

# A comparative analysis of luminous ambience designed for equivalent functions

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**ABSTRACT.** The first part of this work focused on the elicitation of links between qualitative and quantitative approaches for luminous ambience in daylighting. We measured luminance and illuminance levels on glazed and opaque surfaces in interior spaces. We analysed and compared these measures and interpretations to impressions felt by subjects in the spaces, or to intentions expressed by the architect during the design of the project when available. This comparison has proved itself very meaningful and shows that many relations between the intuitive approach and quantitative measured data may be established.

In the second part, we performed a comparative analysis between qualitative and quantitative data for luminous ambience designed for equivalent functions.

It helped us better define the meaning of the qualitative terms used by subjects. It also helped us enrich the quantitative point of view through the definition of new notions such as the rhythm of repetition of contrast levels or the size of surfaces having a particular level of luminance. This work can also be used to enrich the language on luminous ambience and be of great help on the classification of luminous ambience. We use this comparative approach in teaching, in our school of architecture.

Beyond quantitative data, our method allows to perform an analysis closer to architects' needs and expressed in his language. This link between qualitative and quantitative allows to fill the gap between scientific technique and architectural design. It may be included in RADIANCE, to provide results related to architects' intentions.

**Keywords:** Luminous ambience, qualitative-quantitative links, contrasts, gradual ranges of luminance, measurements, feelings

## 1 Introduction

We present here two interior spaces with similar functions but belonging to two different buildings, the *National Superior Conservatoire of Music and Dance of Paris* and the *Institute of the Arab World*. The spaces are: first, the Café –Chapel– of the Conservatoire, a complex space at the intersection of horizontal and vertical passageways; Second, the hall, in the Institute of the Arab World, is also a complex space, allowing for visual views towards other interior and exterior spaces, designed for vertical and horizontal traffic. We have chosen these buildings as their interior ambience have been designed with special care and are of great interest.

In this paper, we focus on the relations between quantitative and qualitative data which define the luminous ambience of these two interior spaces. Firstly, we measured luminance levels on the interior envelopes (opaque and transparent) and, secondly, we

brought out the feelings of subjects in these ambiances. The feelings may either be the actual feelings expressed by subjects in these ambience or the intentions expressed by the architects (the intentions of the architects during the design to use the luminous ambience to cause specific subjects' feelings).

Qualitative expressions and explanations on the relationship between qualitative and quantitative are given. The quantitative data are not presented, as they are too numerous (some can be found in [4]). We present here a full comparative study between qualitative expressions (from feelings) and measured data for the two spaces and only a short conclusion on the comparison between the two spaces as the contrary would have been either too long or difficult to follow.

## 2 Comparative analysis -qualitative, quantitative

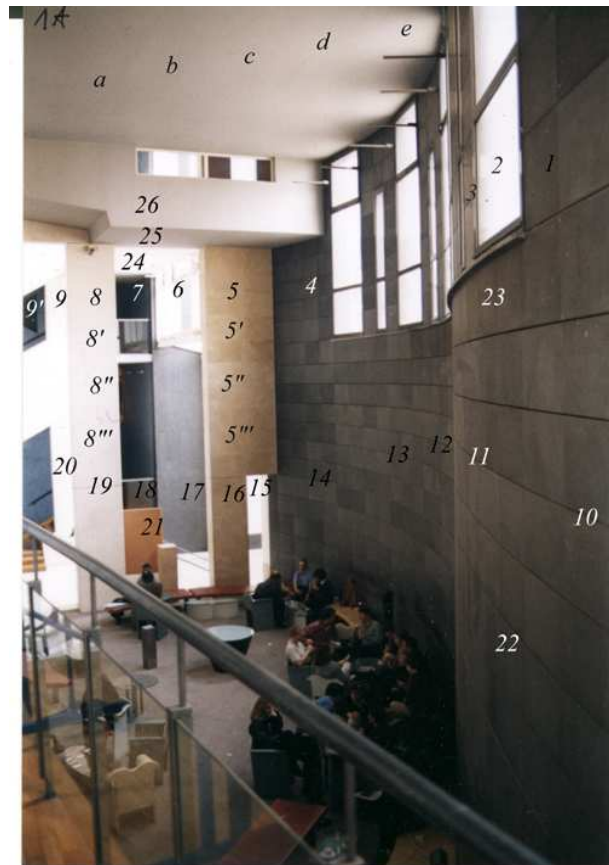
### 2.1 Conservatoire : Café – Chapel

#### 2.1.1 Qualitative Expressions

Christian de Portzamparc described his *intentions* for the ambience of the café during the design as coming from the demands of the students: "Some students prefer a padded, soft and dark ambience [...] the more exuberant are in front of the light, in the café which is noisier." [2] Christian de Portzamparc used the word "Chapel" to qualify this space.

