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Morphological Essay on Favela da Rocinha through Shape Grammar

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Abstract: Favelas and other types of informal settlements are important urban issues in several regions around the world, especially in developing countries. They are the housing solution found by populations with no access to formal real estate market, who still suffer with the precariousness of both buildings and urban infrastructure. This paper presents a brief overview on governmental policies for favelas in the city of Rio de Janeiro along the 20th century, until the present moment, to observe hits and misses and present a morphological study about Rocinha, the biggest favela in Brazil. This work is based on the principles of Shape Grammar and demonstrates patterns of composition, organized in sets of rules that allow producing new designs. The intention is to create a proposal for an objective reading of typical favela spaces, to determine standards and rules that may contribute to architectural and urban designs that are more adequate to the populations they are designed for.

Key words: Shape grammar, Rocinha scenario, teaching observation.

1. Introduction

Observing the plans of improvement for favelas, it is possible to state that, despite some achievements of urbanization projects, very few solutions emphasized typological diversity, construction quality and mutations in the shape of buildings. While we deal with the pandemic caused by the corona virus, with indications of new hygiene routines, we intend to contribute with some thoughts on the spaces of residential and community agglomeration in Rocinha, in the city of Rio de Janeiro, through an analysis from Shape Grammar.

In a favela, inhabitants usually solve their housing needs without any support from public authorities. This urban and architectural informality, typical of favelas, is nowadays a concern, regarding the corona virus spread, and brings up a serious issue of the impasse between government and those who live in places that are not ruled by building legislation.

Even if there is a lot of academic research about favelas, including Rocinha, few propose objective tools for architectural and urban design that aid to qualify life in these agglomerations. Brazilian architecture is characterized by high levels of informality [1], favelas and other informal settlements contain a great part of those self-built edifices.

In this work, we search to identify the specificities of ways of occupation of soil, of buildings, and of the arrangements of inner spaces. The methodology developed aimed to infer a set of rules which express the local morphological characteristics, of both urban and house spaces, in a way that from such rules it would be possible to generate new shapes, always gathering aspects of adaptation and transformation, typical of informal settlements and suitable to the profiles of the dwellers.

This study, started in 2013, is part of a research carried out by the group *A Educação do Olhar: apreensão dos atributos geométricos da forma dos lugares* (*Teaching Observation: Apprehension of Geometric Attributes of the Shape of Places*), which introduces the education of observation as a strategy

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to understand geometric shape [2]. In this sense, Shape Grammar has been investigated for its potential to analyze and synthesize shape, associating design and computational processes.

This paper presents a lecture given at Penn State University, for students of Architecture and Landscape Architecture of the College of Arts and Architecture in 2016, together with observations extracted from technical visits to the favela [3-5].

We intend to think on possibilities of arranging a favela, an issue that has grown with the pandemic and which should already be promoted to improve the quality of the environment, as well as on the elaboration of a system for new design method for social housing, focused on the particularities that are inherent in informal architecture. Also, we aim to create solutions that present varied space organizations for housing, that differ from the logic of the formal city, in a system that includes the local population's own way of composing spaces and building.

2. Brief Overview on Proposals for Improvement of Favelas

Spread over hills and lowlands, Rio's favelas mark the city landscape, as much as the Christ the Redeemer or the Sugarloaf Mountain. Rio de Janeiro is the city with the highest proportion of population living in this kind of settlement in the country. There are 763 favelas, where more than 1.3 million people live [6], making up about 20% of Rio's population. Actually, it is a global situation, as this kind of settlement/informal occupation is home to about 32% of the world population [7].

According to Abreu [8], from the late 19th century to the early 20th century, this kind of occupation was already known in Rio de Janeiro, where a process of urban transformation was going on and there was a demand for housing. There is not a precise record on the formation of the first favelas, but the name comes up with the arrival of the soldiers who fought in Canudos and occupied the slopes of the Providência hill, called Favela Hill in 1887, originating this denomination (op.cit.). Fig. 1 presents the appearance of the first favelas, from Abreu's chronological records.

