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Developing a modelling factor index for transition spaces: a case study approach

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Transitional spaces (TS) are characterized by possession of high gradients of luminances between inside and out, which places a great demand on the users' visual system's function. A satisfactory descriptive indicator of this kind of situation could be a 'modelling factor' (MF), defined from cylindrical illuminance and horizontal illuminance measures. It would provide information on the depth and dimensionality of objects present in the scene, also taking into account a region's overabundance of daylight. A public building was selected as a case study, and solar light behaviour, including its interaction with the space, was monitored. Measurements were taken during an entire year at the start of each season (2008) under clear skies, at the beginning and at the end of each working day. Another measurement was taken in winter (2009) under overcast skies at 13:00, so as to obtain a comparative parameter. It was found that unfavourable conditions were produced in all seasons for about 2 hours, except at 09:15 in winter. All the data collected in the control situation were within the optimum modelling range, with values ranging between 0.3 and 0.4. The MF allows the integration of most relevant factors intervening in TS and emerges as a good descriptor for TS.

Keywords: Daylight impact; light modelling; transitional space; visual adaptation

INTRODUCTION

Transitional spaces (TS) are largely studied and classified according to their thermal behaviour. These studies analyze aspects such as the main façade position, access to direct radiation, seasonal shadows, etc. (Potvin, 2000; Chun *et al*., 2004; Pitts and Salen, 2007). Although there are studies on the spatial distribution of illuminance (Cuttle, 1997), the relationship between third dimension photometry and transitional spaces lighting conditioning are scarce. The term 'visual shock' (Araji, 2004) is used to describe the experience that occupants undergo when they encounter a sudden change in the field of light whose intensity is above or below the limit of the adaptability of the human eye adaptable. A deeper study of transitional spaces' users' visual needs would supplement the study of solar radiation impact on inner–outer TS. The study of optimum lighting conditions in TS would avoid the so-called 'lighting barriers', taking into consideration all negative effects (arising from a lighting design or from the visual environment) and lighting and visual elements that may complicate or difficult people's vision (Santillán and Colombo, 2003). These barriers occur when the time involved does not correlate with the adaptation time required by the user's visual system. Other works present advances concerning 'visual comfort' assessment in this kind of TS, but they do so in terms of luminances obtained from the conversion of illuminances (Araji *et al*., 2007); this imposes certain limitations, since it is only valid if the assessed areas are lambertians and if their reflectances are known (Rombauts, 2001).

The scope of Argentinian current regulations (IRAM-AADL, 1972, 1973) establishes value E_h (horizontal illuminance, lx) of artificial lighting service at different kinds of premises, given their use and the difficulty of the visual task to be carried out. Within this classification, a transitional space is framed according to the kind of visual task in: 'occasional vision only' (E_h min 100lx); and according to the kind of building, premises and the visual task, TS are classified to belong to the category 'entrance hall' (E_h min 300lx). This regulation does not take into consideration the fact that certain kinds of TS receive natural light most of the day and that light, due to its very high potential to illuminate, renders the presence of artificial light imperceptible in inner zones. In relation to daylight control, national

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regulations (IRAM-AADL, 1969, 1974, 1976) only make general descriptive references as regards inner and outer control elements. On the other hand, levels recommended by the law mainly use the E_h parameter, which has the fundamental limitation of not taking into consideration the material complexity of the built environment that is to say the interaction between light and optical properties of the materials.

Similarly, the use of horizontal illuminance (E_h) and vertical illuminance (E_v) as sole parameters leads one to neglect the power that lighting possesses in the modelling of the space (Rombauts, 2001). Lastly, and of greater importance to this work, neither are requirements in relation to the gradation of luminance conditions included, nor is the description of the kind of visual tasks required in these cases (signage, face identification, etc.) provided. In this way, visual processes of transient adaptation, especially when taking into account the dynamic range involved in the space, are very high because the outer lighting conditions possess values that are 10^5 as high as those corresponding to the inner conditions.

