century before being refunded on the Roman ruins of *Icosium* by Prince *Bologhine Ibn Ziri* in the 10th century (WHC.UNESCO 2009). From then on, it was equipped with a fortress (*Casbah*). It was then the door and the defender of Algiers (*El Djazair*), until the arrival of the Ottomans in the 16th century. The Ottomans developed and fortified it. The year 1830 marks the passage of Algiers from Ottoman military city to French capital of Africa, with the work of restructuring of the medina and the progressive demolition of the ramparts to the profit of urban and European architecture ordered.

The *Casbah* represents a standing position above the vaults of the seafront and the port fortifications. The city is structured by two systems of the organization of the urban fabric (figure 1):

- The vernacular building: gathers all the built masses of an Arab-Muslim style which forms the urban unit of the upper ancient *Casbah*.
- Haussmannian plots: this is the colonial intervention which represents the openings in the lower part of the *Casbah* and the boulevards.

Figure 1: An aerial view of the *Casbah* of Algiers

The study area has been chosen for its complexity, both in terms of the urban fabric, its morphology and its vocation. The study perimeter has an urban fabric characterized by the superposition of historical strata. The beginning of the study perimeter is in the Lower *Casbah* with a Roman urban fabric, occupied by the Ottomans and renovated by the French occupation in 1830. It was redeveloped in 2010, which makes it a very recent built environment (figure 2).

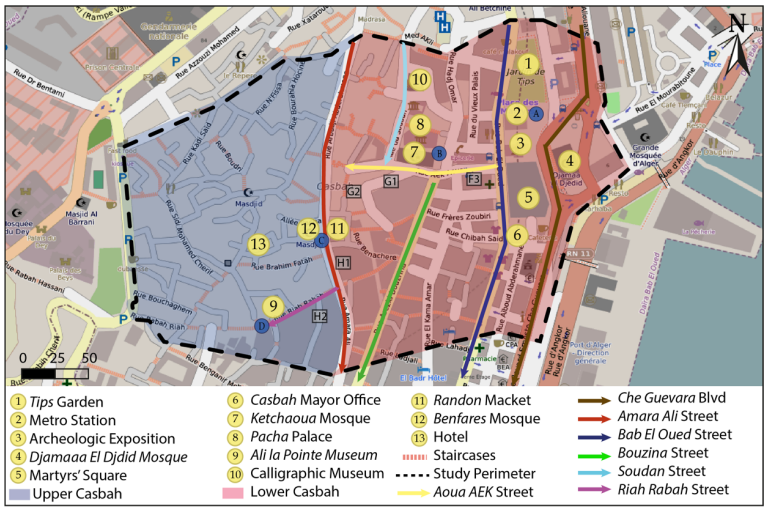

Figure 2: Urban analysis of the Algiers *Casbah*

The amphitheatre site is currently one of the main constraints to urban functioning for a soft mobility. The adaptation to this morphology has led to steep slopes as well as urban staircases and steps at every street corner. As the urban fabric has a historic character, the built environment is old and degraded in a certain place, it is not necessarily adapted to a system of soft and modern mobility. The built environment has certain obstacles that are due to this degradation, as well as others that are the result of the original morphology of the site.

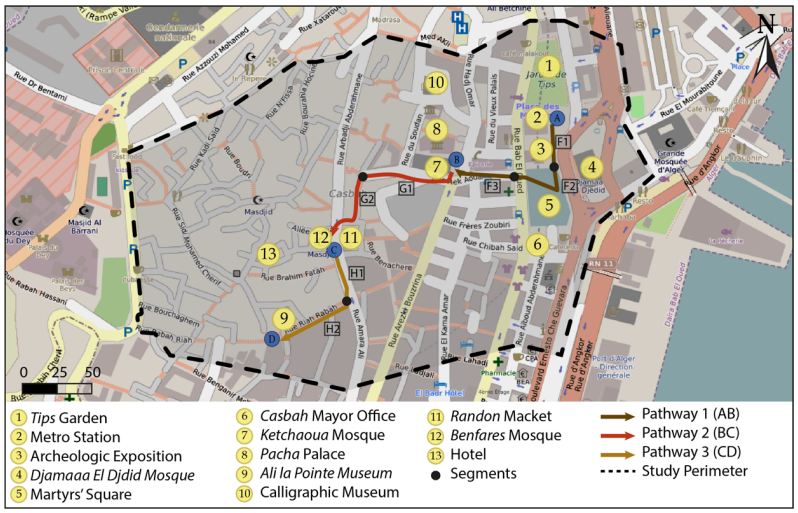

Figure 3: The selected pathway from study perimeter

This beginning of the perimeter of study (figure 3) represented by the pathway AB is also a polarity and a centrality for the city of Algiers with the metro station, the Martyrs' Square which is one of the most symbolic squares of Algiers as well as the "*Djamaa Jdid*" mosque which is a monument of Algiers located on a flat site which gives on the port of Algiers. The second part of the study area is an Arab-Berber fabric renovated by the French occupation in 1830 and which