Among other cities, Rio de Janeiro attracted immigrants, especially the ones that came from rural areas, searching to improve their lives and to access social services [9]. In order to respond to the need for

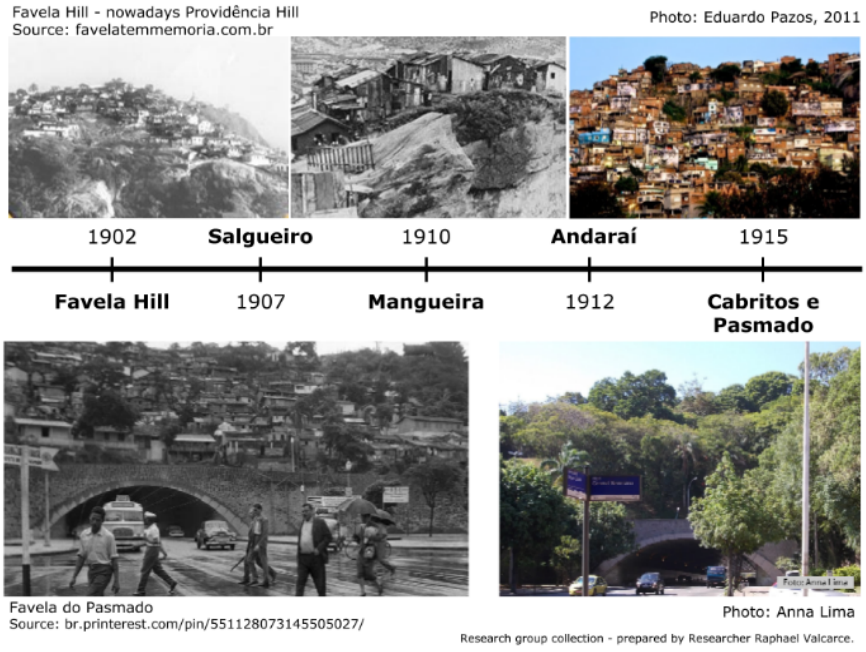

Fig. 1 Timeline—emergence of some of Rio's favelas.
Source: research group collection—elaborated by Pedro Valcarce.

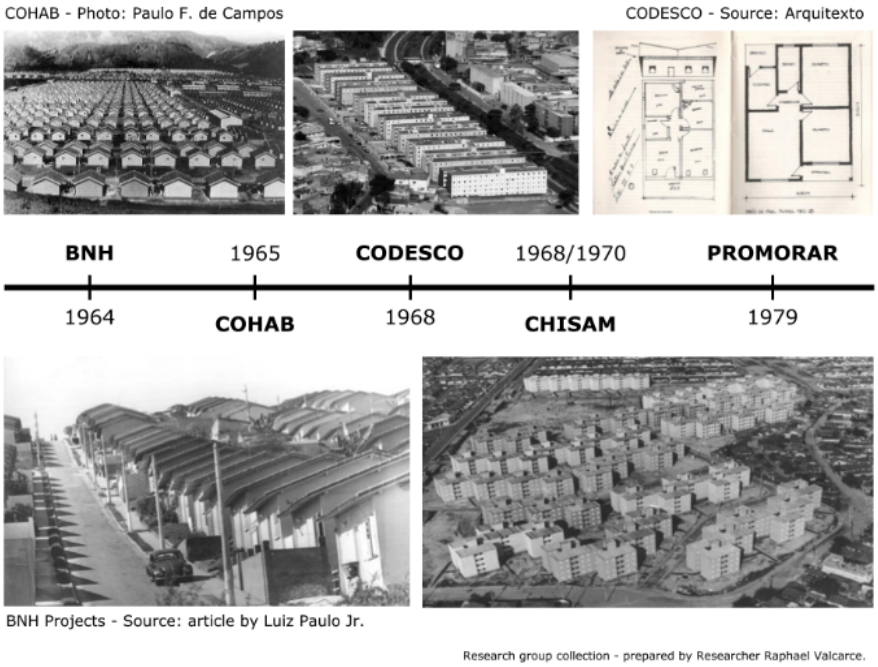

Fig. 2 Timeline—governmental initiatives in the 1960s and 1970s.
Source: research group collection—elaborated by Pedro Valcarce.