THEORETICAL FRAMEWORK

Lighting conditioning of TS to optimize visual response

A *transitional space* is defined as an 'independent dynamic space that has various physical conditions and behaviour' (Chun *et al*., 2004). People use these kinds of spaces for only a short time, as opposed to the case of an office, where its occupants perform their activities for longer periods.

TS are characterized by the possession of high gradients as regards luminances. This imposes a great demand on the users' visual system's functions. The periods involved are not enough to allow the system stable adaptation, especially in regions with a high daylight supply that generates high luminances during daytime. Any sudden and drastic change in lighting, from light to dark and from dark to light, causes the visual system a momentary loss of its normal functioning, with the possibility of causing temporary blindness. In addition, proper changes of the visual system with age must be considered (Bouman and Sagawa, 1999). At around 40 years of age, presbyopia appears in people due to the lenses' lack of flexibility. In addition, close refractive compensation and the need for distance visual compensation also appears. In the decades that follow, decrease in sensitivity to contrast and to chromaticity appears, with an increase in intraocular diffusion with its consequent decrease in the retinal illuminance, and longer periods are required for the adaptation process. These two latter losses are those that need to be considered most in the case of TS.

In addition, if the space possesses a daylight supply, its daily and seasonal variability, its influence with respect to the position of the building in question and its usual hours of use must be considered. All these, can lead to possible situations of disability glare with the consequent visibility loss, due to a decrease in the retinal image contrast (Vos, 1984; Rea, 2000) or because of the scene's darkening. It can be seen that with ageing the effect of incomplete adaptation to luminance changes increases the difficulty to perform visual tasks properly in these kinds of spaces, such as obstacle detection and recognition (for instance, stairs), sign detection (for instance, location sign), the recognition of faces, facial expressions and body language, eye contact, position selection, reading an article or a data visualizing screen, identification of the reception desk, elevator location, bulletin-board reading, etc.

In this sense, the distances that the user of these spaces must cover, as well as the periods of time involved, are crucial in ensuring a good human performance in the built space, since, as mentioned before, lighting conditions can vary drastically when moving the outer part to the inner part of a building and vice versa. In adaptation processes, the visual system possesses three well-differentiated mechanisms in order to adjust to the wide range of luminances with which it can work under adaptation conditions. These values can be very high, such as those of sunlight over a white surface (approx. 10^5cd/m^2), or very low such as values of light on a cloudy night (approx. 10^{-6}cd/m^2).

According to what has been previously described, this work intends to identify those parameters that allow for more efficient diagnosis of TS lighting conditioning, considering the already-mentioned kinds of tasks to be performed in it. All this takes place while the visual system is adapts to dynamic lighting conditions such as high luminances present in the outer part of the building and low luminances present in its the inner part.

This work presents the hypothesis that a satisfactory descriptive indicator of these kinds of scenes could be a 'modelling factor' (MF), defined as the quotient between cylindrical illuminance (E_c) and E_h measures: $\mathrm{MF} = E_c/E_h$. It would provide information on the depth and dimensionality of objects present in the scene, since perceiving a three-dimensional object as it really is requires a combination of light and shadow (shading) necessary; this allows an appreciation of the space significance. Light distribution should be undertaken in a way that excessively heavy shadows (hard shadows) are not present, on the other hand, dim light (soft shadows) predominance is avoided, because in either of these cases perception is difficult (Wilde and Manzano, 1989; Cuttle, 1997; Rombauts, 2001). This indicator would facilitate assessment if space lighting conditions reproduce the environment adequately, so that people who go through it have an adequate obstacle detection and are able to read signage. As found in literature, a *modelling illuminance* between $0.3 < E_m > 0.5$ (Rombauts, 2001) will be considered to lie within optimal modelling ranges. Although this range has been determined, it is used to assess inner spaces, it is considered a valid parameter to assess TS since it integrates light behaviour by means of its interaction with materials of the built space.

METHODOLOGY

The case selected. Climatic characteristics in Mendoza

Given that climatic conditions of the region where a building is located determine the luminous resource availability, the city of Mendoza (Argentina) was selected as a case study for critical characteristics as regards the impact that its design and materiality can have on daytime lighting conditioning, taking into account the region's considerable daylight contribution.

