**EIGHTH INTERNATIONAL SPACE SYNTAX SYMPOSIUM**

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# Can genotype patterns change over time?

## 1. Space syntax and genotype

Space syntax theory (Hillier and Hanson, 1984) proposes principles relating to the social dimension of space. It is argued by this theory of space that the structure of distribution of architecture spaces, by the logic of their configurations, interacts with the ordering of society in which it is constructed, as one of their social systems. Architectural environments, thus, not just generate built forms but also organize patterns of interactions among people by the way their spaces are distributed.

Techniques were generated by Space syntax to identify and describe aspects of spaces that occur in relevant repetitions within diverse systems from a specific society, raising from it correlation to social factors. Such patterns structuring spatial configurations, when found in a consistent way in a sample of architectural cases, are named by Space Syntax as 'genotypes', while the materialization of these abstract patterns in different geometric forms are designated as 'phenotypes'. While phenotype manifestations are expected to develop in an infinite variety, genotype patterns maintain the same descriptions, to delineate the abstract expression of society in space. Hillier and Hanson argued that "different types of social formation…require a characteristic spatial order, just as different types of spatial order require a particular social formation to sustain them" (1984, 27).
This work brings the idea that some aspects of genotypes can change over time, while the stability of genotype characteristics are kept, as the social codes they are expressing may also have suffered alteration along the decades, although the same society continues to be recognized therein. And the possibility to find these aspects seems to depend on a historical sample investigated in a way that differences can emerge.

## 2. Introduction to the research

This paper derivates from PhD research from the same author (Cunha Paula, 2007) which was based on the logic of social significance of architecture in its spatial elements proposed by Hillier and Hanson's theory of space, to verify if and how a sample of 95 apartments randomly collected could, from 1930s to 1990s express (see cases of each decade in figure 1) ways of living and inhabiting through patterns of continuity and changes of spatial configurations.

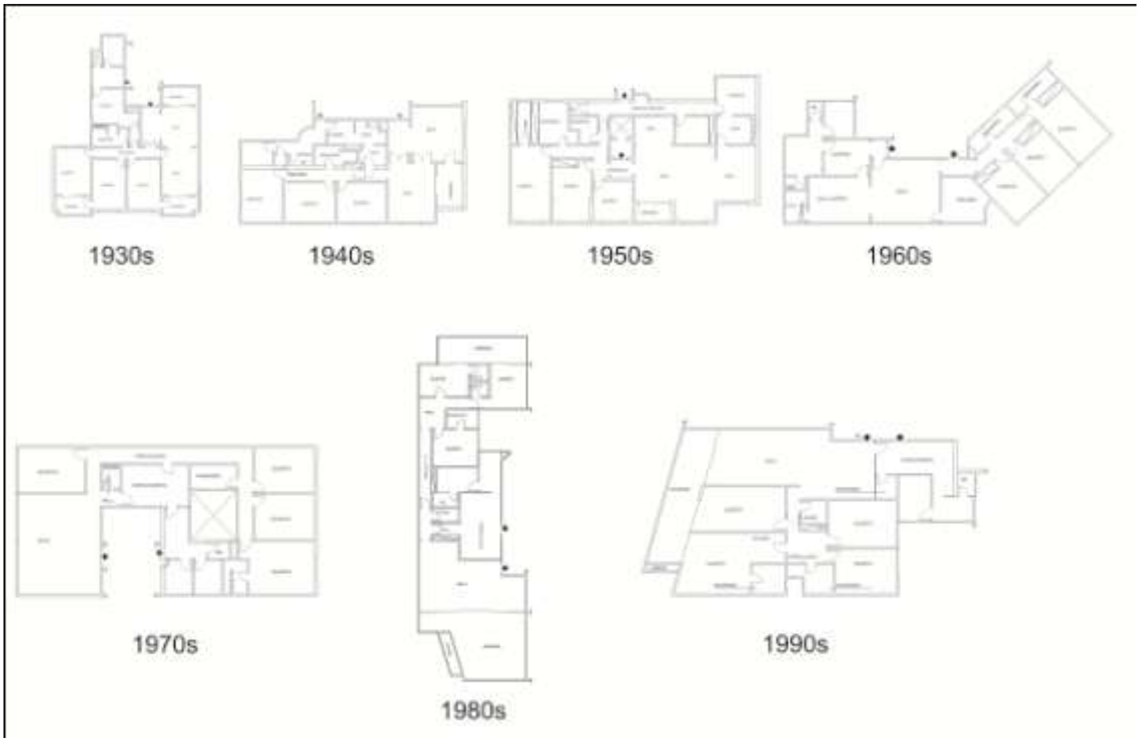



Figure 1 – examples of sample's apartment plans of each decade:

1930s - Living rooms divided by wall demarcations for activities areas definitions (which tend to disappear) and bedrooms closer to social zone, with one bedroom directly linked to it. 1940s – Increasing elaboration of social spaces and no cases of en-suite bathrooms and lavatories up to these years, even in larger apartments. 1950s – More spatial elaboration of social area than in the 1940s and Bedrooms start to gain distance from social zone, with few cases of en-suite bathroom and lavatory. 1960s – En-suite bedrooms, in positions as far as possible from other house rooms, and lavatories are very frequent. Kitchens and social entrance access living room directly. 1970s - Corridors turned longer to separate intimate area, and en-suite bedrooms in almost all cases. 1980s- En-suite bedrooms not just constant in all cases but also for all bedrooms in some apartments. Main bedroom formally elaborated and en-suite bedroom for maid. 1990s- Main bedrooms connected also to social veranda in some cases, besides to intimate corridor.

The investigation started by the quantification of integration relations in the diverse systems, using Space Syntax software, to different labeled spaces of the apartments. Integration, as defined by Hanson (1998, 32) is "one of the fundamental ways in which houses convey culture through their configurations".

There were found 21 different sequences of integration of 6 main labeled rooms, out of the 720 possibilities that mathematically the permutation of 6 distinct values could generate. From these 21 sequences 3 represented more than half of the sampled residences, as strong tendencies of domestic organizations (see table 1).

| Type/decade | 30 | 40 | 50 | 60 | 70 | 80 | 90 | Total |
|---|---|---|---|---|---|---|---|---|
| T1- T<K<L<E<B<M | 0 | 40.9 | 50.10,15,18,19 | 60.3,5,11,19 | 70.5,15 | 80.1,2,4,5,12,16,20 | 90.8,9,13,14 | 22 |
| T2- L<T<K<E<B<M | 30,11 | 0 | 50.4,16,20 | 60.2,13 | 70.1,8(D),14,16,19 | 80.3(D),7,8 | 90.2,4,5,7 | 16 |
| T3- T<L<K<E<B<M | 30.8,16 | 40.12,17 | 50,7 | 60.17,18 | 70.6,12(D),18 | 80,13 | 90.10(D) | 12 |
| T4- L<T<E<K<B<M | 30.18(D) | 40,1 | 50,11 | 60,12 | 70.13(D) | 80,14 | 90,17 | 7 |
| T5- L<T<K<B<E<M | 30,14 | 0 | 0 | 60.15,20 | 70,2 | 80.15,19 | 0 | 6 |
| T6- T<K<L<B<E<M | 0 | 40.2(D) | 50.13,17 | 60,9 | 70.3(D), | 0 | 90,15 | 6 |
| T7- T<L<E<K<B<M | 30.1,2 | 40,8 | 50,6 | 0 | 0 | 0 | 90,12 | 5 |
| T8- T<L<K<B<E<M | 30,9 | 0 | 0 | 60,7 | 70,17 | 0 | 0 | 3 |
| T9- L<E<T<K<B<M | 30,19 | 0 | 0 | 60,16 | 0 | 0 | 0 | 2 |
| T10- T<E<L<B<K<M | 0 | 0 | 50,1 | 0 | 70,2 | 0 | 0 | 2 |
| T11- T<L<E<B<K<M | 30,12 | | | | | | | 1 |
| T12- T<L<B<E<K<M | 30,7 | | | | | | | 1 |
| T13- T<E<K<L<B<M | 30,1 | | | | | | | 1 |
| T14- T<E<K<B<L<M | 30,17 | | | | | | | 1 |
| T15- T<K<E<B<L<M | | 40,5 | | | | | | 1 |
| T16- T<K<B<E<L | | 40,3 | | | | | | 1 |
| T17- L<K<T<E<B<M | | 40,13 | | | | | | 1 |
| T18- T<L<B<K<E<M | | | 50,9 | | | | | 1 |
| T19- T<L<E<M<K<B | | | 50,8 | | | | | 1 |
| T20- T<K<L<E<M<B | | | | 60,4 | | | | 1 |
| T21- L<T<B<K<E<M | | | | | 70,9 | | | 1 |

Table 1 – integration sequences for main spaces: T= transition space/ K= kitchen/ L= living space/ E= exterior/ B= main bedroom/ M= maid's bedroom

Accordingly, the study aimed to verify if permeability patterns could also be structuring the composition of the apartment plans, besides integration patterns, and if so, if their repetitions could be correlated. In case it was occurring, the genotype characteristics resulting from the relation of these different spatial properties could, possibly, be expressing elaborated social connections, bringing more information to the complexity of domestic systems.