has not undergone any major redevelopment since then. It is materialized by the pathway BC, where there are paths from the Arab-Berber period passing by historical monuments with an agrarian urban fabric and narrow and winding streets with public spaces and mixed Arab-Muslim and French buildings. The streets are sloping with some staircases. There is a mixed vocation, a historical vocation with all the historical monuments and the city with a heritage character as well as a commercial vocation with the itinerant merchants and the open-air market and the covered market which all three joined together constitute one of the most popular markets of Algiers. The last part of the perimeter of study materialized by the pathway CD has an exclusively Arab-Muslim urban fabric with a more tourist vocation with the houses of the historical city and the lanes in the slope and especially in the form of steps or monumental urban staircase. These alleyways in the form of steps characterize the old town of the *Casbah* and give it the possibility of following the shape of the site which is very uneven. The chosen pathways were traced by the researchers in the form of a complete chain of accessibility where the users were supposed to experience several urban sequences.

3.2 Investigation's method

To verify our hypothesis, we will proceed in two steps. The first part will be the analysis of the public space of the *Casbah* from it physical accessibility on a micro scale. The second part will consist of an urban modelling at the macro scale with the techniques of spatial syntax.

Accessibility Urban Audit

We did an urban audit, which is an urban survey according to accessibility standards as well as elements that are likely to impact the mobility of people with motor disabilities. These surveys were carried out on three pathways divided into sections in the *Casbah* of Algiers. The objective of this audit is to allow the diagnosis of the accessibility of the space for people with disabilities. An Urban Audit is a work of collection and harmonization of geographical, social, or urban and other data that form a set of reliable information to evaluate the quality of life in an environment according to the context of the study (Cloutier et al 2018). The implementation of an urban audit allows for the collection of detailed, objective and specialized information. This detailed collection (urban audit), on a micro scale, allows the listing of properties and elements potentially present in an urban environment (Chaudhury et al 2011).

The proposed audit was structured in a two-page observation grid, on which there is a series of indicators divided into five main sections. The evaluation of the different accessibility parameters is done according to estimates in degree of presence, absence or restrictions (absent, low, medium, high, impossible access), and for the measurable parameters it is done by placing the parameters between two values (... > parameter > ...), above or below a value (parameter < ... or parameter > ...), knowing that these values are derived from standards and regulations on accessibility, and finally restricting the answers to dichotomous choices (yes/no), (help/obstacle).

The Urban Audits were processed with the aim of being an accessibility indicator, initially based on a scoring system for each section with a percentage of accessibility assigned for each section. This scoring approach was adopted to quantify the urban survey to have quantitative data. We defined a score of 100 points spread over the whole grid. These 100 points were distributed over the five sections of the grid according to the importance of the sections, and according to the number of indicators present in the sections. The scoring system is explained in the following table.

Table 2: The accessibility audit' rating system

Rating	Influence of the indicator	Scoring points
Green	Facilitating	All points
Orange	Neutral	Half points
Red	Brake	No points

Identification of the segment

This first part of the accessibility urban audit allows for the identification of the urban environment in which the segment under study is located. This identification gives an overview of the context of the urban accessibility study, as well as the degree of accessibility of each type of wards. No points were awarded for this component, as it provides an indication of the context of the segment but does not have a significant influence on the movement of people with disabilities on a micro scale.

Pathways' Characteristics of the (27 out of 100 points)

This component allows us to obtain data specific to the physical characteristics of the route, considering the elements that are favourable and unfavourable to the accessibility of people with disabilities. In this way, the characteristics that may influence their accessibility are evaluated.

Staircases and steps (20 out of 100 points)

This section concerns one of the factors that most influences the mobility of disabled people according to the respondents, since a large difference in levels in a route can be prohibitive for the accessibility of a disabled person.

Activities' accessibility (22 out of 100 points)

Beyond the physical characteristics of the space, other sensitive characteristics in terms of attractiveness and ambience are important in the study of urban accessibility, thus several research have emphasized attractiveness and aesthetics as having an incentive or repellent effect on the mobility of users in an urban environment (Victor 2016, Thomas 2004).

Transport and urban elements' accessibility (28 out of 100 points)

This last component concerns transport means and urban elements, such a public transport and its accessibility are evaluated together with parking spaces reserved for people with disabilities, since mechanical transport means are of primary importance for getting to distant urban spaces.

