Light, Colour and Surface Quality as Ergonomic Aspects in Space Recognition and Urban Design: Azulejo's (Glazed Tiles) as a Case Study

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ABSTRACT
The aim of this study is to assess glazed tile’s cladding (azulejo) qualities in urban spaces, to identify its perceptive potential as an ergonomic aspect in urban environment, allowing a more intentional and consistent design and use of the azulejo.

Sight sense and haptic communication in human interpretation of physical reality are crucial: colour, light and surface quality are important features on sensory level information for object and space recognition. In the mental process of spatial organization, differences in the visual perceptive field have an important role. Perception variation, synchronic or diachronic, is crucial in this interpretation process.

The recognized importance of Human Factors in the design process, namely perception issues, emphasises visual and emotional features of materials used in the built environment. The interplay of light on coloured surfaces of azulejos provides perceptive variations useful in mental processes of space interpretation and orientation.

The adoption of a cross study methodology enabled a transversal approach to the subject, including different areas of knowledge, enriching the scope of the study, in an overall ergodesign perspective.

Keywords: Human Factors; Perception; Ergonomics; Azulejo; Light; Colour; Surface; Spatial Orientation.

1. CONTEXT
A vital urban environment is one in which the visual elements - light, colour, and architectonic form - signify and express civic functions (Swimoff 2000, p.IX).

The sense of spatial appropriation by the citizen largely depends on its legibility, symbolic content, safety and welfare, which are linked with the spaces contributing to a harmonious relation between them and the external world (Lynch 2002; Pallasma 2005).

Public space should be designed as an organizing structure of the territory, an area of continuity and differentiation, an axis of urban environment. Creating guidance systems based on structures that promote safety and comfort, will contribute to a more positive environment. In urban areas survival has become not only a physical need, but also a psychological and emotional condition. These areas provide “information overdoses”, diminishing our capability of visually isolate elements. In order to organize our visual spatial memory we need to focus on visual references that allow similarities and differences recognitions, in a permanent comparative process as we move in urban spaces.
1.1. User | Space Relations

Framing and identifying our environment is a vital activity for all movable animals, as Lynch said. Elaborating a wayfinding system through identity structures in order to facilitate life and survival in urban areas has been a constant issue on living beings history.

In environments it is difficult to isolate elements, dissociate them from visual clutter. Information visualization is impaired by congested surroundings of billboards, signage, urban furniture, and mobile structures, and we become a new way of fighting for survival. What draw our attention are the similarities and the differences, the rhymes and rhythms, as stated by Humphrey, "likeness tempered with difference"(1980). This comparative process enables us to find common principles on diversity, recognizing structural principles of knowledge, making possible for us to walk through a mutant reality.

According to Lynch (2002) our process of image building of the city is a collage of successive images, following one another in our mental journey, creating rhythms, defining time perceptions.

At a glance, as stated by Fei-Fei, Iyer, Koch & Perona (2007), a variety of global perceptual features are represented, allowing a categorization of the environment (Torralba & Oliva in Fei-Fei, Iyer, Koch & Perona, 2007). Through sensory channels we gather information from the environment, relating it with previous significant processed data, (Allen1999; Mollerup 2005). While walking through the city, we guide ourselves through this personal mind maps created on basis of meaningful perceptual/spatial/emotional/socio-cultural features.

1.2. Colour, Light and Texture in the Urban Environment

Colour in the urban environment is an expression of a collective identity built by the will of an evolving society, constantly changing, becoming a cultural reference, an important factor for the humanization of public spaces.

The loss of building surface plasticity, motivated by modernist principles, has contributed to vision supremacy on spatial perception. Without tactile elements, which claim physical proximity and interaction with the user | viewer, the architectural structure becomes flat, inhospitable, unfriendly (Pallasmaa 2005).

People appreciate colour and texture variations in their environments (Mahnke 1996; Swinmore 2000, 2003). They consider them pleasant for the eyes and touch, a sign of abundance, a return to Nature, which somehow softens the subject/object relationship: texture appeals to the touch, to an interaction between built and user, not only as functional feature, but also as tactile pleasure, linking us to built environment (Fig.1).

Fig.1 - Relating built environment with nature improves object/user relationship.

Diversity in the urban landscape is considered a vital quality (Humphrey 1980; Lancaster 1996; Lynch 2002). Over stimulating environments can lead to crowding – decrease of object’s perception by the proximity of multiple similar objects (van de Berg,
Roednik & Cornelissen 2007) - affecting our ability to identify basic information in visual fields. As stated by van de Berg, Roednik & Cornelissen (2007), hue and saturation variations, as they cause less clutter, are more suitable for visualizing and understanding information than variations in size and orientation grids. Colour and chromatic diversity, enhanced by light variations, are positive elements in our space image composition, not only for their emotional and psychological value, but also by its sensory capabilities that can alter our spatial perception. According to Frey, Honey & König (2008) when colour information is present users, with no visual impairment, tend to look more often to those locations, particularly when hue variations are used in surface segmentation rather than lightness variations.