Let us keep in mind that: *The ambience of the café has a soft and padded side like a temple and a noisier side where students face the light.*

*Fig. 1 - Picture from point of view B*



#### 2.1.2 Comparative Analysis of Qualitative and Quantitative Data

The Café has been studied from two points of view: A (at the bottom of the stairs) and B (top of the stairs). These two fields of vision have been analysed under an overcast sky for B and a clear, more precisely intermediate clear, sky for A. According to the protocol of measurements, as the space (the windows) is North oriented, a single series of measures under an overcast sky is required. We still measured with visible sun, from another interior point, point A, because the Café is in a complex space and may receive influence from the clear sky due to inter-reflections, despite its North orientation.

The analysis from point of view A will not be detailed here, let us just say that measurements from point A, in the Café, confirmed our findings from point B and confirmed our hypotheses in the protocol of measurements.

### ***Interpretation of measurements from point B***

From this field of vision we see four planes (Fig. 1): a *veiled* plane -dark surface on the right, a *composite* surface -vertical surfaces on the left, the ground and ceiling.

The veiled surface is in bright black marble, against the light and is the back of the Café. When one enters the hall from the street, one faces this elegant surface.

- The maximum contrast of the opaque part (without measuring glazing) is 1:3 (points 10 to 14, 22, 23, etc.).

The contrast, which is just perceptible and very soft (from 1/2 to 1/3), is spread over the whole surface. There are very soft gradual ranges of contrasts on part of this surface. Luminance levels are rather low (5, 9 and 11 cd/m<sup>2</sup>), because the marble is black. However this black is not an absorbing one, not an agent of the world of Darkness. Indeed the surface is very bright. If it were not, luminance levels would be under 1 cd/m<sup>2</sup>, contrasts would be imperceptible, the surface would be monolithic and uniform. Close to this surface, one can feel soft and irrational reflections: By soft, we mean that, in spite of this brightness, there is no reflection of visual spots on the surface. We see it against the light (the glazed surface is on the same plane) and there is no source light to produce reflections. Therefore, existing reflections coming from indirect light reflected in the interior lead to very soft contrasts. However, even if the contrasts are soft, their distribution is not monotonous: the fact that this surface is bright induces a tension. It may be seen as a well taut membrane between the reality of this Café and another world, magical, intimate, and composed of all the strange images that the marble grain creates. The texture of a marble tile and of all the tiles yield an irrational luminous distribution: where clearer is imagined, darker is found, etc. The tension of this membrane helps the thickness of the surface, its heaviness, disappear. Even if a subject does not follow this quantitative reasoning, he/she feels it. The light in this field of vision seems very thin, dark but light, soft and very calm, elegant and magical. The great size of this surface adds a monumental side to this spirit of Chapel.

- The maximum contrast between the veiled and the glazed surfaces is 1:50 (points 1, 2, 3, and 23).

It is very strong. However, the strip of strong luminance (glazed surfaces) is well aligned at a great height and the luminous flux does not directly reaches the students in the Café. The luminous flux goes over them, reaches the opposite interior surface and is reflected. Students are psychologically protected from it. This flux and the contrasts it brings belong to the bridge on the upper level. It delimits the height of the Café.

*Composite surface*: made of several opaque surfaces

- The surfaces close to the space of the Café have contrasts around 1:2 (points 5, 5' , 5' ' , 5' ' ' and 16, and, 8, 8' , 8' ' , 8' ' ' and 19). Gradual ranges are just visible and very soft.

- On the contrary, the global image of the composite surface which is entirely opaque (surface delimited by points 26, 5, 16, 28 and 9' ) is very variable with contrasts up to 1:35. One cannot speak of gradual range. Luminance levels are varied from very low to rather high (point 6 reaches 444 cd/m<sup>2</sup> and point 7 has 4 cd/m<sup>2</sup>): The luminous flux, which crosses the corridor surrounded by the composite surface, is rather important. The students in the Café face the light brought by this flux which continues its trip as a

tangent to the Café.

- The illuminance at table height at point A (limit of the clear area) is 100lux. This illuminance is rather low. Let us say rather dark (a work surface, to read for example, should reach 400 to 500lux). Illuminance on the tables of the Café is much lower.