The Mendoza province is located at 32°8 south latitude and 68°8 west longitude. It has semi-arid/dry weather and for 83% of the year the sky is predominantly sunny, either with a blue vault total or being partially clear with the sun's presence (Argentinean National Meteorological Service, period 1981–90). The annual average amount of sunlight is of 2850h, comparable to that of cities such as Santiago, Chile; Montevideo, Uruguay; Cape Town, South Africa; and Auckland, New Zealand(all belonging to the Southern Hemisphere), and El Paso, Texas, USA; Casablanca, Morocco; Tripoli, Libya; Cairo, Egypt; Baghdad, Iraq; Kuwait City, Kuwait; Islamabad, Pakistan; Shanghai, China(all from the Northern).

Data obtained at the Measurement Station of Daylighting from the Laboratory of Human Environment and Housing (LAHV-INCIHUSA of CCT CONICET Mendoza) (Pattini, 2007) have registered a maximum global horizontal illuminance of 112,500lx (global maximum average 102,469lx), with a dim horizontal illuminance of 68,500lx (dim maximum average 30,567lx) in summer. Maximum values in winter registered global horizontal illuminance values of 84,500lx (global maximum average 56,111lx), with a maximum dim horizontal illuminance of 62,000lx (dim maximum average 20,294lx). These conditions are representative of the geographical location of the Mendoza province and, particularly, of the luminous climate of dry zones where sunny clear skies are predominant.

In view of this climatic conditioning factor, with a high presence of sun throughout the year, Mendoza City has developed itself around a urban tree-lined layout under irrigation and is recognized as an oasis city model. This supply of urban vegetation shadow allows for the mitigation of dry weather harshness and, in particular, it controls solar radiation in summer (Corica and Pattini, 2009). In some cases, where access to a building is withdrawn back from the building line and is therefore devoid of the influence of arboreal shadows, or in winter where leaves fall off the trees, TS or circulation occurs without any control of direct solar radiation.

As for this study case, a public building was selected to be a typical TS since these kinds of buildings generally involve a floor project, with considerable distance between the municipal and building lines, as shown in Figure 1. This is because these buildings require wide access spaces for public circulation, unlike single-family buildings. Also, Mendoza has particular requirements as regards the distance from the municipal to building line because it is a seismic zone; these buildings do not have the direct solar light protection that is customary of the Mendoza city oasis, which is provided by the public tree-lined layout. The studied case is characterized by the possession of an east located façade, so that it receives sunlight directly throughout the morning so as to coincide with the hours of use of the building. The length of the TS is 27m and the time required to cover walking it is approximately 25s.

Figure 2 shows two situations in the TS where measurements were taken: the entrance (left photograph, point 5) and the exit (right photograph, point 7) of the building at 9:15 hours. In these, the height, the position of the solar disc (19.9° in winter) and the building façade can be observed, especially light access to the inner part of the building and its interaction with the materials used in its construction. In addition, sometimes there is the presence of reflections produced in the glass. Figure 3 shows measured points in the three zones identified in the TS: inner (left photograph points, 8; 9), double glazed door (DGD; middle photograph, points 7; 8; 9) and outer (right photograph).

In order to characterize TS lighting conditioning in its main hours of use, E_h and E_c in the entire route (27m) were measured. From the outside to the inside, every 3m in the inner and outer zones of TS and every 1m in the double-glazed door zone located in the entrance of the building, because it generated an annoying brightness at certain hours in the morning (depending on the angle of solar incidence). In this way, a sum of 12 measurements, spread throughout the transitional space studied, was obtained. The TS was divided into three zones: outer, points 1–5; (DGD, from points 6 to 8; and inner, points 9 to 12.