Justified graphs from the exterior were constructed to each apartment and these graphs were then summarized by concentrating groups of spaces with related activities as a single node. This simplification of the justified graphs was previously done by the author (Cunha Paula, 1992) and by Amorim (1999), and seeks to turn visible regularities in the way areas or sectors of specific activities relate to each other (see figure 2). The knowledge of the patterns of correlation between activity areas in an architectural system from these summarized justified graphs can delineate an order of interaction among categories of users of these spaces, which could be covered by numerous intercommunications between spaces in full justified graphs.

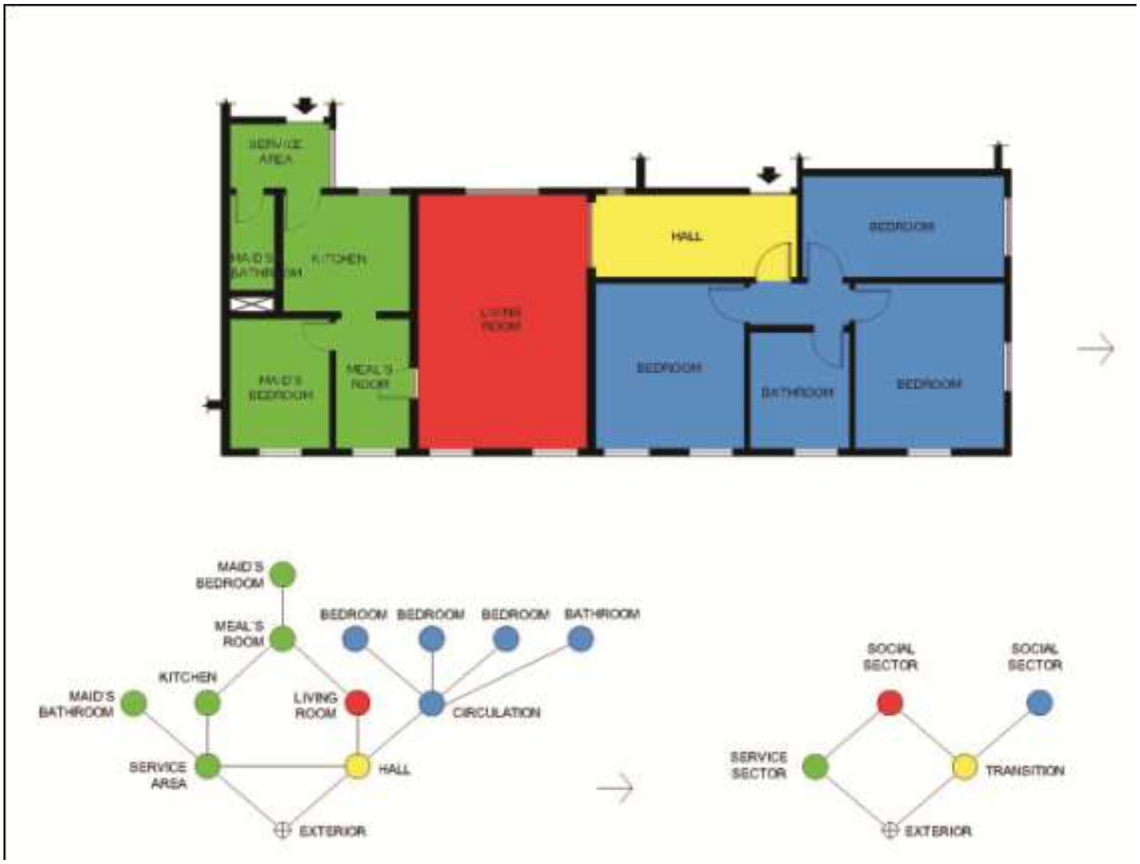
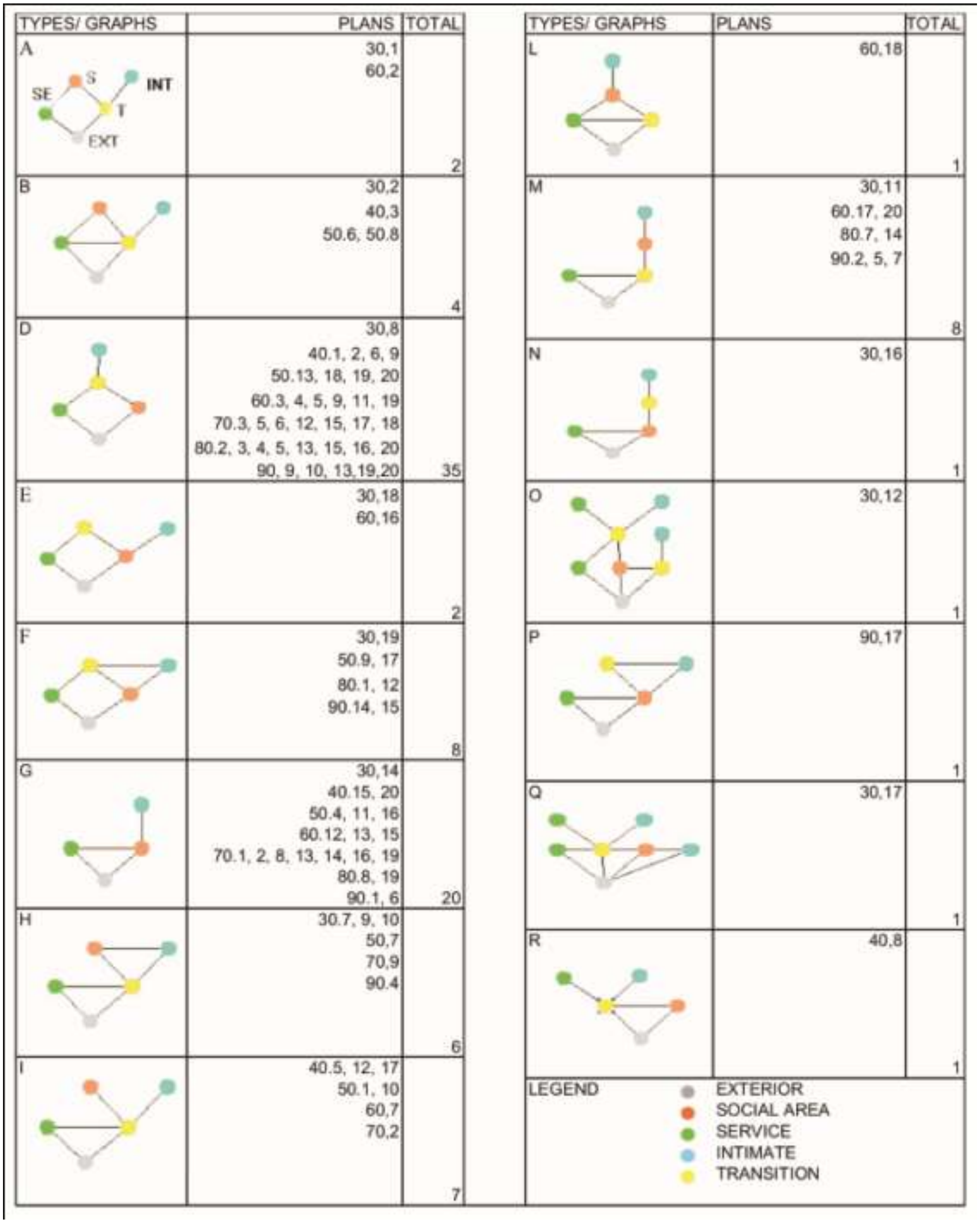



Figure 2 – Exemple of apartment plan from the sample, with different sectors of activities in different colours, and respectives justified graph and summarized justified graph from exterior.