Measurements performed in the Café on the veiled surface (lower part) and on parts of the composite surface which are close to the interior of the Café have low luminance levels, some soft gradual range and low illuminance levels. This corresponds well to the description given by Christian de Portzamparc of a rather soft, calm and padded ambience. The notion of Chapel is particularly related to this rather dark part whose black and bright marble surface against the light yields a subtle, weightless, magical and spiritual aspect. The noisier side, designed by Christian de Portzamparc, is also well shown by measurements, on all the opposite composite surface: strong and varied contrasts, no gradual range, changing level of luminance with rather high luminance for large portions of the surface. The flux which brings light to the interior of the composite surface is tangent to the Café.

Christian de Portzamparc well said: "Some students [...] face the light,...", which does not mean that they receive the light in their face. Indeed no portion of the sky is ever visible from any field of vision, once in the Café.

There is an opposition between low contrasts, soft gradual range and low illuminance on one side of the Café and strong contrasts, no gradual range and much greater levels of illuminance on the other side, close to the exterior of the Café, but visible from the darker part. This opposition is characteristic for this space. The students are protected in a dark and padded space. They feel sheltered, when they see the luminous flux crossing like an exterior limit but not touching them. This opposition between calm and noisy is well shown on this analysis of the measures.

## **2.2 Institute of the Arab world – Hall**

The hall was studied and measured under an overcast sky, a clear sky just before direct sunrays entered the interior (around noon) and with penetration of sunrays (in the afternoon). We only present the clear sky here. The hall is separated: 1- from the library by a glazed surface; 2- from the north-east exterior wall by a glazed surface; 3- from the lifts and the stairs in the middle of the hall by several glazed surfaces (Fig. 3); from the exterior by diaphragms which open and close according to change in exterior climate (Fig. 2).

### **2.2.1 Qualitative Expressions**

*Reality and illusion are difficult to distinguish...* is the meaning of an expression by Jean Nouvel about the Institute for the Arab world. We have no sensation of equilibrium (by one of our students). We will add that we have an impression of thin veils placed in the space.

### **2.2.2 Comparative analysis of quantitative and qualitative data**

*Point of view A towards the facade (south-west, Fig. 2):* It is difficult to speak of opaque and transparent. For the facade wall, very small zones are made of even smaller opaque and transparent ones. On the ground, the images of each small opaque and transparent surface are printed. Despite the opacity of the ground, the repetition of the

shapes of the little zones of the facade reminds us the opacities and transparencies, typical for this place. The ceiling is made of two strips: one with a metallic and rather reflecting frame (like a web) behind which are the spots and a smooth reflecting metallic zone which repeats the fuzzy image of the facade and the ground. The wall at the back is partially transparent, partially opaque and slightly reflecting. The large pylon in front of this wall repeats a distorted image of the facade, which is itself reflected by the ground and the ceiling. Limits between surfaces are not well defined in this space. We do not have a clear sensation of the beginning and the end of the interior. However we clearly feel that we are inside and not outside.

***Under a clear sky  
(closed diaphragms)***

For the facade, the maximum contrast (non-contiguous points) is 1:1500 at noon and 1:850 à three (between points 4 and 25).

Contrasts for contiguous surfaces are presented in the following tables (in these tables, C is for contrasts and LT for Legal Time). Contrasts range from very strong (1:65) to just perceptible (1:1,1). Punctually extremely strong contrasts appear (1:340, black strip on each window vs. sky). All these contrasts are distributed over a rather complicated image which repeats itself on each frame, with each dynamic element, according to a very simple rhythm.



**Fig. 2 - Picture of the facade**

For the facade (see the following table), there are gradual ranges of luminance, but as for opacity and transparency, it is very specific. They are not spread over an opaque surface, since there is no really opaque surface.

POINTS ON THE FACADE	C	HL
38 et 38'	<b>1:340</b>	12
Sky and rubber strip	<b>1:320</b>	15
4 et 9	<b>1:65</b>	12
Sky and interior metallic surface	<b>1:35</b>	15
1 et 5	<b>1:23</b>	12
Exterior, interior metallic surface	<b>1:15</b>	15
8 et 10	<b>1:3</b>	12
Interior metallic surface	<b>1:6</b>	15
23 et 23'	<b>1:2,5</b>	12
Interior metallic surface	<b>1:1,1</b>	15

The gradual ranges are very soft and spread over very small opaque (metallic) zones and they are very interesting.

The light plays a complex game on each of these zones, due to the complexity of the whole and because the surfaces of the little metallic elements reflect light among themselves.