Syntactic analysis

The space was analyzed quantitatively, by spatial configuration values and graphs using space syntax techniques. This method was used to measure geographical accessibility and movement in a macro scale. This method was also used in this study to see if it could predict the movement of people with disabilities.

The spatial syntax method is used to model and predicts the movements of city users at the macro scale, according to the structure and geometry of the city and the urban form of the buildings. It uses computational algorithms to provide insight into the configurational characteristics of the study area. As a result, the use of spatial syntax in urban environment research focuses on the dimensions of space on a macro scale. However, Van Nes (2007) argues that for an optimal reading of user-urban environment interactions, the micro-scale dimensions of space should not be neglected. In this sense, to answer the research question, the results of the syntactic study on a macro scale will be confronted with the results of the urban audit previously presented on a micro scale.

To try to measure at a macro scale: the degree of potential frequentation, geographical accessibility and visual attractiveness and access, an axial analysis will be applied to the case study. Thus, to represent the distance up to which users will have an impression of uninterrupted visibility and permeability when moving through the public space, an axial map of the study cases will be made. The axial map represents the set of longest axial lines that cover all possible paths in the space. With this analysis we will be able to deduce the influence of the geometry of the space through the axial map of movement and geographical and visual accessibility.

DepthmapX software was used to generate the syntactic measures and an axial map which is a bidimensional representation of space, it determines the longest straight lines for pedestrians to follow that cross the convex spaces connected to each other. The measures calculated in the analysis are:

Integration: It is a static global measure. It describes the average depth of space relative to other spaces of the network. It allows us to measure the number of changes of direction made from an axis to reach the other axes of the network. It can predict the movement since the studies have shown that spaces with better geographic accessibility are more likely to be used (Hillier & al. 1993).

Connectivity: It measures the number of visual nodes directly connected to a specific node. Assuming that the most connected spaces are the most accessible since several paths lead to these spaces.

Visibility: The integration of spaces is directly related to the degree of visibility of these spaces, since studies have shown that spaces with a high degree of visibility are the most geographically accessible and the easiest to expect.

4 RESULTS AND DISCUSSION

4.1 Results from the urban audit of accessibility

Pathway AB (figure 4; table 1)

Segment F1: This section dates back to the Arab-Muslim period and was renovated during the French occupation and redesigned in its entirety very recently. It is considered as a resting place and a polarity place in the presence of the metro station, it has a strong tourist value. The overall score of this section in the accessibility audit is 81.25 out of 100. The metro station was assessed as accessible, with accessible metro trains, a regular path with vertical circulation provided by escalators and elevators. The ticket machines and information desks are also accessible. The path from the station exit to Martyrs' Square has good accessibility values, with a flat floor and even pavement. This section is characterized by the regularity of its path with a score of 23.25 out of 27. The fact that it has no steps and staircases that hinder mobility gives it a score of 20 out of 20 for this section. For the section "accessibility of activities" the fact that there are few accessible shops and facilities in the vicinity, such as the *Djamaa Jdid* mosque, meant that this section scored 15 out of 25, which is still an above-average score. For the “accessibility of transport and urban elements”, a score of 23 out of 27 was given. All the urban elements listed are either aid to mobility or do not affect it. The presence of the accessible metro contributes to this score. However, the lack of parking spaces largely reduces this score.

Segment F2: The accessibility audit for this section gave an overall score of 66.25 out of 100. For the "pathway characteristics" section, a score of 18.75 was noted with a fairly even pavement and a flat path. However, the lack of kerbs had a negative effect on this score as the chain of travel is severely limited by the absence of kerbs. The lack of staircases or steps gave this section a score of 20 out of 20 for the "staircases and steps" section. Concerning "accessibility of activities", this segment scored 10 for this section, this is mainly due to the shops and facilities around the square which are not accessible and finally, the section "accessibility of urban transport" this segment scored 18 out of 27 thanks to the nearby metro station and buses. The lack of parking spaces in the vicinity of this segment resulted in non-awarded points.

Segment F3: The accessibility audit for this segment scored 51.75 out of 100. The "course features" section scored 18.75 out of 27, this is due to a slightly uphill topography with a rather degraded and disjointed pavement with holes. The lack of staircases and steps resulted in a score of 20 out of 20 for this segment. The section "accessibility of activities" scored 3.75 out of 20. This very low score is due to the non-accessibility of shops, services and cultural facilities

present, such as the *Ketchaoua* Mosque and the *Pacha* Palace, where there are steps without compensation to access them. For the section "accessibility of transport and urban elements", this segment had a score of 12 out of 28, the presence of buses in the vicinity was not sufficient to raise this score since these buses are not accessible. Some urban elements that could be help for disabled people are not present such as benches. Parking is impossible and the merchandise of street vendors greatly hinders the mobility of people with disabilities.