The purpose in using the justified graphs summarization in this work is to identify patterns of access connections between different groups of activities in the plans, which are socially related to codes of interaction among categories of people who use and experience these domestic spaces.

As seen in table 2, the simplification of justified graphs from the 95 plans led to15 types of permeability graphs. From these graphs six types of graphs appeared to represent a consistent number of apartments, as they are repeated in 6 to 35 cases, while the other 9 are in 1 to 4 cases.



| TYPES/ GRAPHS | PLANS | TOTAL |
|---|---|---|
| A | 30,1<br>60,2 | 2 |
| B | 30,2<br>40,3<br>50.6, 50.8 | 4 |
| D | 30,8<br>40.1, 2, 6, 9<br>50.13, 18, 19, 20<br>60.3, 4, 5, 9, 11, 19<br>70.3, 5, 6, 12, 15, 17, 18<br>80.2, 3, 4, 5, 13, 15, 16, 20<br>90, 9, 10, 13,19,20 | 35 |
| E | 30,18<br>60,16 | 2 |
| F | 30,19<br>50.9, 17<br>80.1, 12<br>90.14, 15 | 8 |
| G | 30,14<br>40.15, 20<br>50.4, 11, 16<br>60.12, 13, 15<br>70.1, 2, 8, 13, 14, 16, 19<br>80.8, 19<br>90.1, 6 | 20 |
| H | 30.7, 9, 10<br>50,7<br>70,9<br>90.4 | 6 |
| I | 40.5, 12, 17<br>50.1, 10<br>60,7<br>70,2 | 7 |

| TYPES/ GRAPHS | PLANS | TOTAL |
|---|---|---|
| L | 60,18 | 1 |
| M | 30,11<br>60.17, 20<br>80.7, 14<br>90.2, 5, 7 | 8 |
| N | 30,16 | 1 |
| O | 30,12 | 1 |
| P | 90,17 | 1 |
| Q | 30,17 | 1 |
| R | 40,8 | 1 |
| LEGEND | EXTERIOR<br>SOCIAL AREA<br>SERVICE<br>INTIMATE<br>TRANSITION | |



Table 2 – Summarized justified graphs for all plans of the sample

Types D and G are the most frequent by far: D is in 35 plans and G in 20. And they are not only along all the period of time, but are also greatly expressive in most of the decades, as can be seen in table 3. D and G access types count to 55 apartments, what is more of half of the whole sample.

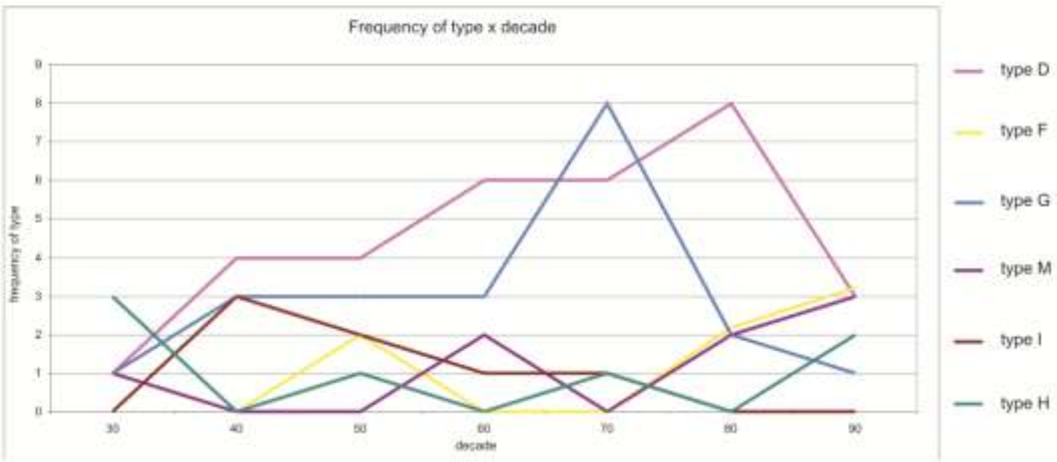


Table 3 – Frequency of the predominant summarized justified graph along the decades of the research.

The persistence of these permeability tendencies led the research to look for the possibility of correlation of these repetitions to the repetitions found in integration types.
The first procedure in this direction was that the number of each apartment plan was substituted by the type of summarized justified graph which represents it, in the table of the main integration sequence (taken from table 1), which generated table 4.

| Type/Decade | 30 | 1940 | 50 | 60 | 70 | 80 | 90 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| T1- T<K<L<E<B<M | | D,D | I,D,D,D | D,D,D,D | D,D | F,D,D,D,F,D,D | F,D,D,F | 22 |
| T2- L<T<K<E<B<M | M | | G,G,M | A,G | G,G,G,G,G | D,M,G | M,H,M,M | 18 |
| T3- T<L<K<E<B<M | D,N | I,I | H | M,L | D,D,D | D | D | 12 |

Table 4 – List of the main types of integration and the plans where they happen being presented by the type of summarized justified graph which represent them.

The analysis of table 4 showed that almost all apartments that had the main integration types had also one of the main summarized access graphs. The most recurrent integration sequence – T1 – happens also in residences in which the distribution of spaces accesses' is mostly as the justified graph more frequent – D. In the same way, the integration sequence that occurs secondly more – T2 - is mostly correlated to G, the permeability simplified graph that follows D in number.
At this point the study went deeper with the intention to better identify the relation that can be established between these spatial properties, seeking to understand how they can contribute to the construction of social interactions in the domestic realm of these apartments.
The closer observation of the six predominant access types delineates that they have just few differences among each others, bringing the question that could they be variations of one or few types instead of being distinct types? Another analytical procedure was

introduced in the study, to verify if this is not a case in which small variations in a sample turn the identification of genotype consistencies as hidden. This procedure is named "small graph combination", and was proposed by Conran Dalton and Kirsan (2005) as the comparison between graphs to see how many normative operations are necessary to transform one into another. A low level of similarity between them, meaning few actions required to the transformation, as defined by the authors, determine a 'genotype signature' between them.

This technique was applied to the 6 summarized justified graphs, looking for pairs of graphs in which the number of actions to normalization between them would be up to three, what would turn their genotype signatures possible. This way types D, F, G, H, I and M resulted in two groups with high similitude level, being D and F in a signature and G, H, I and M in the other. The genotype signatures for permeability were, so, named respectively after D and G (figure 3).