housing, the Company for People's Housing of the State of Guanabara (COHAB) was implemented. Except for some urbanization attempts in 1965, its most notorious accomplishments were the removal and reallocation of people in housing projects especially built for that. In 1964, the National Housing Bank (BNH) was founded and became the main governmental social assistance program for popular housing. However, BNH did not achieve the social sectors with the lowest income, and the increasing borrowers' default made the bank turn their investments to middle and upper-class families and end up shut down in 1986. At federal level, housing policies remained disconnected from other urban policies, until 2003. Around 1960, the *Operação Mutirão* (*Joint Effort Operation*) was implemented and then shut down one and a half year later. But that was the first time residents were directly involved. In 1968, the state governor of Rio de Janeiro gathered professionals like architects, urban planners, and economists, to create the Company for the Development of Communities (CODESCO), in charge of providing technical support and promoting people's participation on the urbanistic decision making. From the three communities CODESCO would urbanize, only Brás de Pina was successful.

In 1963, the Federation of Associations of Favela Residents of the State of Guanabara (FAFES) was created, and then changed into Federation of Associations of Favela Residents of the State of Rio de Janeiro (FAFERJ) in 1975, to defend local urbanization and the end of removals [10]. From 1968 to 1970, Coordination for Social Housing in Rio de Janeiro Metropolitan Areas (CHISAM) removed 100,000 people from their homes and ended operations in 1973[1]. The federal program, *Program for Eradication of Sub-Habitation* (PROMORAR) was implemented in 1979, from interventions that aimed to improve habitation in favelas, without removing residents. Fig. 2 presents the timeline of these initiatives.

Alternating between actions of removal and urbanization in favelas, from 1979 to 1982, mayors of Rio de Janeiro gave attention to residents' needs, such

[1] https://rioonwatch.org.br/?p=4676.

as garbage collection, water and sewage, land titles, urbanization and paving of streets and alleys. In 1987, the *Projeto Mutirão* (*Joint Effort Project*) was implemented, improving, through punctual actions, several favelas.

Nonetheless, it was in 1992 that the city Masterplan created the foundations of a public policy of urbanization of favelas [11] and the actions by public authorities became more expressive, which represented a great advancement for favelas, until then approached as deformities, as unsound areas. Then, in 1994, *Programa Favela-Bairro* (*Favela-Neighborhood Program*) came up as one of the main innovations to reverse urban decadence in favelas. Conceived by the architect Luiz Paulo Conde, head of the city's Urbanism Department at that time, the project planned improvements for urbanism, infrastructure, social actions, and actions of integration with the formal city. The program represented an effective transformation in the relationships with favelas, which started being considered as communities that deserved public funds. The initiative was successful from 1994 to 2007, when the program *Morar Carioca* replaced it. The new program was "considered by the City Hall technicians as a possibility to improve the *Favela-Bairro* program" [12] [our translation].

Comparing the focus of CODESCO, created in the 1960s and the *Favela-Bairro* program (PFB), it is possible to state that the first prioritized private residences; while the latter, 34 years later, prioritized public spaces, with a promise that the community would engage in the discussion of each urbanization project. The next program for favelas, implemented in national scale, was *Programa de Aceleração do Crescimento* (*Growth Acceleration Program*) (PAC), in 2007 (op.cit.). Through this program, public works were installed in favelas, including touristic ones, like the cable car in Alemão Complex and the footbridge designed by Oscar Niemeyer at the entrance of Rocinha, as well as some great designs of public housing and cultural equipment.

In 2009, Brazilian Federal Government released the program *Minha Casa, Minha Vida* (*My House, My Life*) (PMCMV) (op.cit.), aiming to boost economy through the construction sector and to allow low-income families to have their own houses. In an evaluation of the effects of the first phase of PMCMV by Cardoso et al. [13], authors highlight the program's ambiguity, due to peripheralization and implementation of big housing complexes in the suburbs. Fig. 3 illustrates the programs from 1987 to 2009.

Despite the attempts to improve quality of life in favelas, the need for qualified public services was still great. Thus, with a goal of urbanizing every favela in Rio until 2020, the City Hall released the program *Morar Carioca* that intended to be a legacy of the 2016 Olympic Games [11]. For that, a public competition was promoted, to select 40 multidisciplinary offices, which were never hired. The program was firstly planned to follow the practices of the *Favela-Bairro* program, but with more resources. Actually, it was about economic integration, "without any attachment to the discourse of 'urban integration' or 'social legacy', the most incisive removal policy since the military regimen" [14] [our translation]. The project was archived due to what some called lack of political will.