Pathway BC (figure 4; table 1)

Segment G1: This section starts from the *Ketchaoua* mosque and goes up the alley. This alley is a commercial one with many street vendors, and it scored a total of ..... This section scored 16 out of 27 for the "course characteristics" section, which is a sloping course with uneven surfaces and differences in levels. The absence of steps resulted in a score of 20 out of 20 for the "stairs and steps" section. For the section "accessibility of activities", not all shops and services are accessible, which gave a score of 2.5 out of 25. For the accessibility of transport and urban elements, this segment has the same characteristics as the previous one and it has the same score of 14 out of 28.

Segment G2: This leads to the *Ibn Fares* mosque, the second mosque in our study area which is as symbolic in Algiers as the first. This section is intended to be a daily open-air market in addition to the market opposite the mosque which is covered. For the section "pathway characteristics", irregularities in terms of surfacing were noted in the audit, with an ascending slope and the presence of differences in levels, which gave a score of 12.5 out of 27 for this section. The presence of stairs up to *Amara Ali* Street through the mosque without a ramp resulted in this segment scoring 10 out of 20 for the "stairs and steps" section. As for the "accessibility of activities" section, the very high pedestrian flow hinders the mobility of people with disabilities, which in addition to the total non-accessibility of the shops has the same effect. This resulted in a score of 2.5 out of 25 for this section. The absence of nearby transport and the non-presence of mechanical means of transport as well as the presence of goods in the middle of the pathway hinders the movement, which resulted in the section "accessibility of transport and urban elements" being scored 9.5 out of 27.

Pathway CD (figure 4; table 1)

Segment H1: This segment starts at the *Ibn Fares* Mosque and runs along part of *Amara Ali* Street, which is one of the breakthroughs made by the French during their occupation. It scored a total of 43 out of 100 in the accessibility audit. The "pathway characteristics" section scored 11 out of 27 due to its low degree of accessibility caused by the slope, the curved and very degraded pavement, and the difference in levels. As there are no stairs, this segment scored 20 out of 20 in the "stairs and steps" section. For the section "accessibility of activities", this segment scored 2.5 out of 25, this very low score is mainly due to the low presence of accessible commerce and

services. For the section "accessibility of transport and urban elements" this segment scored 9.5 out of 28 for the same reasons as the previous section.

Segment H2: This is the final segment of the study area. It starts at Amara Ali Street and goes up to the *Ali Lapointe* Museum (in memory of a veteran of the Algerian War). During the audit this segment had a total score of 32.5, which is the lowest score of the entire study area. The irregular paving in the form of steps with no means of compensation gave it a score of 9 out of 27 for the "pathway characteristics" section and 8.75 out of 20 for the "staircases and steps" section. The lack of commercial activity and the non-accessibility of the cultural facilities explain why this section scored 3.75 out of 25 for the "accessibility of activities" section. For the section "accessibility of transport and urban elements" it scored 11 out of 28, which can be explained by the non-presence of transport and mechanical means of movement and also urban elements that are not aids to the mobility of people with disabilities.

Figure 4: Views from the selected pathway

Table 3: Scores from the Urban Accessibility Audit

Pathway	Segment	Pathway's Characteristics 27	Staircases and Steps 20	Activities' Accessibility 22	Transports and urban elements' 28	Total Score 100
AB	F1	23,25	20	15	23	81,25
	F2	18,75	20	10	18	66,25
	F3	16	20	3,75	14	51,75
BC	G1	16	20	2,5	14	53
	G2	12,5	10	2,5	9,5	34,5
CD	H1	11	20	2,5	9,5	43
	H2	9	8,75	3,75	11	32,5

4.2 Results from Space Syntax Analysis

As for the variations in the integration values of the system in general (figure 5), we note that the north-south axis making the transition between the Lower *Casbah* and the Upper *Casbah* is the most integrated. The Lower *Casbah* (eastern part) is more integrated, it is the part which underwent breakthroughs during the French occupation in 1830, we can hypothesize that these breakthroughs "aired" the urban fabric and improved its integration, like the *Amara Ali* axis which is the most integrated. Nevertheless, a more detailed syntactic study comparing the urban

fabric before 1830 and after this date could confirm or refute this hypothesis. It is also noticeable that the direction of movement is located on the north-south axes, which benefit from linearity and continuity, and from a strong integration. The east-west axes, perpendicular to the north-south axes, have low integration values since they are discontinuous and do not offer much choice of movement. The upper part of the *Casbah* (western part) is the most segregated, which could be explained by the lack of openings and linear axes to air the urban fabric. The integration values are average in the Lower *Casbah* and increase progressively upwards until they reach their peak in the middle of the *Casbah* (Street *Amara Ali*), these values go down progressively upwards in the upper *Casbah* to reach the lowest integration values of the system.