The measured lighting variables were: E_h at the floor level, measured with a LI-COR 189 radiometer, LI-210 SB photometric sensor and levelling base 2003S; E_c at 1.50m high (LMT PO 3637, Fez = 10). Also, a fisheye lens photographic survey (NIKON COOLPIX 5400 Photographic Camera with flash, fisheye lens NIKON FC-E9 brand) was performed. All measurements were performed under conditions of clear skies (sunny). Measurements were repeated at the beginning and the end of the main working day at two different times, chosen considering their solar incidence angle with regard to the building façade, at 9:15 hours and at 13:00 hours. In addition, a fourth measurement was taken under conditions of cloudy skies (overcast) at 13:00 hours, so as to obtain a comparative parameter. Measurements were taken for an entire year at the start of each season (year 2008), with the objective of observing sunlight's behaviour and its interaction with the transitional space and to ascertain the presence of potential 'lighting barriers'.

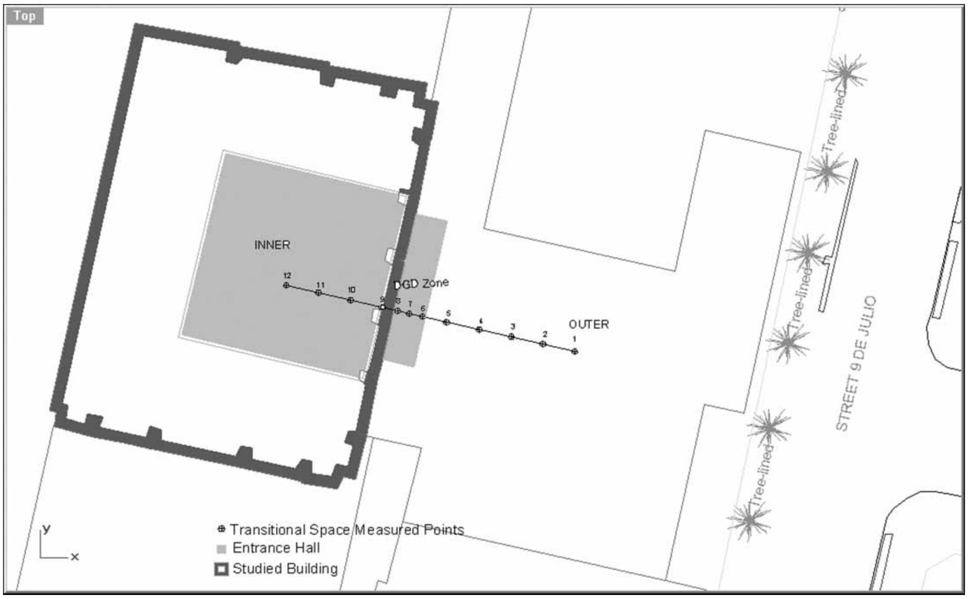

Figure 1 | Municipal building layout

RESULTS

The obtained values of E_h and E_c necessary to calculate the MF, as shown in Tables 1–4. As explained in the Methodology section, values were registered for an entire year at the start of each season (9:15 and 13:00 hours) in conditions of clear skies (completely clear). Likewise, a register of data measured at 13:00 hours under conditions of cloudy skies (overcast) is included to study the space light behaviour under different lighting conditions, where a uniform lighting distribution in the TS would be expected.

In Tables 1 and 2, maximum values of E_h lie between 82,000lx (summer 9:15 hours) and 130,630lx (summer 13:00 hours); minimum values lie between 105.4lx (summer 9:15 hours) and 37.6lx (winter 13:00 hours) under clear sky conditions. Note that the maximum values are obtained in the outer zone of the TS, between points 1 and 5 and that the greatest value differences are produced between points 6 and 8. The minimum values are obtained in the inner zone.

Tables 3 and 4 show the values of cylindrical illuminance (E_c) at 9:15 and 13:00 hours. The resulting registers have a behaviour similar to that of those obtained in Tables 1 and 2. The maximum values are produced in the outer zone of TS between points 1 and 5, values that vary between 18,700lx (summer 9:15 hours) and 130,340lx

Figure 2 | Transitional space were measurements were taken

Figure 3 | Measured points in the DGD zone

(summer 13:00 hours). The greater differences correspond to the double-glazed TS door, between points 6 and 8. The minimum values are obtained in the inner zone.