Since local urbanization became a consensus in governmental politics, the evaluation of these policies has been demanding changes on the view, not only in these programs' intentions, but also in their implementation. The works of the City Hall with residents, to determine priorities, are placed very far from the policies of proletarian parks to which people were evicted in the 1940s. However, the programs for the improvement of favelas and for social housing are still centered in economy, when it comes to either the origins of problems or their solutions. This way, housing policies have been basically assessed for their numbers, regardless of the costs needed to correct negative impacts [12].

Fig. 3 Timeline—governmental initiatives from the 1980s to 2009.
Source: research group collection—elaborated by Pedro Valcarce.

It is worth to highlight that bureaucratic issues may reinforce the scenario of inequality and have a much higher weight than it would be supposed when we address the problem of favelas and informal housing as a whole. Considering Brazil's dimensions and cultural differences, standardized procedures for the whole country end up with being expensive and also inhibiting innovative solutions that could be managed by local governments.

Previous experiences have proved that if urbanizations are carried out in a participative manner, or by self-managed cooperatives, the development of the *favela style* could be a rich urban form for cities. It is necessary to think of solutions that emphasize the diversity of the buildings' design and reflect different habitation needs of the families, in order to adequate the housing unit to families' profiles. With Shape Grammar, we believe we can generate several alternative solutions based on habitation and settlement solutions brought by residents. This can be a partial answer to the questions urban planners all over the world have been asking themselves: how to deal with the one third of the people in the world who will live in informal urban settlements?

3. Specificities in Rocinha

Rocinha is in the southern part of Maciço da Tijuca, a mountain range in Rio de Janeiro. With an area of 143.72 ha, it is between the upper class neighborhoods of Gávea and São Conrado (Fig. 4) and was recognized by law as a formal neighborhood in 1993. It is the most populous favela in Brazil, with an estimated population between 120 and 150 thousand inhabitants.

In the early 20th century, the whole area where now are Rocinha and São Conrado was rural, with some irregular occupations. In the 1940s, there was an increase of the occupation process in the lower part of Rocinha. The real estate growth in the neighborhoods of Ipanema, Leblon, Gávea and Botanic Garden, in the 1950s, also contributed to the migration of many Brazilians from other states to Rio, as construction workers. They built their own houses at Rocinha, using leftovers from construction sites where they were employed.

Fig. 4 Surrounding neighborhoods: Gávea and Lagoa (left) and São Conrado
Source: research group collection.

The growth of Rocinha accelerated in the 1970s, as the Lagoa-Barra road was inaugurated, boosting the development of the region of Baixada de Jacarepaguá by connecting this region to the south zone of Rio, then the richest of the city. Paradoxically, these works caused the first process of partial removal, in 1968. Residents were transferred to houses in other neighborhood, but ended up going back, for the privileged location of the community. In 1971, with the construction and inauguration of the tunnels in Dois Irmãos Hill, a new connection was established and became the main link between the south zone and Barra da Tijuca, then a neighborhood in expansion in Rio.

In 1981, Rocinha was chosen as pilot program for urbanization of favelas, but this time, families were transferred to a building at the upper part of the favela, called Laboriaux. In the following decade, in 1993, a law (Law n. 1995 on June 18) was enacted, to create and delimitate the Rocinha neighborhood. In Fig. 4 two views from Rocinha from surrounding neighborhoods are shown.

4. Characteristics Observed

To address the facts and causes that contributed to the formation of Rocinha, we chose shape as a criterion to infer rules of architectural composition, knowing that the morphology of favela comes up as product of social economic dynamics.

Considering Rocinhas's huge dimension, it was selected for case study an area that was already described in detail, with statistic data collected [15]. In addition to those, visits to the favela and interviews with residents took place. In Fig. 5, characteristics verified going through streets and alleys: the variety of the constructions' volume, their distribution and the formation of paths and surrounding accesses.

Aiming to elaborate a Shape Grammar, we observed aspects that allow establishing a first design language from graphic analysis. The first finding is a strong inclination of the terrain, which forces adaptations that combine accesses through stairs and ramps with buildings that accompany the levelling curves and result into a complicated design of buildings and labyrinthic streets.