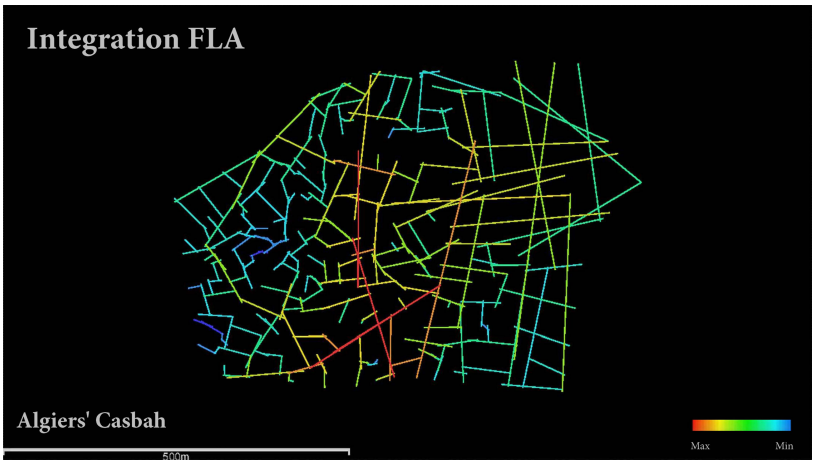

Figure 5: Integration values (Fewest lines analysis)

The integration values for our study area vary between 0,50 and 1,44, with an average of 0,92. These values mean that the system has a very good integration in general. *Amara Ali* Street and the street with the highest integration value of 1,44. The small alleys in the extreme west have the lowest integration values around 0,50. As regards the three pathways studied, the integration values are high and stable from the lower *Casbah* to the middle *Casbah*. The pathway AB has integration values from 1,02 to 1,20, which gives it an average integration of 1,11, which remains a relatively high value compared to the whole system. The pathway BC has values varying from 1,20 at its beginning (*Ketchaoua* Mosque) to 1,35 at its end (*Amara Ali* Street), with an average integration of 1,275. As for the CD pathway, it benefits from the highest integration values, with 1,44 at its beginning (Amara Ali Street) and 1.41 at its end (*Riah Rabah* Street) with an average value of 1,425.

The average connectivity of the system is 3,62 (figure 6). The western part which is the Upper *Casbah* has the lowest connectivity values. The eastern part of the *Casbah*, which is the lower part, has the highest connectivity values. The axis with the highest connectivity value is *Bouzina* Street with 20 connections, this street is part of the breakthroughs created by the French in 1830. Several axes have minimum connectivity values of 1 to 2 connections; these axes are generally small perpendicular streets. The system has a balance of connectivity, i.e. there is no disparity between the connectivity values. The difference between the lowest and the highest value is not considerable, and this is even more obvious if we compare the lowest values and the average

value, which is very close. As far as the studied pathways are concerned, pathway AB has a connectivity value of 11 at its beginning, which is a very good value for the system. Its second part has a connectivity value of 9 connections. The BC pathway is weakly connected with a value of 4 connections for its first part and 7 connections for its second part. Finally, for the CD pathway, it is moderately connected with 13 connections for its first part and 7 connections for its second part.

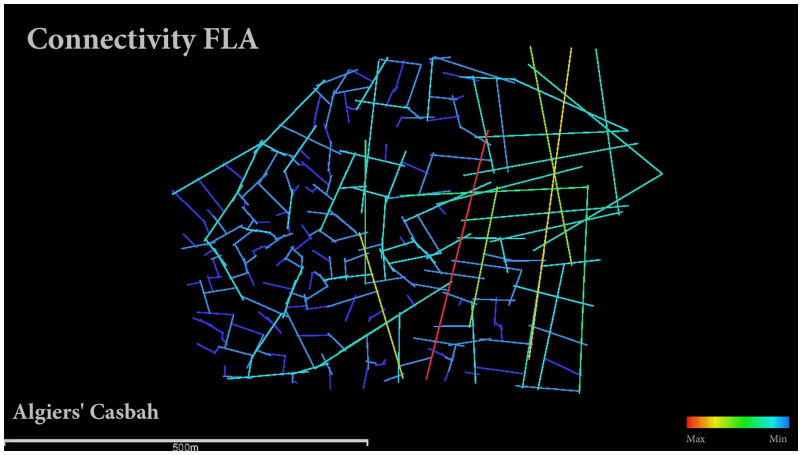

Figure 6: Connectivity values (Fewest lines analysis)

Visibility values have a very large variance (figure 7), the minimum value is 4 located in the western paths of the study perimeter and the maximum value is 30436 located in the east of the Martyrs' Square, with an average visibility of 10908,8. This disparity can be explained by the fact that the urban model of the *Casbah* is based on healthy alleys, and that the lower part of the *Casbah* underwent renovations with the arrival of the French in 1830 to air out the city and impose a more western and European urban model. For our pathways, there is a great disparity between pathway AB, which has high values, pathway BC, which has medium values, and pathway CD, which has low values. Pathway AB has very high visibility values as it is located in Martyrs' Square which is an open space. Pathway BC has medium to low accessibility values. Finally, pathway CD has very low visibility values.