MF CALCULATION

With the E_h and E_c data the MF ($= E_\mathrm{c} / E_\mathrm{h}$) was calculated. Tables 5 and 6 show the values calculated across the four seasons (clear sky) and under the control condition (overcast).The bold text indicates points that lie out of the range of good modelling conditions: $0.3 < \mathrm{MF} > 0.5$, present in the TS studied.

A global analysis was carried out, taking into account the optimum modelling range, $0.3 < E_\mathrm{m} > 0.5$ (Rombauts, 2001). It was found that unfavourable conditions are produced at 13:00 hours (midday) in the four seasons, whereas at 9:15 hours the values fall into the optimum range only in winter, except for point 7 (it lies out of range). These value differences could be caused by shadows and reflections produced in the double glazed TS door. Other seasons, at 9:15 hours, also lie out of the range of good modelling conditions. The modelling conditions that are present at 9:15 hours lie within the acceptable range are because the sun is at its lower position (solar altitude in winter: 19.9°). This solar position favours solar access into the interior of the building, as shown in Figure 2. This does not occur at 13:00 hours, when the sun has reached its maximum height at this time of the year (solar altitude in winter: 33.53°). Consequently, it affects the building in a more perpendicular manner, producing a remarkable difference in the availability of solar light in the outer part of the building and that in the inner part. Whereas MF values higher than 0.6 indicate a prevalence of dim light (soft shadows, conditions produced in the TS inner zone), as shown in Tables 5 and 6, MF values lower than 0.3 indicate the presence of heavy shadows (too hard shadows, conditions produced in the TS outer zone). It is interesting to compare the values obtained on clear sky days at 13:00 hours with those of the control situation, obtained on overcast days at the same time. 100% of the data gathered lies within the optimum MF range, with values between 0.3 and 0.4, as shown in Figure 5 and Table 6.

Table 1 | Annual values of horizontal illuminance – E_h (lx) clear sky

Points		**2008 autumn**	**2008 winter**	**2008 spring**	**2008 summer**
		9:15 hours	**9:15 hours**	**9:15 hours**	**9:15 hours**
1	OUT	10,664	3475	54,350	**74,220**
2		30,180	3758	58,810	**78,390**
3		50,020	3969	59,920	**79,400**
4		49,090	4011	59,890	**80,900**
5		46,750	4002	61,140	**82,000**
6	DGD*	51,980	2286	62,690	**78,330**
7		49,760	**449.8**	63,640	**74,900**
8		37,220	684.6	29,760	**3120**
9	INN	**2180**	788.2	**602.1**	**1382**
10		**959.8**	298	285.3	820
11		**337.9**	178	185.2	233.4
12		160	140.5	115.3	**105.4**

Bolded text indicates points lying out of the range of good modelling conditions ($0.3 < \mathrm{MF} > 0.6$).
*DGD.

DISCUSSION AND CONCLUSIONS

The MF is a valuable TS assessment tool. It allows for the integration of the most relevant factors intervening in this kind of space, such as: *optical properties of the materials*

Table 2 | Annual values of horizontal illuminance – E_h (lx) clear sky and overcast

Points		2008 autumn 13.00 hours, clear	2008 winter 13.00 hours, clear	2008 spring 13.00 hours, clear	2008 summer 13.00 hours, clear	2009 winter 13.00 hours, overcast
1	OUT	**99,700**	64,580	**102,500**	**128,670**	29,100
2		**100,230**	64,880	**102,680**	**130,470**	29,320
3		**101,020**	65,300	**102,610**	**130,630**	27,790
4		**110,750**	63,350	**100,900**	130,030	27,250
5		**99,350**	63,480*	**100,700**	**130,340**	28,420
6	DGD*	**97,950**	**45,110**	**105,800**	6766	27,570
7		**4292**	**881.4**	**2915**	**2586**	4538
8		2565	**368.6**	720	900	852
9	INN	**568**	159.1	**173**	**411**	402
10		**206**	**110.5**	**100**	**209**	215
11		**124**	**51.8**	**82**	**98**	281
12		**72**	**37.6**	**55**	**59**	111