The result is that luminance distribution is neither uniform nor "flat". Apart from these mini soft gradual ranges of luminance, the surface of the facade is therefore made of well-defined contrasts whose values are very varied and in a well-defined rhythm. We can say that the face of the building which we see from the interior is a highly precise drawing, very contrasted, with soft gradual ranges of luminance and that it is very luminous.

*For the ground*, contrasts range from rather strong (1:20) to soft (1:7). The ground is coloured in a grey close to the one of the metal and rather reflecting. One can notice, for example, that the reflections of the pylon and of the facade are superimposed. Because of the facade reflections, the ground surface has the same images as the facade. The ground has rather strongly marked contrasts. Their values vary, but are lower than the ones on the facade. Their rhythms are identical to the one on the facade. Luminance values do not reach the ones of the sun visible through the facade. The sky reflection on the ground yields a luminance that is 10 times lower: the sky has been measured at 7627cd/m<sup>2</sup> and the reflection of the same point on the ground at 739cd/m<sup>2</sup>.

POINTS ON THE GROUND	C	HL
<b>s8 et s7</b> Luminous spot on a metallic frame and a black strip	<b>1:15</b> <b>1:20</b>	12 15
<b>s1 et s2</b> Luminous spot on a rather bright ground and the shadow alongside	<b>1:17</b> <b>1:9</b>	12 15
<b>s3 et s6</b> Luminous spot on a rather bright ground and the shadow alongside	<b>1:15</b> <b>1:7</b>	12 15

One cannot really speak of gradual range of luminance, except for the pylon. We see the same building "face", but with less precision, weaker contrasts, no gradual range of luminance and less bright, just as if we saw the same face behind a veil.

*For the ceiling*, contrasts range from soft (1:7) to nearly imperceptible (1:1,1). The ceiling is made of some sort of rather reflecting grey metal (a smooth strip of metal, as a metallic net). One can see a rather fuzzy and dimmed reflection of the facade and of the pylon. Hence, the surface of the ceiling is made of contrasts within the soft range.

POINTS ON THE CEILING	C	HL
<b>a et b</b> Artificial source, metallic surface	<b>1:7</b> <b>1:2,5</b>	12 15
<b>d et e</b> Metallic surface	<b>1:5,5</b> <b>1:3,5</b>	12 15
<b>c et d</b> Metallic surface	<b>1:2,3</b> <b>1:2,6</b>	12 15
<b>g et f</b> Metallic surface	<b>1:1,3</b> <b>1:1,1</b>	12 15

Their values little vary and there are gradual ranges of luminance which soften them even more. Values are inferior to the ones on the ground. In fact, it is just as if a second veil had been set, the face is even fuzzier and softer, but still present.

POINTS ON THE PYLON AT THE BACK	C	HL
<b>32 et 33</b>	<b>1:3</b>	12
<b>33 et 34</b>	<b>1:1,6</b>	12
<b>31 et 32</b>	<b>1:1,3</b>	12

*The pylon* at the back has soft and very soft contrasts. There are gradual ranges of luminance on the whole surface. The face is no longer visible, but in our mind.

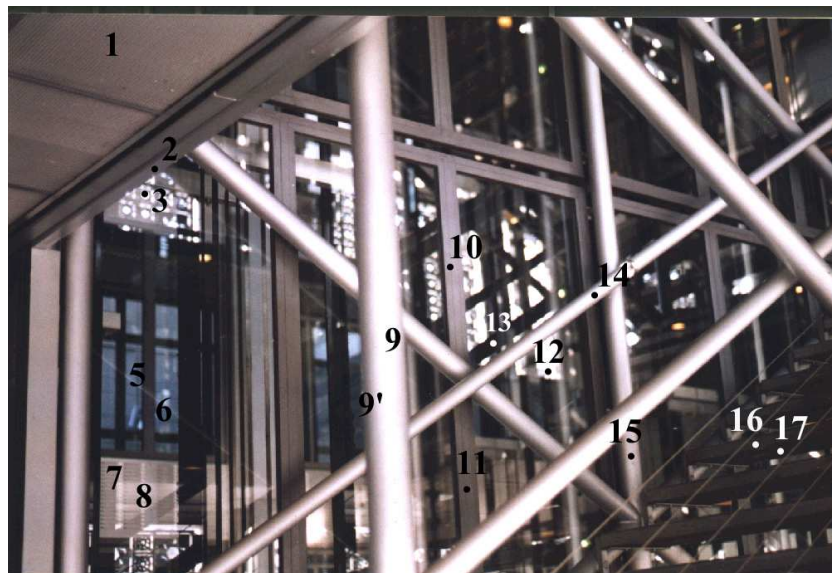
On the whole, luminance at 3pm is greater than the one at noon. The sun at noon (10am solar time) is just behind the facade and sunrays are parallel to the facade which is south-east oriented. Only the sky light is distributed inside. At 3pm (1pm legal time),