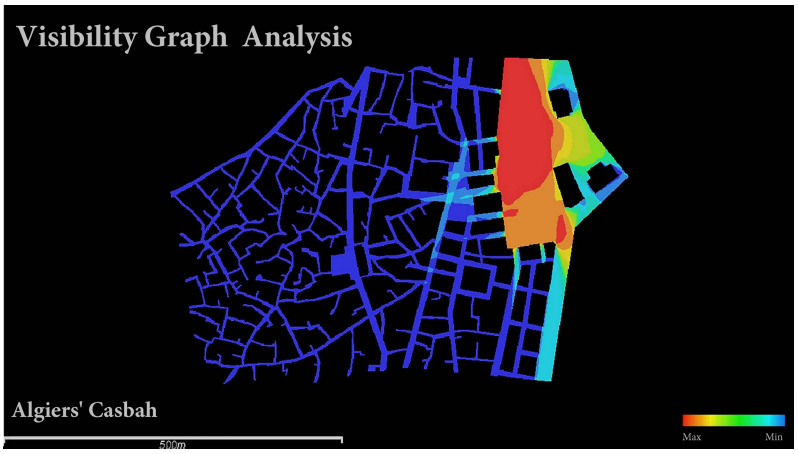

Figure 7: Visibility Graph Analysis

4.3 A Broken Mobility Chain

The recently renovated Lower *Casbah* has good accessibility, from the metro to the end of the Martyrs' Square, the built environment scored very well in the urban audit, with a regular pavement in good condition, elements to compensate for differences in level and rest areas. The transition from Martyrs' Square to the intermediate part of the *Casbah* marks a drop in the degree of accessibility in the urban audit. This decrease in accessibility coincides with the period of development or renovation of the built environment. In the curves shown (...) it can be seen that the time which major renovations were carried out largely affects the degree of accessibility of the built environment. In the selected pathways, the further one goes, the more one gets into the old city. Pathway AB is the most recent which was renovated in 2018. The BC pathway is part of the Lower *Casbah* which was renovated in 1830 by the French who creates breakthroughs. The CD pathway is part of the beginning of the Upper *Casbah* which is an Arab-Muslim fabric with the last major developments it underwent dating from before 1830 during the Ottoman period, since then no major redevelopment, preservation, or revitalization action has been carried out on this part of the historical city.

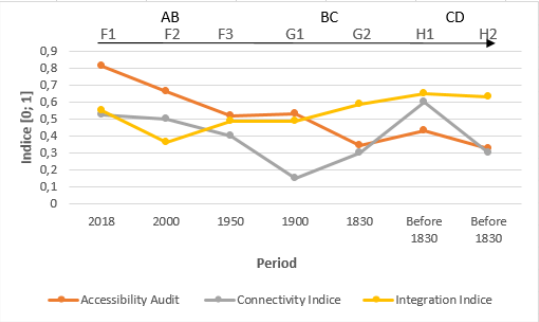

Figure 8: Variation of syntactic and audit values in pathways

The state of the buildings of the *Casbah* in the intermediate and upper part of the *Casbah* is worrying. This side of the city is in a very advanced state of degradation, whether for the buildings or for the public space. In the urban audit, the pavement was a very important indicator of the score of each segment. The degraded pavement in disjointed and irregular cobblestones, degraded tiling or even perforated and bumpy asphalt proved to be obstacles that break the chain of movement. In addition to the pavement, the slopes, the differences in levels and the steps, proved to be indicators that give an important weight positively or negatively to the urban audit of accessibility, thus the very uneven site of the *Casbah* requires these slopes and steps. However, no reflection was thought to compensate for these potential obstacles what makes the public space inaccessible for the people having a disability. Having a great tourist potential, the urban audit of the historical city of the *Casbah* showed that its activities and services lack accessibility. Indeed, the *Casbah* is full of monuments and historical or commercial facilities, but the use of these activities is limited to people with disabilities.

