

Daylight at home: differences between developers and architectural competition houses

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ABSTRACT: The research studies the day-lighting and sun-lighting of the living space of six models of houses design by architects and developers. These models were the result of a typological study of two groups of affordable medium-sized detached houses located in northwest France (225 real-estate development houses and 78 architectural competition houses with no specific client). The results show that all the models allow a satisfactory to very satisfactory level of daylight and sunlight. The differences appear in the way that the light is distributed, while the developers houses present smaller openings with several orientations resulting in a longer day-lighting autonomy, architectural competition houses offer a more heterogeneous disposition of openings with a predominance of the big mono-oriented opening that creates harsh contrasts and glare.

Keywords: daylight, domestic architecture

1. INTRODUCTION

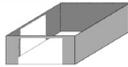
In France, more than half of the households live in a single-family house. This type of residence represents the ideal for a vast majority of the population in part because it is seen as conveying the most comfort. Recent studies [1, 2, 3] show that basic comfort (bathroom, toilet and central heating) is taken for granted and that the conception of comfort has evolved in order to include other notions as privacy, day-lighting and noise. This conception can be encompassed by the notion of ambient-environment that includes the built environment, the physical phenomena and the way they are perceived. The production of houses has embraced the evolution of the notion of comfort and even uses it in there sales pitch, specially the references to natural lighting. But how well does residential architecture respond to these new demands? The production of houses in France is mainly in the hands of real-estate developers; only 5% are built directly by an architect. Many reasons can explain this phenomenon. First of all, the law requires the signature of an architect only for constructions over 170 m² (1700 ft²) and the mean size of a house is of 110 m². The other reasons have to do with the architect/client relationship as well as with the image of the house. In order to go beyond the issue of domestic “aesthetics”, we suggest the possibility of analysing the day-lighting qualities of houses as a means to distinguish the production of architects and real-estate contractors.

2. THE SAMPLE OF LIVING SPACES

Our research studies specifically the day-lighting and sun-lighting of six models of living spaces of houses, three design by architects and three by real-estate developers (Table 1).

The 6 models are the result of a typological study of the living space of real-estate development and architectural competition houses [4]. 303 houses were analysed. 225 houses were part of a real-estate development north of Nantes, France, that did not impose a specific builder and includes houses designed by architects, catalogue houses and self-construction. The other 78 houses were projects presented to 2 architectural competitions for houses under 100.000 €. The whole sample was studied according to the size and disposition of the openings, orientation of the space and relation with the street and the garden.

Table 1: Characteristics of the cases of living space (dimensions in meters).

	Room Shape	Room Size	Openings (height x width)			
			South	West	North	East
Real-estate dev.	1  South	7,1 x 6	2,2 x 2,6	1,2 x 1,8	1,2 x 2,2	
	2  South	6,2 x 6	1,2 x 1,8	2,2 x 2		2,2 x 1,5
	3  South	6,6 x 6	2,2 x 1,8	1,2 x 2,8	2,2 x 1,9	
Architectural competition	4  South	5,5 x 5,9	2,2 x 3,8	2,2 x 2,5		
	5  South	5 x 6	2,8 x 5			
	6  South	4,9 x 5,5	2,2 x 4,1	2,2 x 2,9		1,2 x 2,4

The three most important dispositions for each type of house were chosen for this study. The real-estate development houses present three openings with at least one towards the south (figure 1). Case N°1 presents a picture window towards the garden with smaller openings west and north. Case N°2 is orientated east/west with the biggest opening towards the garden at the west. Case N°3 is similar to the first but with the picture window towards the north were the garden is.



Figure 1: Example of a living space of a real-estate developer house.

The architectural competition houses present three distinct cases (figure 2). Case N°4 consists of a space with two openings in an angle, one of which is a picture window orientated towards the south garden. Case N°5 has only one very large opening orientated south towards the garden. Case N°6 resembles the disposition of the real-estate development houses but with much larger openings. It presents two big picture windows orientated south (garden) and west, with a smaller opening towards the east.

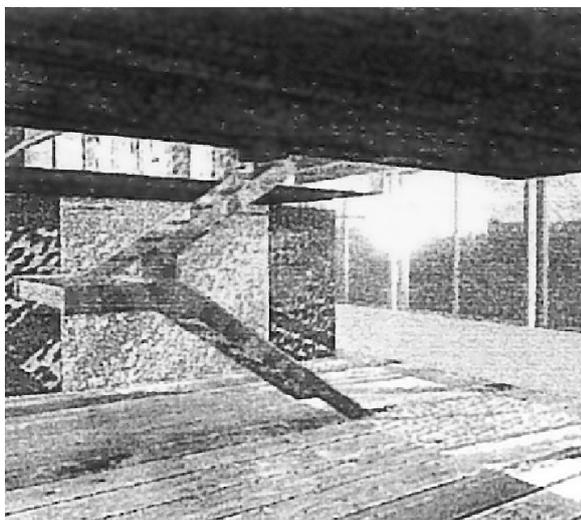


Figure 2: Example of design of a living space of an architectural competition house.