Bolded text indicates points out of range of good modelling conditions ($0.3 < \mathrm{MF} > 0.6$).
*DGD.

that the space is composed of, because the material reflectance directly affects illuminance measurements; *geographical location* and *building orientation* (time and solar angle); *distance and the time spent to cover this space*; *influence of the built environment* (sky view factor and building factor); *hours during which the building is used*; and the *predominant sky type*. On the other hand, the MF also takes into consideration the characteristics of the human visual system, given that it imposes a certain range within which lighting conditions allow for a correct appraisal of the space and object modelling present in it. Although the visual system can adapt to a very wide range of luminances, in the presence of changes, it requires time during which that adaptation takes place. This adaptation process may take several minutes, depending on the initial and final luminance levels. In the case of TS, the disabling factor is exactly the presence of sudden changes in lighting, produced at relatively short time periods, particularly with regard to the case studied. The estimated time to cover the TS involved is approximately 25s, which is a relatively short time period to deal with such changes.

Table 3 | Annual values of cylindrical illuminance – E_c (lx) clear sky

Points		2008 autumn 9:15 hours	2008 winter 9:15 hours	2008 spring 9:15 hours	2008 summer 9:15 hours
1	OUT	2700	1200	15,701	**17,300**
2		15,700	1300	16,750	**18,200**
3		16,500	1300	16,990	**18,700**
4		17,000	1400	17,270	**18,700**
5		17,200	1400	17,400	**17,800**
6	DGD*	16,800	1000	16,510	**16,600**
7		16,100	**323**	14,610	**4100**
8		8800	370	1190	**2415**
9	OUT	**1540**	370	**392**	**1116**
10		**700**	142	170	369
11		**300**	74	110	137
12		100	52	73	**76**

Bolded text indicates points that are out of the range of good modelling conditions ($0.3 < \mathrm{MF} > 0.6$).
*DGD.

In this case study an important factor to take into account from the analysis of results is the that of the optical properties of materials that constitute the TS. The zone in the TS where the DGD is placed could be considered to be the interference zone. At this zone, reflections caused by optical properties of the predominant material (glass) are produced, as shown in point 7 (9:15 hours, winter) and point 8 (9:15 hours, autumn) from Figure 4, where a particular behaviour in the obtained values can be observed. From analysis and comparison of graphs obtained with the MF at 13:00 hours, it can be observed that the graph obtained on an overcast day in winter lies within the optimum modelling range (natural) (Figure 5). As a result, it can be inferred that this

Table 4 | Annual values of cylindrical illuminance – E_c (lx) clear sky and overcast

Points		2008 autumn 13.00 hours, clear	2008 winter 13.00 hours, clear	2008 spring 13.00 hours, clear	2008 summer 13.00 hours. clear	2009 winter 13.00 hours, overcast
1	INN	**99,700**	64,580	**102,500**	**128,670**	8500
2		**100,230**	64,880	**102,680**	**130,470**	8800
3		**101,020**	65,300	**102,610**	**130,630**	8900
4		**110,750**	63,350	**100,900**	130,030	8900
5		**99,350**	**63,480**	**100,700**	**130,340**	8400
6	DGD*	**97,950**	**45,110**	**105,800**	6766	7600
7		**4292**	**881.4**	**2915**	**2586**	1600
8		2565	**368.6**	720	900	229
9	OUT	**568**	159.1	**173**	**411**	126
10		**206**	**110.5**	**100**	**209**	89
11		**124**	**51.8**	**82**	**98**	65
12		**72**	**37.6**	**55**	**59**	45

Bolded text indicates points that are out of the range of good modelling conditions (0.3 < MF > 0.6).
*DGD.

TS design would be adequate if the predominant luminous climate of the region were to be an overcast sky (Mardaljevic, 2008); more important, the need to create typical designs taking into account the luminous climate characteristics of each place in particular as it becomes evident.