An ergonomic use of colour can highlight details, break monotony by introducing rhythm and proportion, increase spatial readability by differentiating volumes, establishing figure/ground clarification, rank spaces (Porter 1982; Merwein, Rodeck and Mahnke 2007), guide the traveller (Manhke1996; Porter and Mikellides 1976) improving wayfinding and wayshowing tasks (Mollerup 2005).

2. **AZULEJO’S AS A CASE STUDY**

   Size, shape, colour and location are part of the mental process of objects and space organization (Swirnoff 2003; Allen 1999). These are fundamental factors in user’s efficiency, as they promote environment recognition and categorization (Friedman & Thompson 1976). Colour draws our attention, and is a relevant feature in emotional memory building, promoting the establishment of centres of interest in the visual field. The use of colour in urban design, associating meaningful emotional and sensory features to the tactile qualities of the materials, can help to increase readability acting as important factor in wayfinding and wayshowing processes.

   Because of its intrinsic qualities (clay’s plasticity, glaze’s characteristics), extrinsic qualities (colour, gloss, texture), and emotional characteristics (easily recognized, familiarity), azulejo’s cladding can provide aesthetic pleasure, human comfort, reflecting as well ergonomic concerns. By creating surfaces with great perceptual variation regarding colour, texture and graphic design, with haptic qualities and symbolic significance, they allow different forms of visual communication in the object | environment | observer system (Lobo & Pernâo 2010).

2.1. **Azulejos as Potential Emotional Landmarks**

   Since Ancient Times, the use of ceramic in claddings and structural elements has integrated architecture in a comprehensive way. Glazed or natural its presence is atavistic, with a socio-cultural significance, expressing the action of the human hand, embodying customization as opposition to the cold impersonal and flawless materials of mass production. Over the centuries, glaze tile claddings embodied religious and political convictions, cultural and artistic expressions communicating social evolutions.

   Azulejo’s claddings because of their inherent characteristics, resulting from the nature of the material and its production process, make the perceptual experience a noticeable event through the significant variations that occurs with different light conditions, viewing proximity or distance, or angle of vision.

   Sensory-perceptual features make azulejo eligible not only as functional protection material, but also as differentiation element, with a social function: guiding element and landmark. Its surface qualities – colour, texture and gloss - consequence of the material nature; the variety, stability and longevity of glaze’s colour, even in high saturated hues when compared to other materials; the shifting brightness due to the reflectiveness of glossy glazes; the possibility to create random colour patterns or graphic designs on the surface; the chance of texturing the surface, give glazed tiles is distinctiveness.
Visual, cultural, and symbolic features of azulejo elect it as an improving element in urban environments, not only as an architectural protective skin, as also a potential emotional landmark (Fig. 2).

Fig.2 - Azulejos as emotional and iconic references.

2.2. Azulejos Colour, Texture and Reflection as Detachment Factors

The azulejo laying process results in an irregular surface where incident light bounces and scatters, creating multiple colour and light reflection perceptions. Azulejo's colour variations in terms of chroma are consequence of glaze's thickness and evenness: more thickness results in a higher saturation. These colour variations are further strengthened by the effect of embossed motifs on the glaze: relief "opens" the glaze, which becomes less thick on prominent lines, losing colour saturation; on the contrary, on "lower" areas of the surface, due to glaze's accumulation, the colour saturation increases. This colour unevenness creates a coherent variety in the surface (Fig.3), contrary to plastered or painted surfaces - where colour is uniform and monotonous – or colourless glass surfaces were colour is inconsistently changing, becoming an ambiguous feature.

Fig.3 - Colour variation in azulejo's claddings – glaze evenness and surface qualities as modifiers.

When light interacts with glazed tiles cladding, it scatters in different directions. Depending on the viewing angle one can "see" a mirrored surface, a specular reflection or a sum of coloured squares of the same hue, but with different lightness and chroma (Fig.4).
The reflectivity of a glossy glaze, affects the colour of the surrounding buildings through the reflection of light rays, and brightness reflection. This apparent colour modification of the tiles as a consequence of the reflection of surrounding colours, and the quality of the light reflected by azulejo’s surfaces, create an emotional atmosphere (Zumthor 2006), which stand out from its environment. Glossy surface colour reflection is much stronger than that of a matte surface (Lancaster 1996), and colour saturation perception changes, as specular reflection depends the observer situation. For this reason an azulejo’s surface detach from other adjacent areas, painted or plastered.

Colour and texture can merge with distance, but the reflectiveness of a glossy glaze will contribute to the detachment of that surface, over the background of the other buildings, increasing spatial legibility (Fig.5).

Even in dim light situations, when colour and graphic design are not clearly seen, and/or correctly perceived, the reflection from the glossy surfaces of azulejos claddings will contribute to the building recognition, and to is detachment from the surrounding background (Davidoff 1991). Taking this in consideration, the use of glazed tiles be a helpful tool in urban design clarifying figure (urban equipments) / ground (azulejos claddings) relations trough colour and brightness contrasts, increasing spatial legibility.