Buildings in Rocinha usually have more than one household, with accesses at different levels, and a volume that tends to verticalization and brings a risk concerning its stability. The gauge of most buildings in the sector studied includes 3 or more floors. The real estate dynamics distinguish from the formal city and there is the so-called "right to the *laje* (*upper-slab*)", in which one owner sells the top of their house (the upper slab, the *laje*) to another person, as a lot that is available for construction [16]. In most houses, there is no concern to the aesthetical composition of the façades, which usually results from the needs for access, and ventilation/lighting. Also, roofs and water tanks (mostly blue ones) are very visible elements if one looks from the top of the favela.

Most lots are totally occupied, with very little free space on the favela ground level. That makes the *lajes* play a role of backyard. Situations in which the building area advances over the streets from the second floor are not uncommon and create tunnels on many alleys. Very small distances of about 25 cm are found between constructions, by which plumbing passes [16].

Fig. 5 Constructions in Rocinha.
Source: research group collection.

In our research, nine housing units were surveyed. Of those, seven were multi-family and two, single-family, and they had from four to six floors. Units have areas that vary between 24 m^2 and 182 m^2. Rooms found were living room, usually through which one accesses the house, kitchen, bathroom (sometimes more than one), and most of them had bedrooms. One unit was of *studio* kind.

5. Shape Grammar

To develop the work herein, a methodology of analysis was created using concepts from Shape Grammar, a formalism introduced by Stiny and Gips in 1971 [17]. It consists in the development of rules of the a > b type (if there is "a", replace it with "b"), but using shapes instead of letters. Methodologies of analysis of shapes, types and spaces can be developed from these concepts, producing processes to identify shapes and recognize patterns. Most studies on Shape Grammar are analytic applications consisting in examination of an architectonic corpus of analysis, with elements that appear to have morphological similarities with one another.

6. Rocinha Grammar

The study in Rocinha resulted into two parallel and complementary shape grammars: the first one with rules of urban design, and the second, for definitions of buildings.

Favelas grow from irregular land occupations and the ordering of use and land occupation in Rocinha is a crucial matter to ensure better life conditions to its residents. Its spatial arrangement is greatly due to topography, which boosts precariousness of living conditions, with risk of landslides, and restricts the conditions of circulation and access.

Acknowledging this structural particularity of the favela, to define rules for building settlement and streets, we distinguished two kinds of house implementation: those located in the lower and flat part of Rocinha, and those located in regions with rugged topography. While the first presents an orthogonal road layout and more linear lots; the second, in which occupation follows topography, results into a more organic design.

In the definition of the settlement rules, visits to Rocinha were essential to aid to understand the structure of urban area, organic and so hard to apprehend only from aerial and satellite photos or from the City Hall blueprints. The latter, by the way, are old and incomplete, as favela areas were, for many years, excluded from city maps, which also made it difficult to study the past. Once streets were more clearly mapped, it was possible to observe some patterns, in this apparently chaotic blueprint, and infer a set of rules that govern the tracing. Fig. 6 shows the five first rules defined for the Urban Grammar. R1 shows a house on the main street, while R2 considers the possibility of a repetition, up to 10 houses, when then R3 should be mandatorily applied, inserting a new secondary street or an alley.

The possibility of contiguous constructions was conceived, on the façade that comes behind the

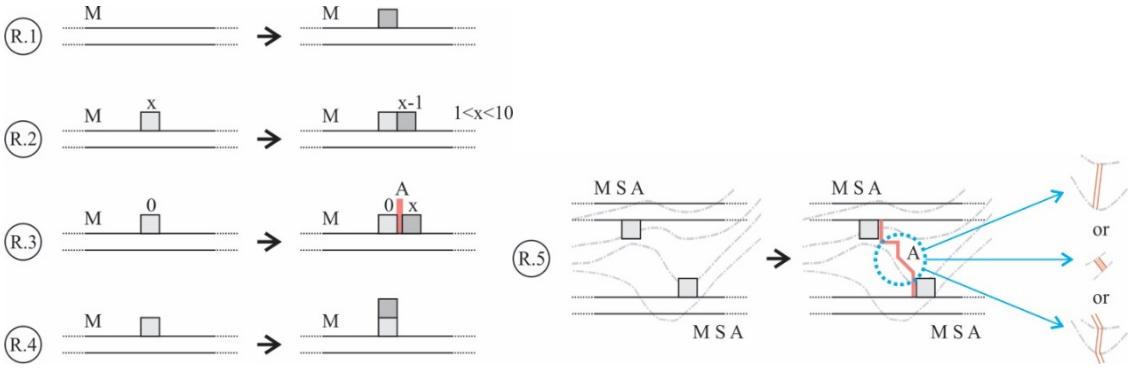

Fig. 6 Rules for inserting lots and creating alleys, from a main street.
Source: research group collection.

constructions that already exist on the main street, R4. R5 represents the connections between two streets, through alleys, ramps or stairs, alternatives that vary according to the distance between levelling curves.