Table 5 | Annual values of MF – clear sky

Points		2008 autumn 9:15 hours	2008 winter 9:15 hours	2008 spring 9:15 hours	2008 summer 9:15 hours
1	INN	0.3	0.3	0.3	**0.2**
2		0.5	0.3	0.3	**0.2**
3		0.3	0.3	0.3	**0.2**
4		0.3	0.3	0.3	**0.2**
5		0.4	0.3	0.3	**0.2**
6	DGD*	0.3	0.4	0.3	**0.2**
7		0.3	**0.7**	0.2	**0.1**
8		0.2	0.5	0.03	**0.8**
9	OUT	**0.7**	0.5	0.7	**0.8**
10		**0.7**	0.5	0.6	0.5
11		**0.9**	0.4	0.6	0.6
12		0.6	0.4	0.6	**0.7**

Bolded text indicates points that lie outside the range of good modelling conditions (0.3 < MF > 0.6).
*DGD.

The obtained results reveal that the TS studied is a complex space. Nevertheless, the norm requires only minimum horizontal illuminances between 100 and 300lx, values easily exceeded during hours in which the lighting originates predominantly from a natural source (sunlight). Besides, since cylindrical illuminance is not required as an assessment parameter, the influence of materials used in the construction of the space, which interact with the day lighting and artificial lighting available, is rejected. So much so that in the zone considered to be the ‘entrance hall’, as expressed by the norm, average E_h values of 557lx are registered at 9:15 and average horizontal illuminance values of 344lx are recorded at 13:00 during the winter season. On the one hand, this shows sunlight influence and hourly variability, and, on the other hand, the absence of regularity, as regards the space lighting, could indicate problems in the visual adaptation of users. Therefore, it is considered that the recommendation coming from the norm does not suffice.

Given the vast lighting variability in this kind of space, the generality of a norm could be oversimplifying. What artificial lighting power would be necessary to balance the daylight intensity present in the outer part of a building? In order to solve this situation, taking advantage of the available solar energy for illumination, one would need to generate a certain lighting permeability to redesign the space or to include in the construction code certain recommendations where other relevant factors already identified would be provided for.

Table 6 | Annual values of MF – clear sky and overcast

Points		2008 autumn 13.00 hours, clear	2008 winter 13.00 hours, clear	2008 spring 13.00 hours, clear	2008 summer 13.00 hours, clear	2009 winter 13.00 hours, overcast
1	INN	**0.2**	0.3	**0.2**	**0.1**	0.3
2		**0.2**	0.3	**0.2**	**0.1**	0.3
3		**0.2**	0.3	**0.1**	**0.1**	0.3
4		**0.2**	0.3	**0.2**	**0.1**	0.3
5		**0.2**	**0.2**	**0.2**	**0.1**	0.3
6	DGD*	**0.2**	**0.1**	**0.1**	0.6	0.3
7		**0.7**	**0.7**	**0.7**	**0.5**	0.4
8		0.5	**0.8**	0.6	0.6	0.3
9	OUT	**0.9**	0.6	**1.0**	**0.8**	0.3
10		**1.1**	**0.7**	**1.0**	**0.7**	0.4
11		**0.8**	**0.9**	**0.9**	**0.9**	0.4
12		**1.4**	**1.0**	**0.9**	**1.0**	0.4

Bold text indicates points that are out of range of good modelling conditions ($0.3 < MF > 0.6$).
*DGD.

On the basis of the optimization and exploitation of daylighting, based on climate, it could, for instance, be recommended that entrance façades of buildings facing eastwards, possessing large TS, should mediate their TSs in order to alleviate potential visual problems.