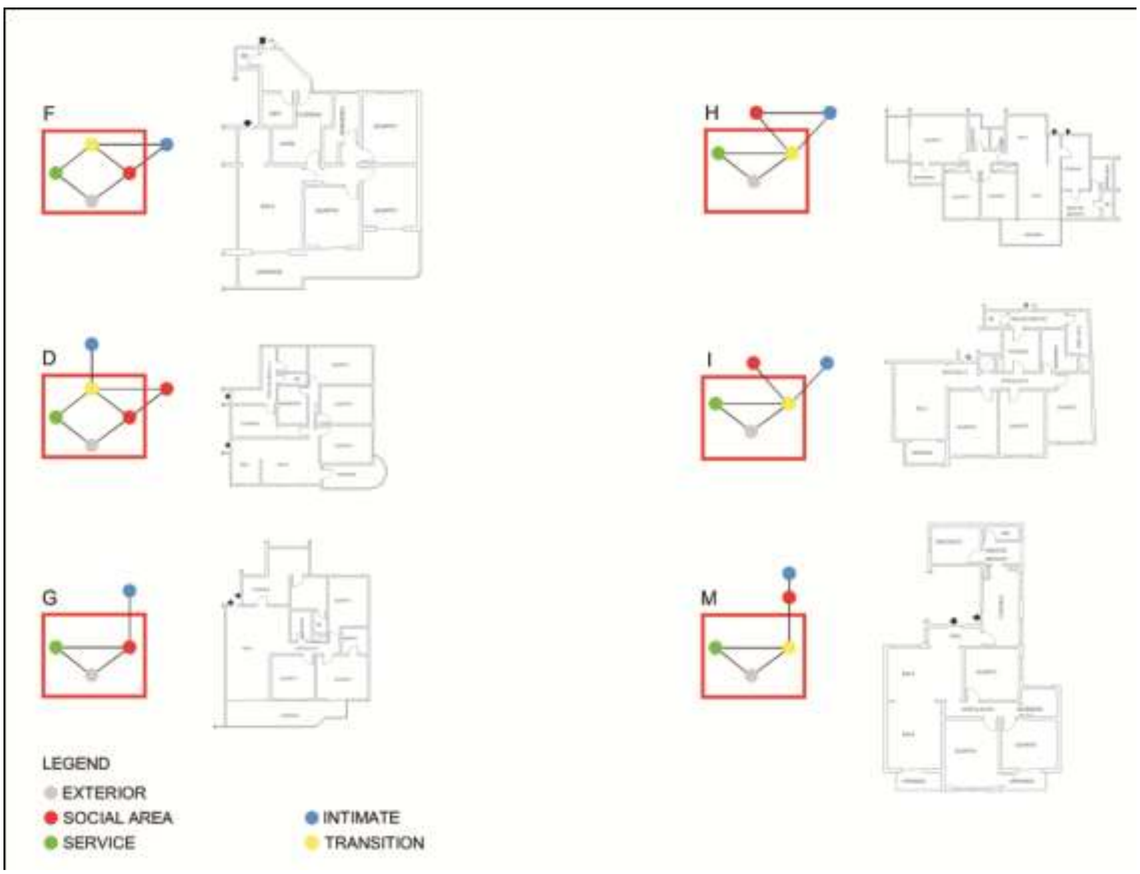



Figure 3 - Main summarized justified graphs and examples of plans of each type

## 3. Mutating genotypes

Reporting to table 4, it appeared that the integration type T1 relates to genotype signature D, T2 to G and T3 to both D and G signatures.

The correlation between these genotype signatures of permeability with their access characteristics being considered both before and after normalization, and the main types of integration describe two different orders that structure most of the apartments of the sample, as genotypes. These genotypes were also named after D and G, as they are constructed respectively by access aspects of genotype signature D with both integration types T1 and T3, and access characteristics from signature G with aspects from integration types T2 and T3.

The particularity of the genotypes found is that although they maintain main characteristics structuring all the cases in where they happen they can present variations in some aspects for group of cases of specific periods of time, as it can be observed in table 5.

| Genotypical Signature D | Genotypical Signature G |
|---|---|
| Service sector accessed since the exterior | service sector accessed since the exterior |
| Service sector always connected to transition space | service sector connected to social or transition space |
| Service sector always connected to transition | service sector connected to transition or social space |
| Social sector always connected to exterior | social sector near or away accessed from the exterior |
| Social sector connects to intimate through ring | social sector connected to intimate through ring or not |
| Intimate always connected to transition, same also social | intimate always connected to social, some cases also transition |
| Transition as distributor but away from the exterior | transition, if exists, as distributor with the exterior |
| Transition always existing | transition doesn't always exist |

*Characteristics of integration types T1, T2 and T3*

| T1 | T2 | T3 |
|---|---|---|
| Centered on the movement | centered on the occupation | centered on the movement |
| Transition – more integrated space | living room – more integrated space | transition – more integrated space |
| Kitchen more integrated to living room | living room more integrated than kitchen | living room more integrated than kitchen |
| Exterior in medium position | exterior in medium position | exterior in medium position |
| Main bedroom well isolated | main bedroom well isolated | main bedroom well isolated |
| Maid's bedroom – most segregated space | maid's bedroom – most segregated space | maid's bedroom – most segregated space |

*Characteristics of genotypes D and G, found by the correlation between aspects of genotype signatures D and G and integration types T1, T2 and T3*

| GENOTYPE D | GENOTYPE G |
|---|---|
| always transition spaces and as the most integrated space | transition spaces not in all cases |
| transition as distributor spaces, far from exterior | transition as distributor spaces, close to exterior |
| kitchen more integrated than living room | living room more integrated than kitchen |
| **living room as most integrated than kitchen in cases of 1930s, 70s to 90s** | living room as most integrated space |
| social area always directly connected to exterior | **social area directly linked to exterior mainly in the 1960s and 1970s** |
| transition space always connected to intimate area | transition space connected to intimate area in 1950s/ 1990s (through rings) |
| **social space directly connected to intimate area in 1980s/ 1990s (through rings)** | social space always connected to intimate area |
| intimate area as very segregated | **intimate area more segregated in 1930s, 50s, 60s, 80s and 90s** |
| **exterior far from transition space as distributor** | exterior connected to transition space as distributor, when this transition space exists |
| maid's bedroom as the most segregated space | maid's bedroom as the most segregated space |

Characteristics that suffered changes along the study time period

Table 5 – Characteristics of genotypical signatures D and G, integration types T1, T2, T3 and genotypes D and G

In this way, genotype D delineates houses where relationship among people is suggested to happen more while they cross each others in corridors than in rooms, for the relatively higher integration values of transition spaces and the constancy of their existence in apartments of the sample. This spatial characteristic implies not just a different dynamic of the experience – in corridors people are mainly walking while in activity spaces they tend to not – but also temporal distinctions: meetings in transition areas induce to not last long while in rooms they tend to extend in time. Interactions among people in apartments with genotype D, on the other hand, tend to be disconnected to exterior, as access to outside space is distant from integrated corridors and in medium level of integration of the systems. The movement of people in the kitchen is suggested to be the second more integrated while the living areas tend to have less frequent use.
Nevertheless, due to mutations in genotype D for cases of integration type T3, in the 1930s living room appears more integrated than kitchen and in the 1970s and 1990s both cases happen. Service cells are always directly linked to exterior, in all cases of the both genotypes, but in genotype D people that usually circulate this area, mainly maids in this society, can enter from the street directly to the room that mostly aggregate peoples connections – kitchen. The social zone is also directly related to outside, facilitating peoples entry into the house – mainly inhabitants and visitors. Although, as social rooms are not so integrated it seems to suggest that this route is not as frequently used. Access to bedrooms is not through social spaces, but after corridors far from exterior, indicating that the intimate area are kept far from the knowledge of the rest of the house, what is intensified by the high segregation level of the main bedrooms suggesting also not much movement in these private rooms. Maids bedrooms are even more isolated. The second mutation found for this genotype D is that in the 1980s and 1990s the bedroom areas gain an optional direct link with the social zone, due to patterns of permeability of F, introducing the possibility of people and activities of bedrooms to interact with the social zone movement, and with visitors that can be there. This tendency happens also in the 1990s for characteristics of T3.

In the apartments of genotype G the use of living areas is more stimulated than of any other space of the house. In the 1930s and 1940s this social zone was rather anticipated by corridors that distribute the access to different areas of the house and function, also, as intermediary filter among spaces and people inside and outside the apartments, due to M and I summarized access types in T2 and T3, which bring corridor to intermediate this connection. These circulations spaces are not present in all cases, as it happens in genotype D. But when they exist they tend to be very integrated, for the conjunction between integration type T3 and access types M, H and I from 1930s to 1960s, turning less probable the movement of people in the living spaces. In the 1950s this transition filter existed for access types H and M, but after this decade the social entrance directly linked the exterior to social spaces. From the 1960s on, on the other hand, this genotype stopped being influenced by T3 and its high integration pattern for corridors that were dividing the main movement of the house between corridors and living rooms in the cases of genotype G with T3. Kitchens do not sustain the tendency for so many peoples integration in genotype G as they do in genotype D (where it happens due to both T1 and T3) and the service places and their usual category – servants – reach at other houses' rooms closer to the outside, without penetrating much in the systems. These aspects conjugated seem to indicate an intention to restrict the interaction of service areas with social spaces, habitually addressed to interactions between maids and inhabitants, concentrating servants more in their service zones and inhabitants in the others areas. The exterior, as in cases of genotype D, is kept rather as far away of what happens in the apartments, as activities inside the houses are very less connected to the movement outside. Intimate spaces tend toward isolation and few encounters happening there, for their constant low integration values. To reach intimate spaces it was necessary to pass through social spaces in the 1930s, but not in the 1940s, for the influence of access type I. After this decade the way to bedrooms came back to be through social spaces, due to access types G and M, with optional routes through corridors in the 1950s and 1990s, for access characteristics of H. A maid's bedroom, on the other hand, continues to be, as in genotype D, the most isolated key room of the apartments.