Considering local topography and displacements among points of interest, rules were also defined for the connection between streets and for filling empty spaces, where houses with quite irregular shapes are implemented.

Just like in settlements, topography also dictates the shape of buildings, usually staggered and reproducing level curves. Those houses usually contain more than one home, and sometimes they have accesses at different levels, and projections that cover some parts of the streets and make up tunnels in narrow alleys. The volume that composes this set of constructions and the inner organization of houses was objects of the second phase of this work. Rules were also inferred for recurrent elements of the external part of the buildings. Thus, in this grammar's vocabulary, elements like slabs, walls, balconies, sheds and water tanks were included.

The Grammar of Rocinha buildings has as references Palladian Grammars [18], Malagueira Grammar [19] and Colors Grammar [20]. The first two present rules for producing spaces from recursive subdivision, in addition to the definition of use of the spaces through labels. The third reference introduces color to the vocabulary elements, in order to denote different characteristics to similar elements, thus reducing ambiguities and restricting solutions. It plays a role similar to labels, but visually easier to work with. Colors were used since analysis sketches, relating colors to functions, until the formatting of rules, as a conditioning element, as presented in Fig. 7. At the analysis stage, they help to identify functional composition patterns. To form the rules, they aid conditioning for applying rules.

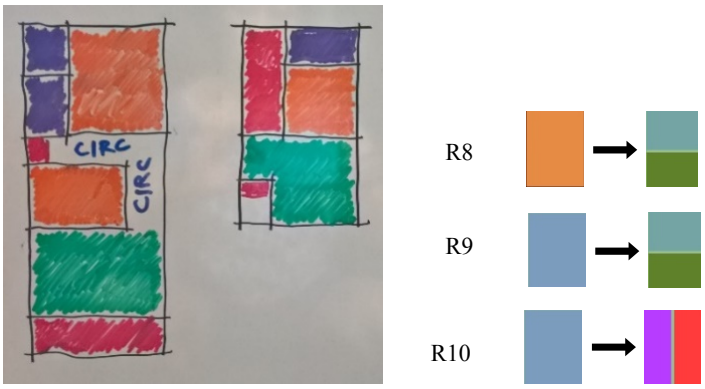

Fig. 7 Analysis sketches and some rules for the space subdivision. Attribution of colors.
Source: Margaret Chokyu.