3. METHODOLOGY

The study of the six models of living space consists in the analysis of day-light factors, lighting autonomy, sun-lighting and solar loads. The study is done in order to find elements that will allow the comparison between cases.

Daylight factors were calculated using the Dial-Europe program [5] which allows the estimation of the direct components of the day-light factors as well as to calculate the reflected components and the solar autonomy. The sun-lighting evaluation was done using qualitative analysis of the solar spot dynamics calculated for summer and winter using the software developed in our laboratory.

4. DAY-LIGHTING EVALUATION

The results of our simulations show that for all of the models the conditions of natural lighting are satisfactory, even in some cases very satisfactory (Figure 3). In the first five cases, we found high levels of solar autonomy since the disposition and size of the openings assure from 61% to 72% of autonomy at 300 lux. The sixth case allows a higher autonomy because it assures 85% at 300 lux and even guaranties 76% at 500 lux.

The living space of the real-estate houses cases N°1, 2 and 3 present three openings with three orientations of which at least one is a standard picture window (2,2 m x 2 m). This distribution produces well-lit zones on three sides of the space leaving only the centre of the blind wall with low levels. Even if the contrasts are not mastered, these cases present a sunlight pattern that spreads during the day.

The architectural competition houses N°4 and 5 present less openings but larger in size than those of the real-estate development. These two cases present a very well-lit zone that contrasts with the area towards the blind walls. Since the source of light is reduced to one or two walls, the variations of lighting during the day are less important than in the cases with three orientations. This contrast in lighting can create discomfort.

Case N°6, that has an openness index (I_o) of 86% and presents three big picture windows with three orientations, allow light to penetrate even the farthest areas which allow a better control of the contrast between zones.

5. SUN-LIGHTING EVALUATION

At first glance (Figure 4) the difference in sun-lighting between the real-estate and the architectural competition houses is evident. Due to the much larger glassed area, the living spaces of architectural competition houses present more sunlight both in summer and winter than the real-estate houses. Furthermore, simulations show that the solar loads of the architectural competition houses can be up too three times higher then those of the real-estate houses.

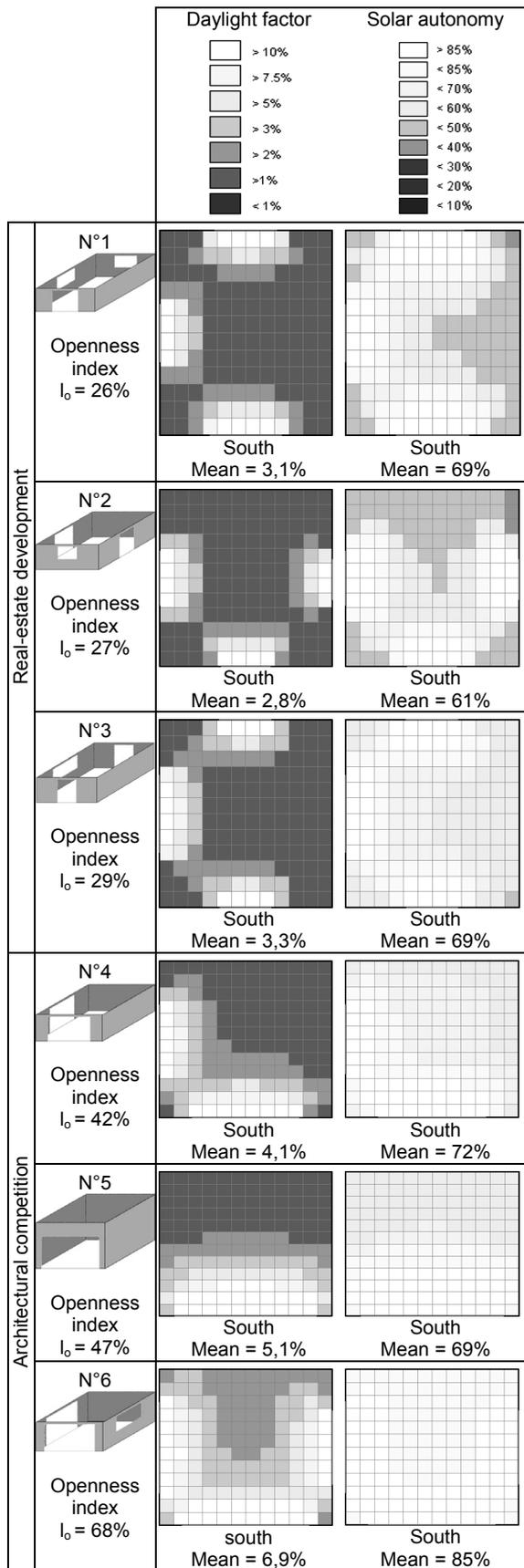


Figure 3: Daylight factors and solar autonomy of the 6 cases of residential living space.