4.4 (In)Compatibility of Historical Cities' Design and Mobility of People with (Dis)Abilities

The axial map in Fewest lines analysis contains 260 segments for an area of about 4.5 km², which is a very large number of segments compared to the area of the study perimeter. This is due to the urban pattern of this historical city, which has a very large network of streets spread out in a tree structure. This network is characterized by high integration values, where all axes, even the most minor ones, are likely to be used and to be natural generators of movement. The same observation was made for connectivity, where spaces are connected enough to keep a balance between the built environment locally without being a connection to the whole city.

As for visibility, the *Casbah* had very low scores in the intermediate and high parts that did not undergo piercing and ventilation operations during the French occupation. This is explained by the introverted character of the historical city of the *Casbah* with narrow, healthy streets. This urban model is intentional, characterized by the period of construction with an urban configuration favoured by a socio-cultural dimension where the prudish is an important characteristic in the way of life of the Arab-Berber society of the time. This spatial configuration is also made in such a way that it is helpful to proximity between the inhabitants. This is characterized by a desire to encourage natural solidarity and mutual aid, values that are paramount in Arab-Muslim societies. Beyond the mobility of people with disabilities and the tourism dimension, this model promotes proximity between residents. This proximity is very important for the most vulnerable people as it generates mutual help and support between residents.

Indeed, these specific characteristics of historical Arab-Muslim cities create an atmosphere in the district as well as a social link between the residents. The notion of the neighbourhood, "*El Houma*" in the Algerian dialect, is very important, where the spatial dimension and the social dimension are one and the same. The spatial configuration is made according to a social dimension and social practices are generated by the spatial dimension of the neighbourhood. As mentioned earlier, there is a desire for social proximity generated by the urban configuration, and this proximity creates a family atmosphere among the residents, who all know each other. In addition to favouring proximity, the urban model of the *Casbah*, characterized by its axial map, shows the importance given to the user, since the city is planned on a human scale with an atmosphere which favours the development of the user. The only drawback is that residents with a disability do not have the possibility of optimal mobility, which is compensated for by mutual aid and care from other residents.

The urban pattern with the axial map of the historical city of the *Casbah* clearly shows an opening in the eastern part, which is the Lower *Casbah*, and a progressive introversion towards the west in the Upper *Casbah*. This opening/introversion relationship can be explained by the

different occupations that took place in the past. These historical occupations have had an impact on the urban configuration of the city. If we focus on this opening/introversion ratio in the confrontation of the axial map and the results of the urban audit, we notice that the highest degrees of accessibility in the audit were marked in the most open part. This can be explained in the first place by the fact that this part has recently been renovated and thus modernized. Secondly, these results may also express a need for benchmarks and visibility in terms of openness to a better accessibility for people with disabilities. The values of integration and connectivity, indicative of movement and ease of geographical access essential for mobility. These values were best rated in the intermediate part, which is a transition between the Lower *Casbah* and the Upper *Casbah*. This part is semi-open, since it underwent urban fabric airing operations during the French occupation in 1830 with the creation of openings, but these operations were not as important as in the Lower *Casbah*, where a clean sweep of the past was made.

Figure 9: A view from the Lower *Casbah* and the Upper *Casbah*, *Ketchoua* mosque in the foreground and *Ibn Fares* mosque in the background

4.5 Preservation Versus Modernization: Overtake This Urban Dichotomy

Through these observations, we suggest, to allow better accessibility for people with disabilities in the historical city of the *Casbah*, it would be necessary not to oppose or create a duality between the openness of the urban pattern and its introversion or between its preservation and its modernization. A compromise should be found between integration, openness, modernization, preservation and physical accessibility. According to the results of the research, the most beneficial method would be in the first place not to carry out preservation-only or modernization-only operations, but to carry out operations for the revitalization of the historical city. This means modernization actions in addition to the preservation of the built heritage with the objective of keeping the character and identity of the place. This means considering the history of the city as well as its sociocultural character, so as not to denigrate the historical urban model who forges and characterizes the history and urban identity of the city where the user is not excluded. This

explains why too much modernization of the historic city will take away from its charm and identity.

Whereas one of the characteristics of the *Casbah* of Algiers, it is that they crossed time without undergoing major operations of renovations. It is an authentic city which did not denigrate itself to undergo the harmful effects of modernization on its identity. This observation can be paradoxical since if this situation continues for a long time, the city risks becoming a ruinous city given its advanced state of degradation. To remedy this, a strategy of revitalization must be set up urgently.

One of the parameters which has been given great weight in the urban audit is topography. However, the space syntax method does not consider the topography of the sites. Indeed, the syntactic study considers the sites to be flat, which is problematic in studies of accessibility for people with disabilities. The main limitation of the study of the mobility of people with disabilities in sites with a hilly morphology is that the topography is not taken into account. The second limitation is the physical dimension of the space at the micro scale. Indeed, this kind of historical city has a brittle and degraded built and urban framework, and space syntax does not take into account the specificities of the urban framework. The regularity of pathways, access to buildings and urban elements were important indicators in the urban audit but were not taken into account in the syntactic study.