This way, mutating genotypes D and G indicates fundamentally diverse patterns mainly for social and service spaces, which are the areas where mutations occurred, in the direction to approximate their characteristics, while experiences tended to happen rather similar in relation to exterior and different bedrooms of the house.
Movement, not occupation, patterns are privileged in genotype D, with higher integration in the corridors. In genotype G, on the other hand, occupation is more stimulated, for rooms are more integrated than circulations. Nevertheless, along the years, corridors are more frequent in G and they rather assume people distribution for each activity area, what was done before by social zone. In genotype D, on the opposite, corridors have this function weakened in the last two decades. In both genotypes social spaces tend to connect to intimate areas directly by the end of XX century. And genotype G agrees with genotype D in the last two decades in placing the service zone apart. In genotype D exterior is kept accessed directly by social spaces, from the social entrance, while in genotype G it happens in the 1960s and 1970s, but in other decades this link is made through transition spaces. This way, abstract models of inhabitation found in the research - D and G - indicate different directions concerning social areas, which suffer some transformations in specific decades, while they keep similar patterns of gradating segregation to outside spaces, main and maid's bedrooms in relation to the rest of the house.

These are some aspects of the sample's domestic realms allowed to be delineated by persistent general characteristics of both integration and permeability summarized justified graphs. Results grasped by the study of summarized justified graphs express main access relations between spaces and users categories.
On the other hand, the analysis of full justified graphs can bring to light important specific spatial aspects to the understanding of how spaces tend to be distributed in the sample along the years. This way, seeking to investigate the mutability found for the two genotypes, the next stage of this research is to identify, describe and correlate several specific configuration and compositional aspects of apartments from both the whole

sample and genotypes D and G, searching for similarities and distinctions that can be summed up to the different general abstract patterns found for genotype models.
In order to correlate the diverse results from each configuration aspect to be studied for this historical sample – rings, sequences, bushes, depths, space-types and convexities – these results were organized using a technique developed also in this research, called descriptive tabulation.

**4. Descriptive tabulation technique**

Descriptive tabulation is a manner of ordering diverse information from spatial results, through the application of Space Syntax methods in a single table, in a chronological sequence, in a way that allow the generation of several Cartesian graphs relating some of these factors in a way that facilitates the presentation and understanding of different relations across time. For example, the justification of plans' access graphs reveals the possibility of systems permeabilities, classified by Space Syntax as rings, bushes and sequences. So, following the logic of descriptive tabulation, all possible information that can be extracted from graphs is listed in a single table as:

Plan year
Plan decade
Total number of rings
Total number of external rings
Sectors involved in external rings
Maximum depth of external rings
Minimum depth of external rings
Total number of internal rings
Sectors involved in internal rings
Maximum depth of internal rings
Minimum depth of internal rings
Number of sequences
Maximum depth of sequences
Minimum depth of sequences
Sectors involved in sequences
Number of bushes
Maximum depth of bushes
Minimum depth of bushes
Sectors involved in bushes

| DECADES | [illegible] | [illegible] | PLANT | EXT RING | SEC IN EXT TO RING | E-RING TO DEPTH | INT RING | SEC I TO RING | I-RING FROM DEPTH | I-RING TO DEPTH | TOTAL RING | TREE | TREE FROM DEPTH | TREE TO DEPTH | SEC IN TREE | BUSH | SEC IN BUSH | BUSH FROM DEPTH | BUSH TO DEPTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 30 | 30.18 | 30.18 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 3 |
| | 34 | 30.12 | 30.12 | 2 | S/SE/T, S/T | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35 | 30.16 | 30.16 | 1 | S/SE | 1 | 2 | S/T, T/I | 1 | 2 | 3 | 1 | 1 | 1 | SE | 0 | 0 | 0 | 0 |
| | 35 | 30.19 | 30.19 | 3 | S/SE/T, S/SE/T/I | 3 | 6 | S/I, S/T/I, T/I | 2 | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 36 | 30.11 | 30.11 | 1 | SE/T | 1 | 1 | I | 3 | 3 | 2 | 1 | 1 | 1 | SE | 1 | [illegible] | 3 | 3 |
| | 37 | 30.10 | 30.10 | 1 | SE/T | 2 | 1 | S/T/I | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 37 | 30.14 | 30.14 | 1 | SE/S | 2 | 3 | S/I | 2 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 37 | 30.2 | 30.2 | 3 | S/SE/T | 3 | 3 | S/SE/T | 1 | 1 | 6 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 3 |
| | 37 | 30.7 | 30.7 | 1 | SE/T | 3 | 3 | S/T/I | 1 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 38 | 30.1 | 30.1 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 38 | 30.8 | 30.8 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 4 | S | 0 | 0 | 0 | 0 |
| | 39 | 30.17 | 30.17 | 7 | S/SE/T/I | 2 | 1 | T | 2 | 2 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 44 | 40.20 | 40.20 | 1 | S/SE | 3 | 6 | S/I | 2 | 4 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45 | 40.15 | 40.15 | 1 | S/SE | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 4 |
| | 45 | 40.17 | 40.17 | 2 | S/SE/T | 3 | 1 | S/T | 2 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45 | 40.2 | 40.2 | 2 | S/SE/T | 3 | 2 | S, T/I | 1 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45 | 40.5 | 40.5 | 1 | SE/T | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 47 | 40.12 | 40.12 | 2 | S/SE/T | 3 | 1 | S/T | 1 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 48 | 40.1 | 40.1 | 3 | S/SE/T | 4 | 3 | S | 1 | 3 | 3 | 0 | 0 | 0 | 0 | 1 | [illegible] | 4 | 5 |
| | 48 | 40.8 | 40.8 | 1 | S/T | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | S | 0 | SE, I | 2 | 4 |
| | 49 | 40.13 | 40.13 | 1 | S/SE | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 4 |
| | 49 | 40.3 | 40.3 | 2 | S/SE/T | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 49 | 40.9 | 40.9 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 50 | 50.4 | 50.4 | 1 | S/SE | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 4 |
| | 51 | 50.17 | 50.17 | 2 | S/SE/T/I | 4 | 1 | S/T/I | 1 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 51 | 50.7 | 50.7 | 1 | SE/T | 1 | 10 | S/T/I | 1 | 4 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 52 | 50.11 | 50.11 | 1 | S/SE | 4 | 1 | S/T | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 53 | 50.1 | 50.1 | 1 | SE/T | 2 | 2 | S/T/I | 1 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 53 | 50.6 | 50.6 | 2 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 53 | 50.9 | 50.9 | 3 | S/SE/T/I | 5 | 2 | S/T/I | 2 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 55 | 50.15 | 50.15 | 1 | S/SE/I | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 55 | 50.16 | 50.16 | 1 | S/SE | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 4 | 5 |
| | 56 | 50.10 | 50.10 | 2 | S/SE/T | 3 | 3 | S/T | 2 | 3 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 4 |
| | 56 | 50.14 | 50.14 | 2 | S/SE/T | 3 | 3 | 0 | 2 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 57 | 50.20 | 50.20 | 2 | S/SE/T | 4 | 1 | S/T | 2 | 4 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 5 |
| | 57 | 50.8 | 50.8 | 7 | S/SE/T | 4 | 6 | S/SE/T | 1 | 4 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 58 | 50.19 | 50.19 | 1 | S/SE/T | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 4 |
| 60 | 60 | 60.16 | 60.16 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 2 | 4 |
| | 60 | 60.7 | 60.7 | 3 | S/SE/T | 3 | 3 | S/T | 1 | 4 | 6 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 5 |
| | 62 | 60.2 | 60.2 | 2 | S/SE/T | 3 | 1 | S/SE | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 5 |
| | 62 | 60.9 | 60.9 | 1 | S/SE/T | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | SE | 1 | 0 | 2 | 5 |
| | 63 | 60.12 | 60.12 | 2 | S/SE/I | 3 | 1 | S/I | 2 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 63 | 60.15 | 60.15 | 3 | S/SE | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 4 | 5 |
| | 63 | 60.4 | 60.4 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 64 | 60.13 | 60.13 | 1 | S/SE | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 64 | 60.19 | 60.19 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 65 | 60.5 | 60.5 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 66 | 60.11 | 60.11 | 1 | S/SE/T | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 6 | SE | 0 | 0 | 0 | 0 |
| | 66 | 60.17 | 60.17 | 1 | SE/T | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 5 |
| | 68 | 60.20 | 60.20 | 1 | SE/T | 1 | 2 | S/I | 2 | 4 | 3 | 1 | 1 | 4 | SE | 0 | 0 | 0 | 0 |
| | 69 | 60.18 | 60.18 | 2 | S/SE/T | 3 | 1 | S/SE/T | 1 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 69 | 60.3 | 60.3 | 1 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 5 |
| 70 | 70 | 70.17 | 70.17 | 1 | S/SE | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 2 | 4 |
| | 70 | 70.18 | 70.18 | 1 | S/SE | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | SE | 1 | [illegible] | 3 | 6 |
| | 70 | 70.20 | 70.20 | 1 | SE/T | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 2 | 3 |
| | 71 | 70.14 | 70.14 | 1 | S/SE | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 5 |
| | 73 | 70.6 | 70.6 | 1 | S/SE/T | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 4 | 5 |
| | 74 | 70.1 | 70.1 | 1 | S/SE | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 74 | 70.2 | 70.2 | 1 | S/SE | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 5 | SE | 1 | [illegible] | 4 | 6 |
| | 76 | 70.15 | 70.15 | 2 | S/SE/T | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | [illegible] | 4 | 7 |
| | 76 | 70.16 | 70.16 | 1 | S/SE | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 2 | 4 |
| | 76 | 70.3 | 70.3 | 1 | S/SE/T | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | SE | 1 | [illegible] | 2 | 4 |
| | 77 | 70.12 | 70.12 | 4 | S/SE/T | 3 | 2 | S/T | 1 | 3 | 6 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 5 |
| | 77 | 70.19 | 70.18 | 1 | S/SE | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | SE | 1 | [illegible] | 2 | 5 |
| | 77 | 70.5 | 70.5 | 1 | S/SE/T | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | [illegible] | 3 | 6 |
| | 77 | 70.8 | 70.8 | 1 | S/SE | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 6 | S | 1 | [illegible] | 2 | 4 |
| | 78 | 70.13 | 70.13 | 1 | S/SE | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | [illegible] | 2 | 4 |