Two other results must be pointed out. First, the configuration of the living spaces of the real-estate houses seem to present a better control of contrast (glare effect) and of summer overheating. The three cases of real-estate houses allow a lower penetration of the sun during the summer and the possibility of transversal ventilation that mean a lesser risk of overheating. In the three cases of architectural houses, the abundance of sunlight produced by large openings towards the south and/or the west, induce very high risks of overheating. This can be more important in the cases N°4 and 5 that do not allow transversal ventilation.

The second consideration is that the configurations of the real-estate houses produce a dynamic sun-lighting pattern, with a large variety of shadow effects: a thin beam that sweeps the room, the west window that produces a spot of sunlight that moves in the middle of the room and the opening at the north that invites the sun early in the morning and late afternoon during the summer. This dynamic is extreme in the case N°2 where east and west openings sweep the room during the day with a wide diversity of angles. On the other hand, the pattern of sun-lighting of the architectural competition seem more "saturated", less dynamic and more regular.

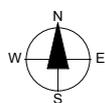
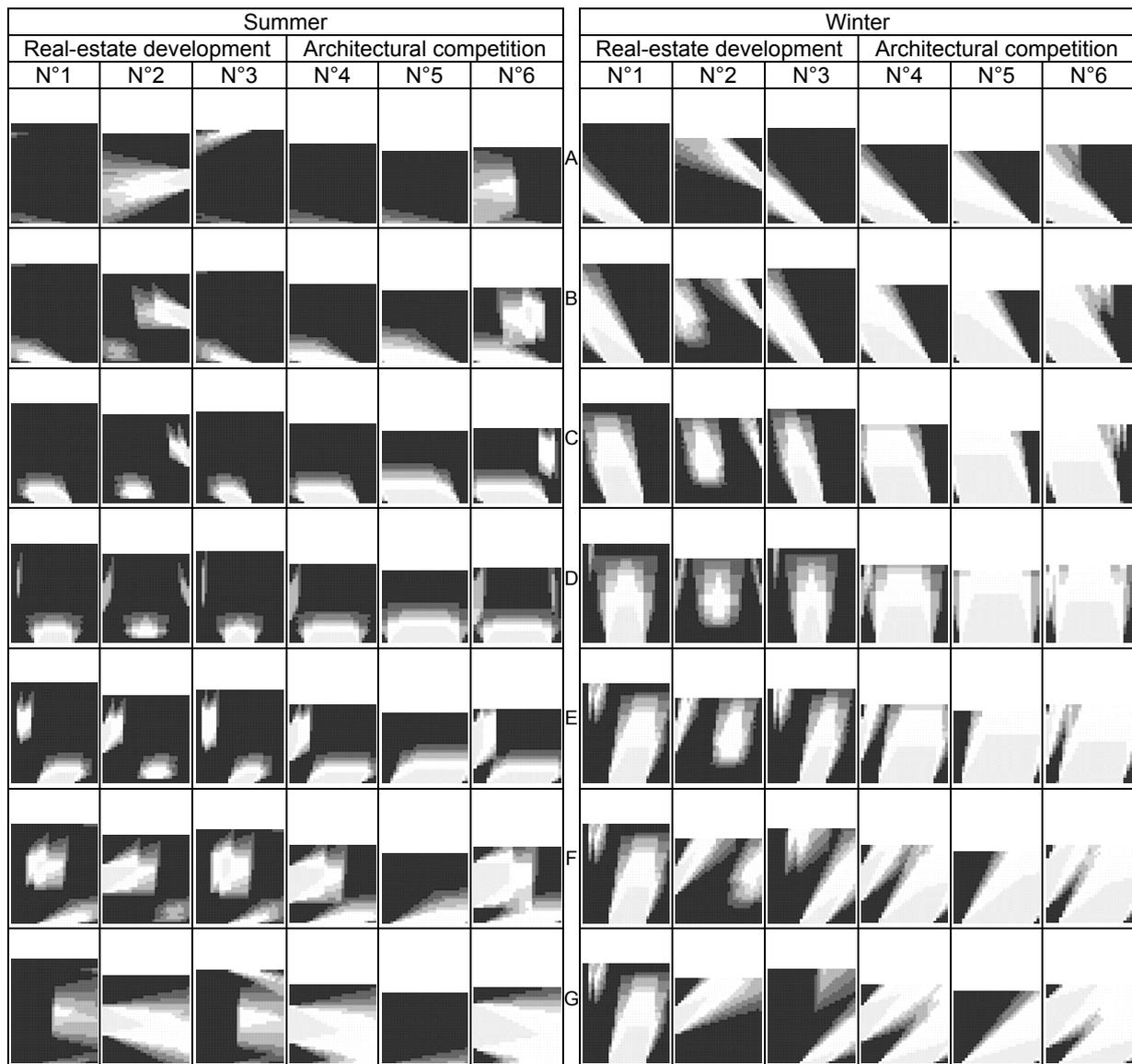
6. DISCUSSION OF RESULTS