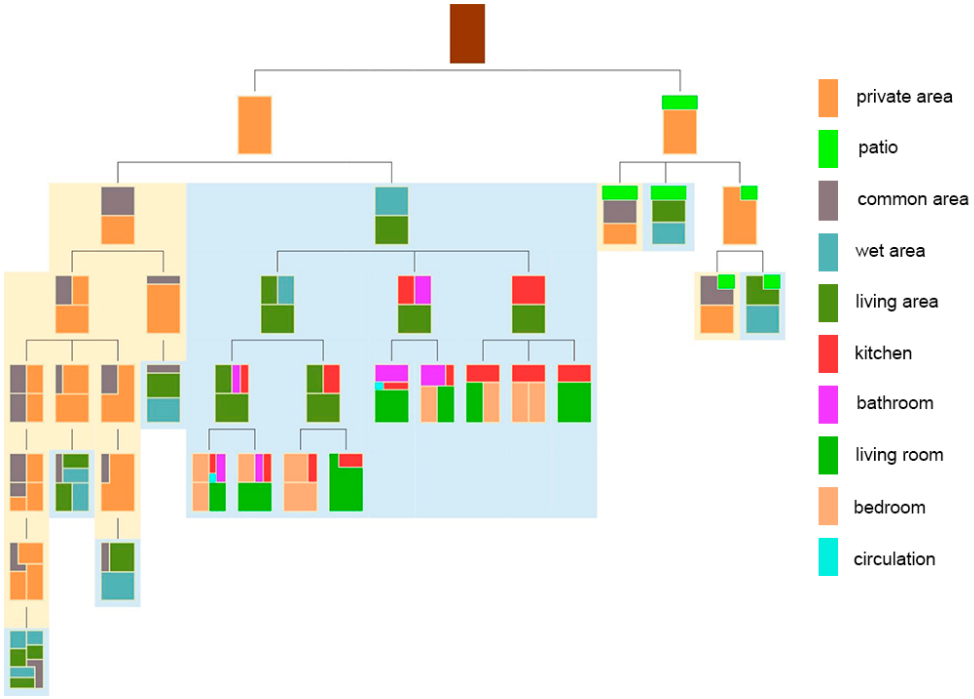

Fig. 8 Tree diagram demonstrating the application of rules for the buildings.
Source: Margaret Chokyu.

The Grammar of buildings is divided in 6 stages: occupation of the lot, compartmentation of internal spaces, compartmentation of units, realignment of the walls, insertion of openings (doors and windows), insertion of new floors and conclusion. Like in any grammar, rules must be applied in a finite sequence, recursively from an initial form, making up an algorithm that will define a final product that is the initial one, altered as rules were implemented.

The application of rules according to conditions does not result into predetermination or rigidity, once possibilities multiply, as observed on the tree diagrams in Figs. 8 and 9, in which different arrangements can happen from a same initial form. In Fig. 8, from the lot, the brown rectangle, the following line shows the different possibilities in stage 1. Then, there is the application of stages 3 and 4, in which units are subdivided and a specialization of functions occurs. The yellow branch indicates arrangements for multi-family units, whereas the blue one indicates arrangements for a single unit.

The next stage, of rearrangement of internal and external walls, is parameterized with sizes and distances according to the dimensions observed in studied buildings.

Some possibilities of stage 5 can be observed in Fig. 9, with the insertion of new floors configuring the volume of the buildings, including possible advances over the street. At this stage, there was also attention to the arrangement of the *lajes*, with the insertion of external elements observed in technical visits: parapets, sheds, small constructions, water tanks. Due to the favelas particular dynamics, this *laje* can become another inhabited floor at some point, when a parapet can become the closing wall for that floor. Red walls indicate façades, which allows inserting windows and/or doors at stage 5.

The last stage of the work of composing a Shape Grammar consists in computing rules, which means applying them to reproduce the corpus of analysis—which proves their functioning and efficacy, and also producing new ones that fit in the same type.

The set of rules defined in this study represents a local reality and is useful to demonstrate that Rocinha has its own spatial composition patterns. This recurrence may reflect a lifestyle to be understood and