Table 6 - table listing permeability aspects: rings, sequences and bushes

The table generated this way makes it possible to construct several combinations of aspects results, in Cartesian graphs, as minimum and maximum depth of internal rings, the number of sequences and sectors involved in bushes, as shown in figure 4. These graphs delineate correlations in a clear way, that allows verification of, inclusive, the mutability of genotype aspects, as graphs were constructed for both sample and the two genotypes in this work. So, it appears simple to check that internal rings occur more by the end of the 20$^{th}$ century than before, both as to the whole sample and the genotypes, besides other data as to the frequency with which they occurred, which cases and genotypes that are deeper or shallower. It is also clear from the graphs in figure 3 that sequences are concentrated in the 1980s and 1990s, and that they occur more in genotype G than in D. And that bushes formations in the sample are almost exclusively related to intimate cells, and that they are more frequent in genotype G than in D.

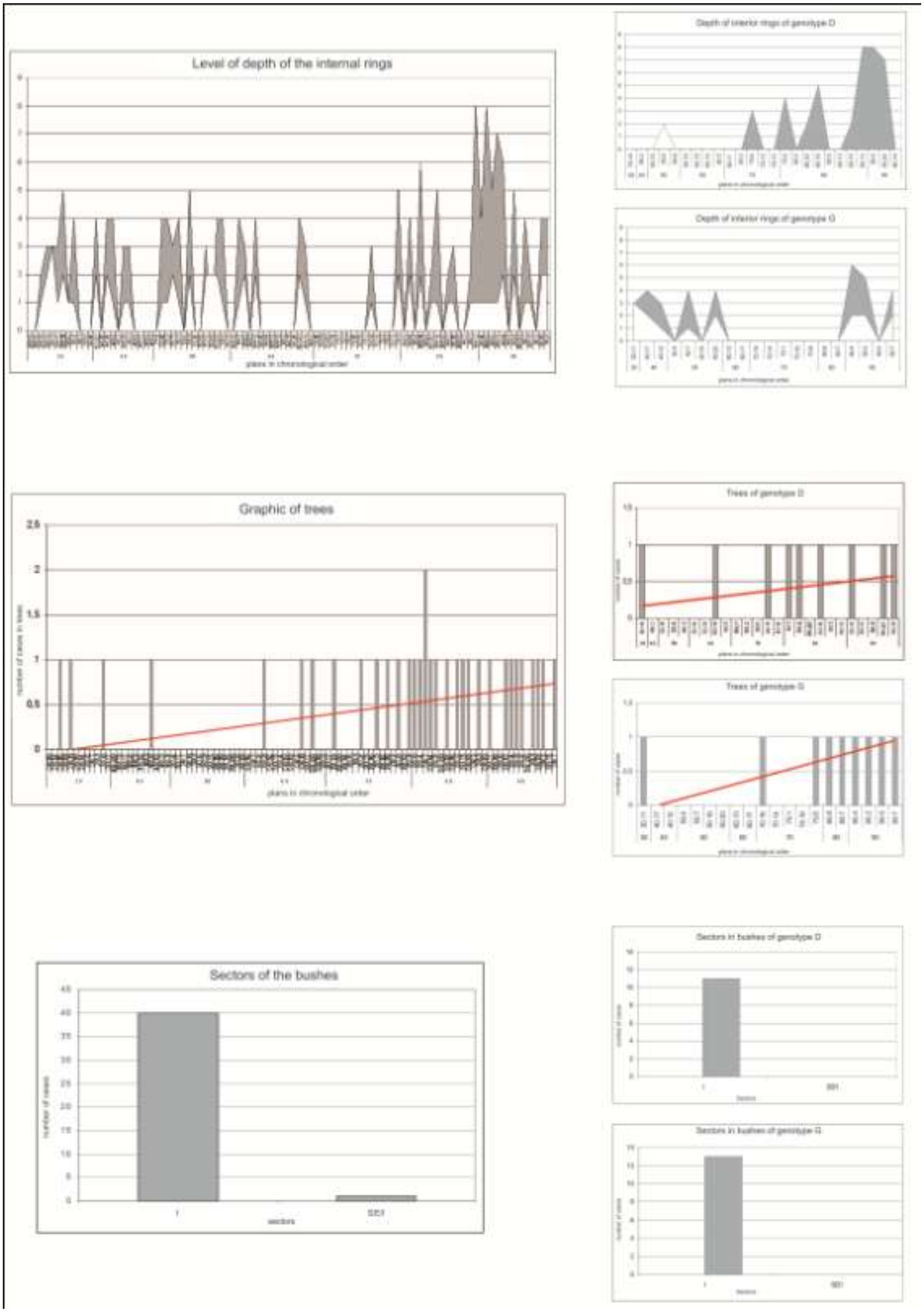



Figure 4 –some Cartesian graphs generated from this table

Descriptive tabulations were also constructed to investigate space-types, convexity, depth and geometric areas. The use of this method to analyze space-types aspects revealed diachronic transformations which could be hard to identify if the several numerical results were manipulated in another way with less visual representation. Using the descriptive tabulation logic the table list was generated with the most numerous aspects from space-types results, in two levels: general – with quantity of each space-type, total number of spaces, percentages of each space-type per system (see figure 5). And by sector of activity – with percentages of each space-type for key spaces, for each sector, per each decade.