In the opposite, the syntactic study has provided important insights into the spatial configuration of the historical city. These insights have contributed to a better understanding of the urban pattern of the city. The space syntax gave good indications of the potential use of the urban space, which informs about the movement and spaces that can be used by people with disabilities if only the urban configuration on a macro scale is considerate. In future perspectives of planning strategies, the space syntax is useful to show which strategies to adopt and to avoid. Indeed, the visibility measures were a reflection of the history and the socio-cultural dimension of the historical city. The low visibility values have highlighted the "prudish" and introverted aspect of the urban model of the *Casbah*, which characterizes its identity and the way of life of the residents rooted in the culture and history of the city. With the values of integration and connectivity, a second point came to the fore, which is the desire for spatial proximity that is a vector of mutual aid and solidarity between residents, which also characterizes the identity and culture of the city. In this way, the socio-cultural values of the *Casbah* are reflected in the spatial configuration, which in turn has been designed to promote this "family" dimension at the neighbourhood level. From these observations, we deduce that the study of the mobility of people with disabilities in historical cities requires a study on two scales, macro and micro.

5 CONCLUSIONS AND RECOMMENDATIONS

This contribution showed the complexity of studying the mobility of people with disabilities in protected historical cities. Mobility factors in micro and macro levels have been identified. The inclusion of all users in their diversity has to be taken into account in upgrading actions combining heritage preservation and modernization or updating of the built environment. As mentalities have changed, historic cities must be updated to accommodate all members of society, even the most vulnerable, to ensure the "right to the city". Compromises have to be made, as this type of historical city is inscribed on the UNESCO World Heritage List and consequently benefits from measures to protect its built environment. Accessibility actions require heavy work, which is not possible in protected built environment and its heritage character. These works will potentially not be in keeping with the heritage character of the city and will alter the historical character of the city. In addition, some of the accessibility actions are not feasible. In our case, the morphology of the site is so uneven that there are steps in the majority of the streets, most of the narrow and streets do not allow for the implementation of an alternative element to these steps, like ramps or elevators. By this observation, we estimate that the *Casbah* of Algiers and certain historical cities cannot be accessible at 100% for people with disabilities. Nevertheless, it is necessary to have a consideration to make accessible public spaces where it is feasible.

Through the contextual study, we have identified some feasible recommendations for a better accessibility of the historical city of the *Casbah*, several points have emerged during the transcription of the results:

- The reflection on an optimal and accessible transport network around the *Casbah*.
- The development of removable ramps which integrate into the urban environment without denigrating it and which can be removed to respect the protected character of the city.
- The study of the possibility of putting the access of shops and services on the same level or of putting removable access ramps.
- Regularize the shopping streets so that goods do not encroach on the pathway.
- Repair damaged pavements, fill gaps between paving stones and file down bulging and uneven paving stones.
- Consider installing removable elevators in certain places to allow people to cross landings.
- Think about a fluid and accessible pathway to visit the *Casbah*.
- Adding urban elements which are aids to mobility.
- Adding reserved parking spaces in the Lower *Casbah*.
- Adding a shuttle bus that will go around the *Casbah* and access to the interior of the *Casbah* to make it easier to reach the historical city.
- Clean the streets regularly to avoid waste being an obstacle to mobility.

It is true that these recommendations serve the mobility of people with disabilities, but they serve all users in a perspective of universal accessibility. This universal accessibility will inevitably boost tourism, with a historical city that will be embellished and attractive to tourists. Indeed, this historical city with occupations from different periods contains archaeological and heritage remains, which are a very important tourist potential. Unfortunately, this potential is not exploited. In this context, possible studies by the approach of accessible tourism would be interesting for the *Casbah*, other studies could also be interested in the *Casbah* by a historical approach by analysing the evolution of its configuration through the era and the various occupations that it had in an objective to revitalize it and to make it accessible by respecting its process of evolution. Finally, the space syntax has shown some limitations in terms of predicting the movements of people with disabilities, since it fails to take into account the physical and sensory obstacles at the micro-scale. To overcome this problem, one solution would be to quantify urban accessibility using measurement models deduced from field studies that are specific to people with disabilities, and to link it to syntactic values. Space syntax can enrich thinking about urban configuration of cities and which configuration can match with people with disabilities' requirements. It offers an idea of which spaces are most attractive, and these are the spaces that are most desirable for people with disabilities. This methodology of confronting the space syntax on a macro scale and the urban audit on a macro scale, could be interesting to test on other historical cities in different geographical and socio-cultural contexts to study the accessibility of these cities for people with disabilities.

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