The most efficient architectural form of TS is related to its corresponding climate condition (Chun *et al.*, 2004), as well as the position of the building and the optical properties of the materials chosen to its conformation. Therefore, it is verified that in luminous climates, where sunny skies are predominant, the main façade position of buildings and the TS lighting conditioning are critical factors that must be considered (Mardaljevic, 2008). It is proven that through modelling calculus that the space presents lighting conditioning

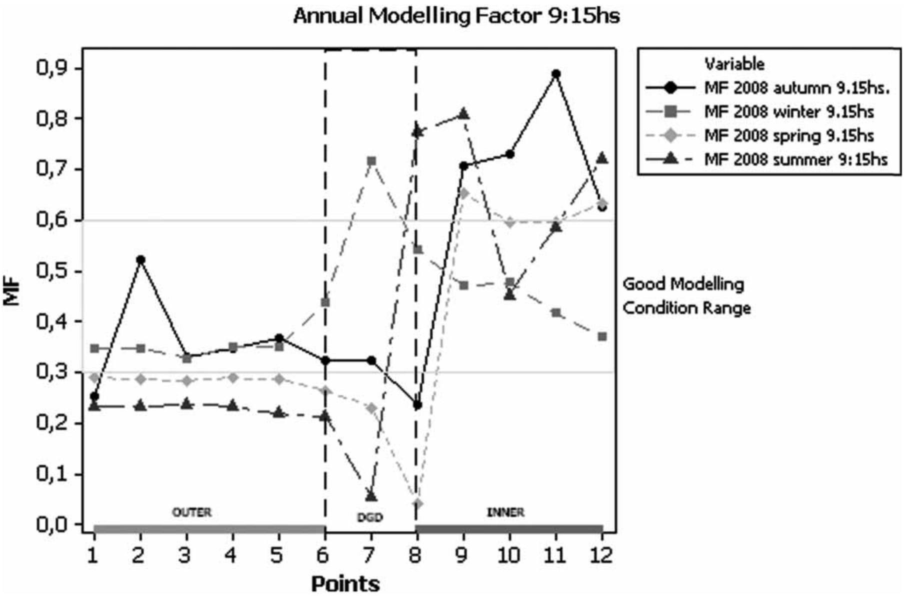

Figure 4 | Annual MF at 9.15 hours

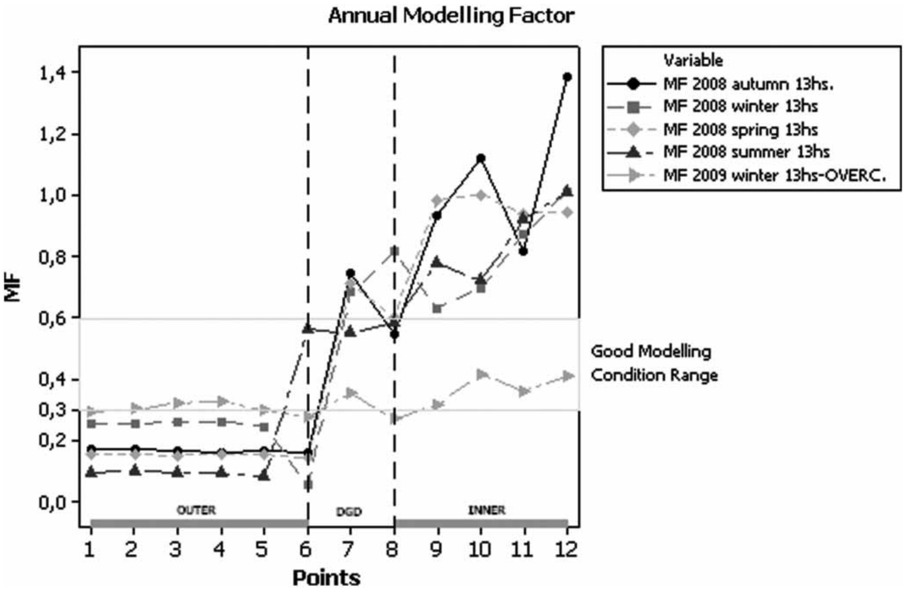

Figure 5 | Annual MF at 13.00 hours

problems. The morphological–architectural relationship between the studied TS and the luminous climate of the location is not optimized. As a result, there is the potential for the generation of visual problems of comfort and safe movement. Future interventions in the built space could solve these already-verified kinds of problems, such as improving daylight's access to the inner part of the building in a diffuse way and reducing the direct radiation present in the outer part of the building. Thus what will be achieved is a better light distribution and a gradual transition that does not pose any risks to the built space's users.

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