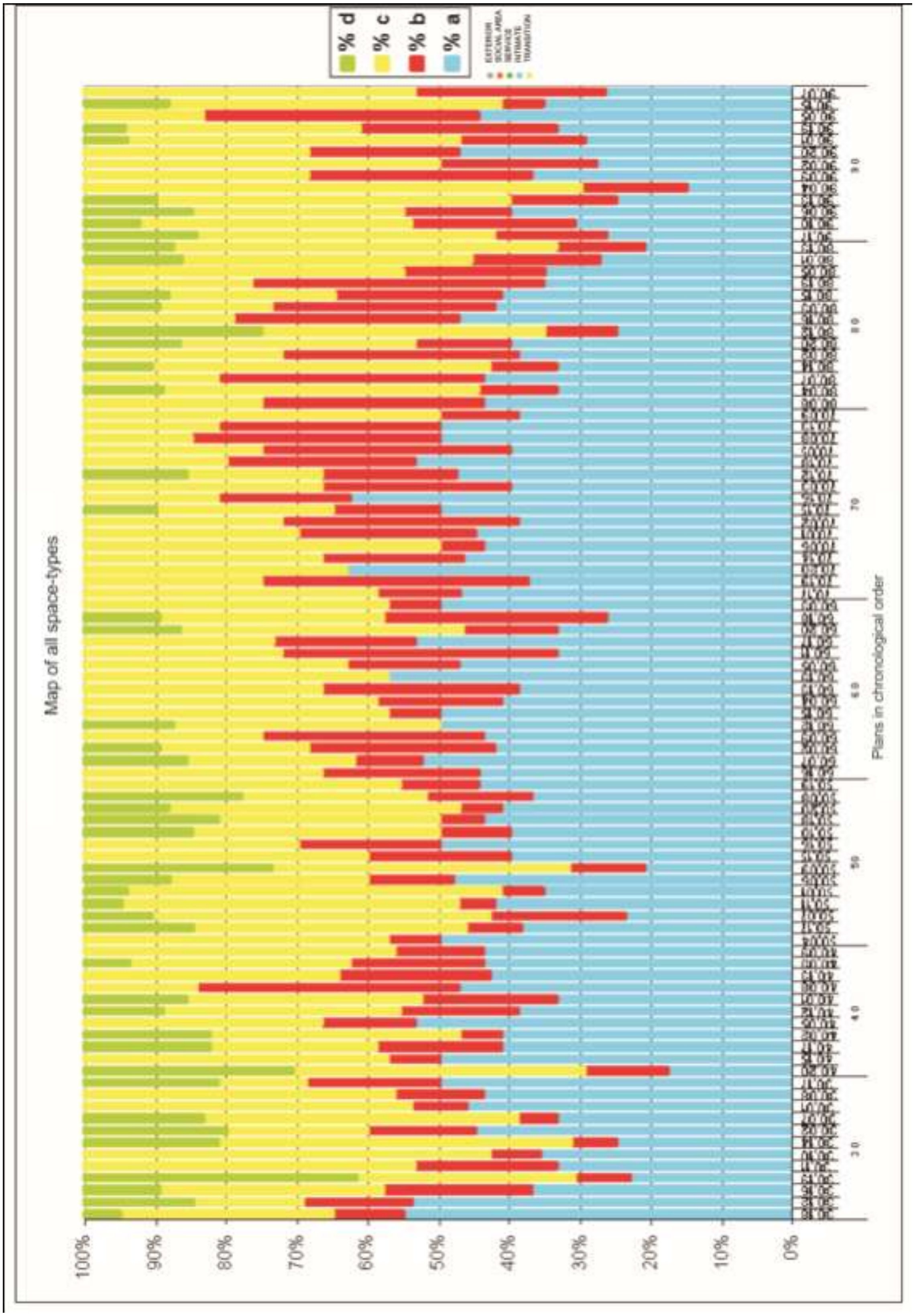



Figure 5 – Map of all space-types.

Graphs resulting from these procedures turn the numerical abstraction of systems in visible movements across time. An example is the clear identification of when and how en-suite bedrooms started to take part of the samples program, expressed by main bedrooms going down as space-type a while en-suite bathroom for the main bedroom goes up, as shown in figure 6. The indication that main bedrooms are less space-type is because it is leading to en-suite bathroom is confirmed in graph of space-type b, where they appear to grow in the same period of time, although this graph was not included in this paper.

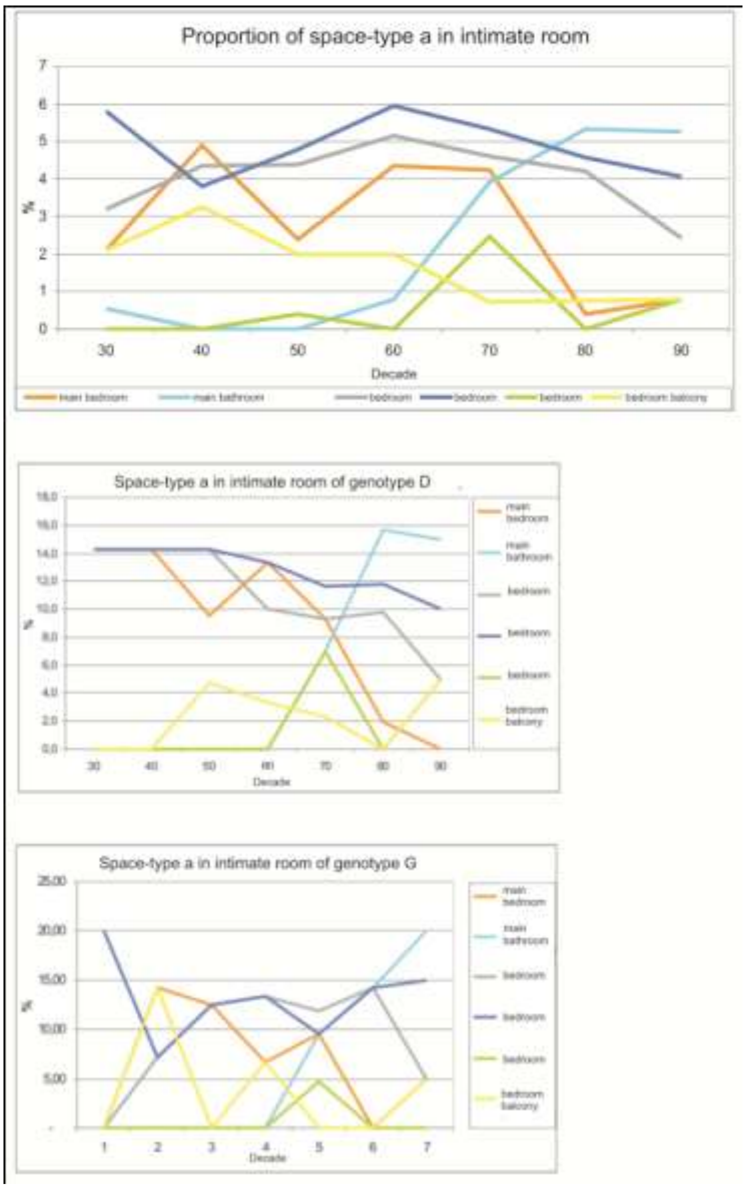



Figure 6 – Space-types of intimate room.

Another example, shown in figure 7, describes the tendency of maids' bedrooms to be leading to another space, to en-suite bathroom: so they turn to be space-type b instead of a, while maid's bathroom is the only space that grows as space-type a by the end of the century.

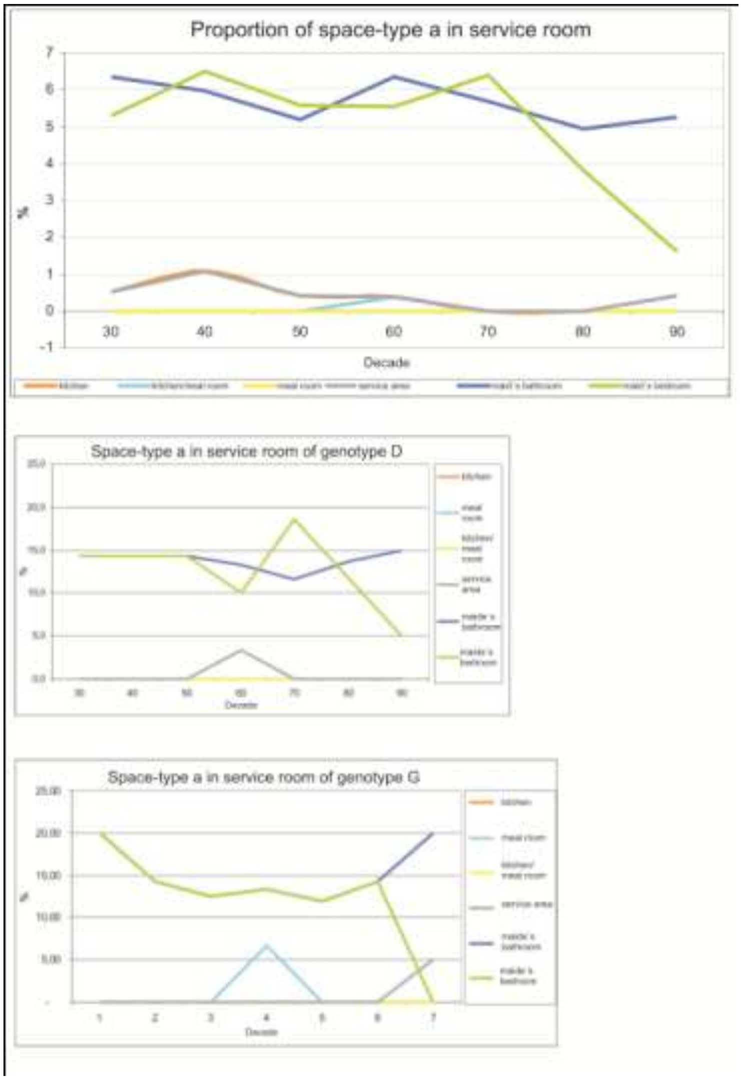



Figure 7 – Space-types of service room.