The six cases that we studied propose satisfying to very satisfying conditions of sun-lighting. The disposition and size of the openings assure good conditions of natural lighting with no differences between the real-estate houses and the architectural competition houses

The comparative study of the two groups shows a marked difference between the amounts of glassed surfaces. The openness index of the architectural competition houses is almost twice that of the real-estate houses. Another difference between the groups is disposition of the openings. The real-estate houses present windows disposed towards three orientations while the architectural competition houses have a much more varied set of dispositions that go from mono-oriented to three orientations.

The real-estate houses present three orientations with at least one big picture window. This disposition allows more sun-lighting autonomy without necessarily having bigger openings. These openings offer a good natural lighting but leave darker areas. Nevertheless, the size of the standard windows can reduce the cold-wall effect.

All the cases present a risk of overheating during the summer. The configuration with north-south openings and a window towards the west (N°1 and 3) present little variation between the summer and the winter solar loads. Case N°2, which disposes two picture windows on an axe east/west and a smaller opening towards the south, presents a large variation between the solar loads for each season. During the summer, the solar loads are twice as high as those during the winter. These can mean a high risk of overheating in summer without the advantage of solar heating in winter.



- A: Beginning of the morning
- B: Middle of the morning
- C: End of the morning
- D: Middle of the day
- E: Beginning of the afternoon
- F: Middle of the afternoon
- G: End of the afternoon

Figure 4: Dynamics of solar spot in the six cases of domestic living spaces, for typical periods of day in summer and winter

The configurations of the architectural competition houses are much more diverse and have bigger openings than the real-estate houses. The openness index is almost two times higher than that of the real-estate houses but that does not assure a better sun-lighting autonomy. It is only in case N°6 that the big glassed surfaces allow a considerable gain in sun-lighting autonomy. The contrast between well-lit shadowed areas that we find in the other models produces a glare effect that is minimized in case N°6.

But this extremely well lit case that can accommodate activities that require good lighting is ill suited to handle other activities that demand less light as watching television or working on a computer.

Configuration N°5 (one big glassed wall towards the south) presents a good compromise between the contributions of the solar loads to the heating during the winter with less possibility of overheating during the summer, but the glare effect is much more pronounced since there is only one source of sunlight.

The big glassed surface can also cause a cold wall effect during the winter.

It is possible to consider case N°6 as the ideal because it presents a very good level of natural light, a great sun-lighting autonomy and few shadowed areas which diminish the glare effect. But a high and uniform sun-lighting are not necessarily the researched characteristics of the living space of a single-family house.

It is important to say that with the increase of sun-lighting come problems of privacy, overheating during the summer and of heat-loss during the winter. Certain dispositions proposed by architects in their architectural competition entry's seem to not take these elements into consideration and design living spaces that, even though well-lit, need a series of additional devices in order to control user privacy as well as high solar loads during the summer. On the other hand, the real-estate houses that present more openings but that are smaller are less exposed. This translates into more privacy, less heat-loss during the winter and a better control of summer overheating.

Based on these results it would be possible to say that real-estate houses have a better control of natural lighting factors. But this conclusion is too general and needs to be discussed and elaborated.

These research results do not allow us to establish if real-estate contractors and architects consciously master natural lighting or if the luminous ambient-environments are the product of other considerations and experiences or the result of routine. It is necessary to take into consideration that the analysis that we have done is based on general and expert recommendations of what is considered good lighting. Since most of houses that were studied are the result of the desires of a specific client with specific needs that influence the final design. It is therefore difficult to establish if the natural lighting of the living space is the result of the skills of the designer or the desires of the client.

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