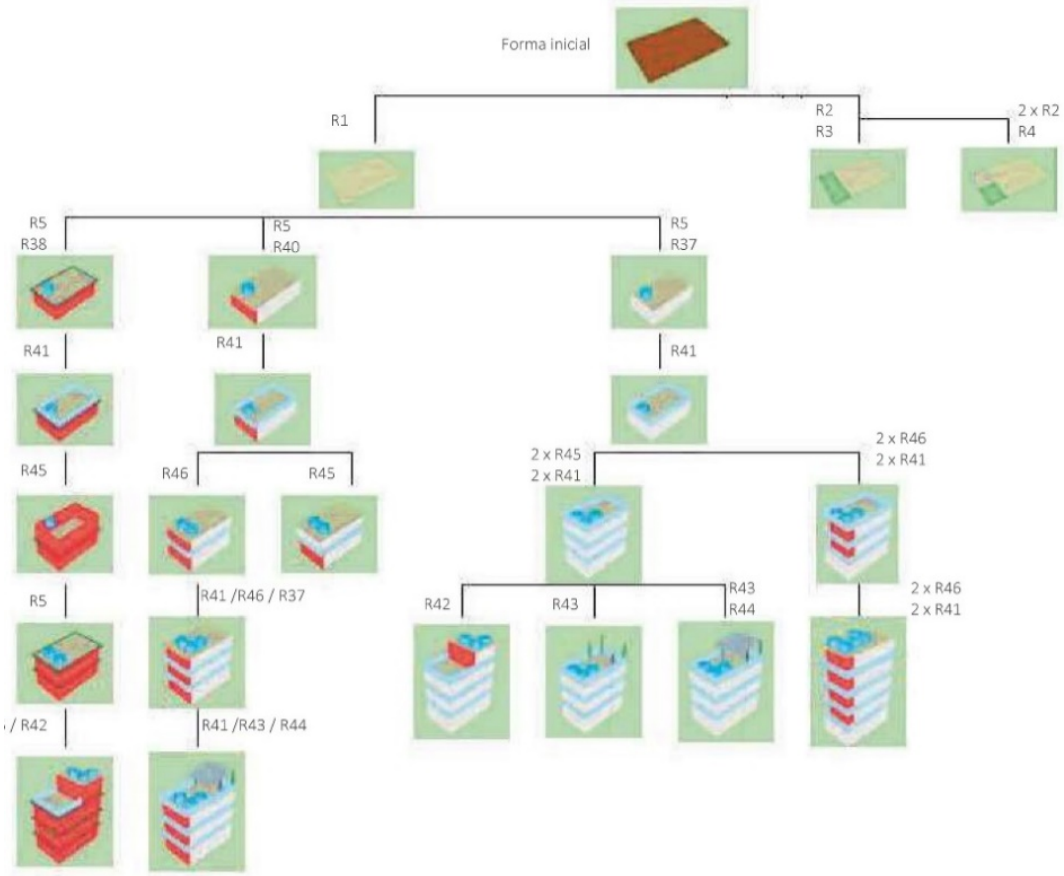

Fig. 9 Tree diagram demonstrating the application of rules for the buildings.
Source: Margaret Chokyu.

respected, and present solutions for designs of social housing and urbanization of precarious or informal settlements, that are usually disregarded by experts. However, the grammars presented can not be directly applied to designs, since they present inadequate dimensioning, especially regarding health conditions. Nonetheless, a correction in parameters would allow producing designs that are coherent with local realities and adequate in health conditions.

The knowledge about the community has been deepening along the process of analysis developed by the research group that studies Shape Grammar applied to informal city. We have participated on the development of two PhD thesis: one by Professor Margaret Chokyu, under the title "Regras do Espaço informal: A Gramática da Forma na Rocinha" ("Rules of the informal space: the Shape Grammar in Rocinha") [16] [our translation], that goes deeper into the analysis of houses in Rocinha, in what concerns the composition of internal spaces and volume; and another by architect Débora Verniz, who analyzes the Santa Marta favela, under the title "Understanding the Genesis of Form in Brazilian Informal Settlements: Towards a Grammar-Based Approach for Planning Favela-Like Settlements in Steep Terrains in Rio De Janeiro" [21].

7. Conclusion

The overview on improvement plans for favelas in Rio de Janeiro shows that the matter of social housing is not having significant progress. At the same time, favelas grow, with irregular settlements, occupying risky areas, increasing the number of rooms towards the sides and up, expanding their areas over neighboring houses, huddled, with very narrow passages, cubicles without any ventilation, making up

an environment that is not only potential for contamination with COVID-19, but also with so many other diseases, like tuberculosis.

Visiting Rocinha, it was noticed that the scenario described above repeats, and the formal design of settlements and buildings mostly results from topography, which makes living conditions worse and restrict circulations and accesses. However, their spatial characteristics contain elements of Brazilian popular architecture that could be incorporated to social housing designs.

The goal of the work is to define rules that show the combination of different elements that compose informal architecture in customized patterns of urban settlements. However, rules must go through changes, either to refine them, or to cover occurrences that have not been identified yet. So, technical visits to the favela are still necessary, but public insecurity and the pandemic are currently making it harder to access Rocinha for new studies.

On the other hand, the exercise of this kind of design must especially focus on the process of defining standards, like in Malagueira, creating a generative design. For that, rules must be prepared in a user-oriented computational logic.

Considering the importance of addressing the informal city, in this paper we presented a set of rules defined by the Shape Grammar, gathering local morphologic characteristics, to allow new designs, always merging aspects of adaptation and transformation—which are typical of informal settlements—and adequate to the profile of residents. The problems of insecurity and violence have been slowing the research up, but the importance of the method of analysis and, above all, the importance of thinking about solutions that emphasize the diversity of the design of the buildings and reflect the different habitation needs of the low-income population, remain.

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