And in the study of dimensional areas the increase of sizes of apartments appeared to be related to growth of social verandas in the last decades, visually described by the tabulations, as seen in figure 8, in their different manifestations in the whole sample and in each genotype.

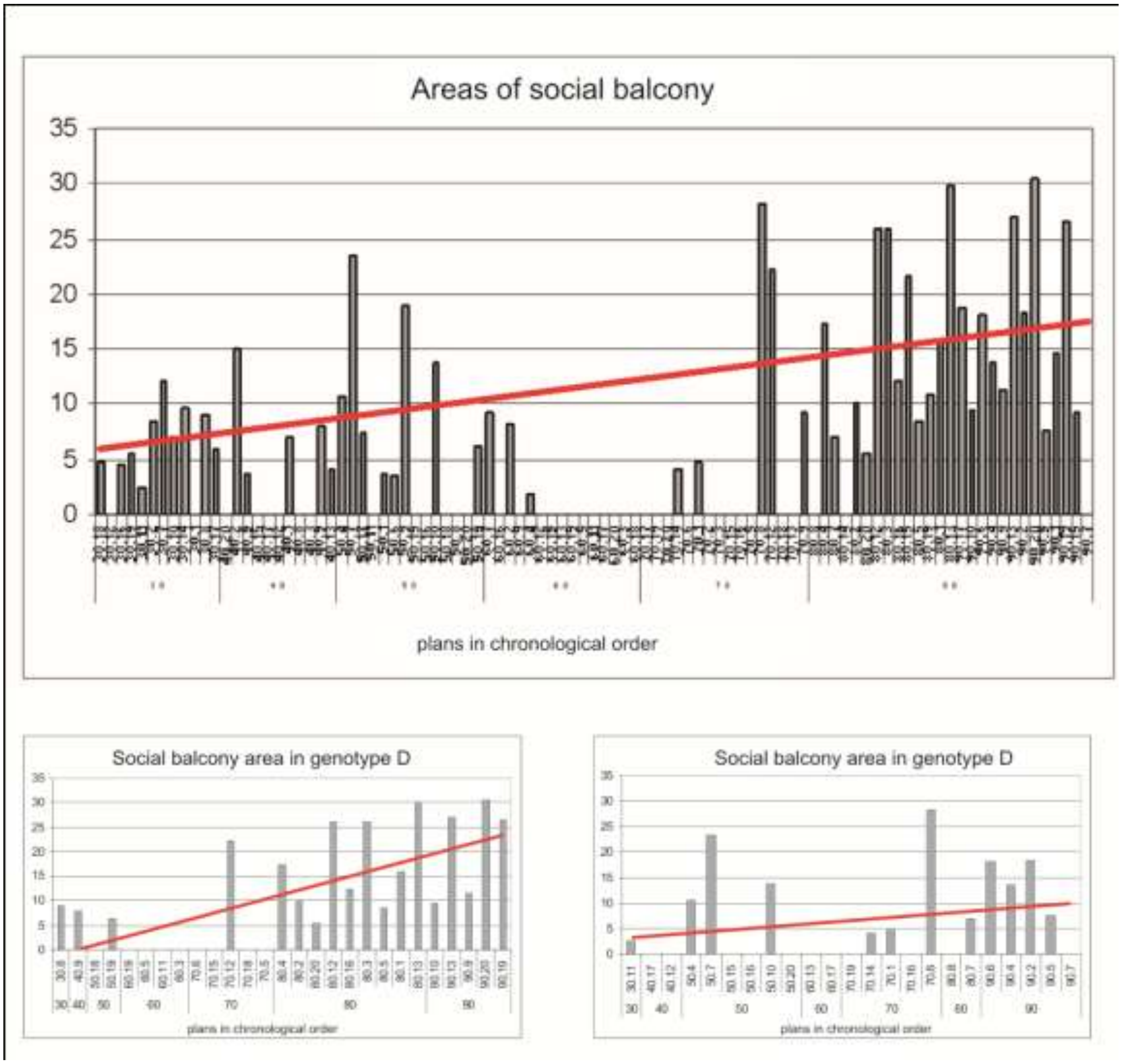



Figure 8 – Areas of social balcony.

**5. Analysis of results of descriptive tabulation and mutating genotypes**

Results from the investigation done with descriptive tabulation method, for diverse configuration and compositional aspects of spaces of the sample contributed to confirm characteristics of the mutating genotypes and to amplify the knowledge of spatial distinctions between these two structural patterns, bringing more detailing configuration and compositional information of them, which lead to the direction of association between these patterns and models of social group.

These results confirm changes in genotypes D and G for different periods of time. Genotype D goes to a fluidity tendency, through mobility and higher knowledge between spaces of the house. On the other hand, although Genotype G manifests some aspects of these characteristics by the end of 20th century, it stimulates much more situations structured by genotype D that have more external and internal rings, which reach at higher depth along the decades. The opposite happen to cases of genotype G.

What was verified is the growth of options of ways through the house in genotype D, interconnecting more circuits and users to more spaces, which can also lead to more interior areas to the systems, as time passes. While in genotype G what tended to increase was the control of people circulation through these rooms.
Nevertheless, the fluidity found in genotype D seems to not be extended to all rooms of the apartments. This genotype seeks to isolate service areas, organizing them in sequences across time, more frequently than in genotype G. And the intimate cells start also to be distributed more frequently as bushes accessed by corridors in genotype D, getting more distant from the rest of the house during the final decades of the century. In genotype G this characteristic occurred from the first decades, and intensified over time.

This way, intention of fluidity in genotype D happens while the houses also maintain, and even reinforce, spaces a part for the privacy of inhabitants, isolating their individual rooms and making the presence of servants discrete as time passes.
Other spatial resources utilized to guaranty either distance or interaction between contexts was the growth (or lack thereof) of distance between rooms of the house: in genotype D this manipulation of spaces led living rooms to situations closer to the street, des-ritualizing the transition between interior and exterior of habitations. It does not happen in genotype G, which keeps the intermediation and formality between these two universes, while living rooms come to shallower positions in the systems.
Kitchens tended to move closer to the service access to outside in both genotypes, turning, along with other service spaces, in almost a detached area of the apartments. Privacy is also reinforced by the crescent depth of connection of bedrooms. Again this strategy happens more in genotype D than in G. So, individual worlds of intimate rooms are kept apart while areas usually accessed by non-inhabitants – visitors and maids – become more connected among each others and with exterior in D, while them are kept separated in G.
These results were also identified in data found from the space-types analysis, in which positions related to control – types a and b – appear more related to genotype G than to D. On the other hand, both genotypes, in relation to space-types positions, tend to let positions that stimulate movement to happen more. Once more, these positions in genotype D articulate the promotion of knowledge and interaction for apartment spaces and categories, decreasing control relations, while in G space-types guarantee and expand surveillance conditions.
In relation to compositional analysis, information generated seems to delineate genotypes aspects which were coherent to the data resulting from the investigation of spatial configurations: of structural codes that conserve hierarchical characteristics to genotype G and others that signalize to opposite direction, of more fluidity for genotype D. Apartments from genotype G tended to keep their convexity and dimensional areas almost without alterations. Their social sectors neither grew significantly nor were many verandas added by the end of the century. And bedrooms in G did not suffer much convex elaboration in their spaces. On the other hand, these relations were explored in genotype D, which had bigger living areas with large verandas and cases of inhabitant bedrooms quite articulated convexly.

## 6. Last speculations

Based on a structure of control, with hierarchical differences inscribed in its spaces, genotype G seems to relate to the traditional model of family described by Bruschini (1990) as “hierarchical, asymmetric, ritualized”. These results appear as coherent to the fact of social area to be rather concentrated in the living room, where this genotype is centered in terms of integration, instead of privileging the generation of distinct rooms in this zone – as lavatories for social zone and veranda. On the other hand, in apartments from genotype D seem to be dissolving controlling relations through fluidity and centrality in circulations, what remind new possibilities of familiar organization that Young and Willmot (1973), cited by Bruschini (1990), define as going to the direction of “a ‘symmetric’ structure, with predominance of a equanimity distribution of conjugal papers”, characteristics which appear compatible to social rooms of larger dimensions and less divided convexly, besides other aspects found.

It seems, so, that the possibility to verify mutability for the genotypes allowed this research to reach at rich knowledge about the two orders that structure spaces from most apartment of the sample. This elaborated data can be related to the understanding of more complex social expressions embedded in spaces, and would, probably, not have been accessed if genotype characteristics were considered just as stable aspects along the whole period of time studied.

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