sunrays directly enter the building. Luminance levels are therefore greater at 3pm. On the contrary, it is worth noticing that luminance ratios between contiguous points are greater at noon than at 3pm, contrasts are more important before sunrays enters the building. There may be two explanations to this curious phenomenon: when sunrays hit the facade, the luminance of sun spots inside greatly increase. However, due to the numerous inter-reflections and to the semi-bright character of the materials, these sunspots act as many small lamps which illuminate the parts left in the shadows. Moreover, when the sun is present, the overall luminance around the sun increases and contributes to the increase in diffuse lighting, therefore to the increase in the luminance of points which are not on the sun spot. These two phenomena contribute to a very important increase in the illuminance and luminance for points which are not directly illuminated by the sun. Hence, it diminishes contrasts. For example, point 1 increases from 652 to 1222cd/m<sup>2</sup> (1.8 times) between noon and 3pm whereas point 5 increases from 28 to 79 (2.8 times).

***Point A towards the middle of the space***

This field of vision is made of several glazed surfaces, with the space for the lifts, the transparent lifts them-selves and the north-east exterior envelop of this part of the building. Many images of the facade are reflected on these glazed surfaces. Several



**Fig. 3 - Point A, towards the middle of the space**

metallic pipes and their images in the glazing cross this space from different angles.

The contrasts range from extremely strong, 1:254 (overcast sky), strong 1:50 (points 2 and 3), to just perceptible 1 : 1,5 (points 16 and 17).

We again see the more or less fuzzy or precise veiled face of the facade, sometimes dimmed sometimes bright. However, all the veiled faces visible through the glazed surfaces are mixed with the shadows and the reflections of the pipes and the pipes themselves, which cross this space. Here and for this field of vision only, the distribution of luminance is very varied and the frequency of variations is very high. There is no repetition or rhythm despite the complexity of the image. It explains the feeling of loss of equilibrium. The space has no real gravity to feel where the ground is. One does not know what is an element and what is its image, what moves and what is fixed. In the same way, the movements of the many lifts lead to numerous and frequent variations in the overall field of vision. In our view, it explains the loss of equilibrium felt by some subjects. It is typical of the hall which as more faces under clear sky than under an overcast one. Nonetheless, it stays vertiginous under any sky.

### ***Short comparative analysis of the two spaces***

The Café is surrounded by opaque surfaces, the Hall by glazed surfaces. Despite this fundamental difference, the two let see a very small fraction of the sky and the sun though the presence of natural light is strongly felt. In the Café, this comes from the small solid angle from which one can see the high windows. In the Hall, it is due to the characteristic of the protection: glazed surfaces are cleverly protected from the exterior, openings are spread all over the facade, but are of different sizes and very small.

The fields of vision offer many compositions in the two spaces. There is no uniformity or monotony in neither of them. In the Café, the fields of vision are differentiated and characterised by high and low oppositions of contrasts. On the contrary, in the Hall, there is no opposition, it is more like a story which continues but becomes fuzzier and softer from one surface to another, from one view to another.

We can say that the lighting of the two spaces is efficient for the functions of the spaces and that these spaces are comfortable. Let us say that they are both pleasant, even if the dimensions of personalities have not been taken into account in this study. For example, the question of equilibrium, which may be unpleasant for some, should be re-examined from this point of view.

## **3 Conclusion**

The comparative analysis between qualitative and quantitative approaches has been very significant and rich. It has been used with benefit in the teaching in our school of architecture and students have welcomed this method.

Students in architecture (and architects) commonly use in their practice of design qualitative notions to express their intentions for a future ambience. The use of our method provide quantitative thresholds in order to define the poetic descriptions from a technical point of view. This link between qualitative and quantitative allows to introduce the qualitative definitions in the design, knowing that the quantitative one would be difficult to integrate.

It has also led to two new research directions to be studied in the new future. For future research, it will be interesting to study with psychologists the sensitivity to perception compared to dimensions of personalities (how it influences behaviours in an interior space). The second direction for research will study the links between feelings and qualitative expressions about the luminous ambience in a given space.

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