2.3. Azulejo’s Claddings as Spatial Reference

Wayfinding is a structured process in which we try to establish relations among multiple stimuli. This process of assimilation is a continuous of classifications, through which we mentally “ordered” rhythms and rhymes, setting visual and emotional harmonies in space (synchronic), and time (diachronic) (Humphrey 1980), developing an internal representation of perceived environmental features (Golledge 1999).
Glazed ceramic cladding provides visual and tactile richness, allowing diversity in the perception of the object at different distances and viewing angles, making them easy to recognize, and to remember. The orthogonal grid resulting for the laying process, the colour variation, the gloss and brightness, the graphic and embossed motifs create an array of clues assisting urban user/explorer needs in city mapping.

The observer/object relationship determines azulejo's claddings perception: if we consider the observer in motion, the variation of the distance will result in different visual stimuli that attract our attention, from the overview vision to detail proximity, triggering new visual sensory-perceptual experiences (Fig. 6 and 7). Due to the optical mixture phenomenon, at an urban scale we are able to see a uniform colour, as we move closer this impression is converted into brightness and similar colours; at an even closer distance an array of colours and textures is revealed, with tactile qualities and graphic patterns.

![Fig. 6 and 7 - The effect of user's point view and distance in azulejos claddings perception.](image)

Proximity or distance leads to different visual patterns. These stimuli changes, as long as they are understood as stimuli modifications and not as new stimuli, can contribute to a better understanding of the environment: representing shape modification, change of direction or time elapsed trough colour and reflections variations, progression or location in mentally designed route. Texture scaling is one of the primary sources of information to understand three-dimensional shapes (Todd, Thaler, Dijkstra, Koenderink, & Kappers, 2007).

Unity and complexity conveyed by ceramic glazed tiles provide balance to the environment (Lobo & Pemão 2008, 2010). Recognition and categorization cognitive processes make use of visual data to help on explorer relative positioning. Gradients of scaling and optical mixture of colours, textures, patterns and laying grid can indicate user's position regarding the building. The way we perceive azulejo's cladding patterns, their texture or the grid created by the tile laying, is fundamental for referencing our position in relation to that surface. If they are clearly perceived, the distance is proximal and the viewing angle is close to 90°. If texture, pattern and grid merge into a homogeneous colour, then the viewer is at a greater distance, or the viewing angle is smaller, or both (Fig.8).
The shifts in specular reflection, associated to brightness variations on the surface can also help to identify the relative position of the viewer, and building, in regard to the sun (Fig.9 and 10).

Diversity tends to arouse visual perception (Foster 1976), which can lead to a clearer understanding of urban space (Friedman & Thompson 1976). This enables us to feel the pulse of facade rhythms, leading the eye and body to discoveries, in this place of experiences: the public space.

2.4. Azulejo’s Claddings as an Ergonomic Factor

In an urban environment, our attention needs to be stimulated; colour can act as an information finding system (Mollerup 2005). People with normal vision are more receptive to hue contrasts, visually impaired persons or colour blind are more sensitive to differences in value than in hue. Although brightness and reflection are generally negative factors in terms of visual communication for people with impaired vision, in the case of azulejo it might work as visual a reference.

The main problem concerning the use of glossy surfaces in the built environment is
glare. Due to its chemical and physical characteristics azulejo's gloss level is never high enough in order to produce uncomfortable glare, visual distress or disorientation in the user. Azulejo's laying process results in a non-coplanar surface, as described earlier, reason why specular gloss happens very briefly and in small areas. Outdoor environment pollution also contributes to prevent glare by producing a dusty veil on azulejos surfaces that prevents glare, though maintaining its reflectiveness.

The reflections caused by the incidence of light on its surface, which vary with the angle of vision and with the inclination of the sun, will provide specific differences in brightness, allowing movement references for those with impaired vision or colour blinded, without becoming a visual uneasiness. Even if you have similar hues in contiguous façades, azulejo's perceptive variability is recognized as a reference, helping us when moving.

Given the plasticity of the ceramic body it is also possible to add textures and relieves, mechanical or manual (Fig.11), to the tiles surface, giving them haptic value, which enables their use as guidance systems, as Braille writing channel, tactile letters or signage for orientation processes, either in public or private environments.

![Fig. 11 - Haptic qualities of ceramic material can be used as facilitating structures in visual and tactile information.](image)

As architectural skin azulejo's claddings doesn't need extra supporting structures, therefore minimizing the physical obstacles and visual clutter in the environment, and the production of new unneeded artefacts (Fig.12).

![Fig. 12 - As architectural skin azulejos can convey information without need of extra supporting structures, diminishing the numbers of obstacles in sidewalks.](image)

3. CONCLUSIONS

In this study we demonstrated and underlined the important role of ergonomic features from azulejos claddings in the emotional and functional quality of urban spaces. As an architectural skin azulejos can facilitate problem solving related to space, light, and protection from the weather agents, making it also possible to introduce visual - colour, gloss
and texture – and symbolic features in the environment that may positively influence the living practices of the inhabited areas (Fig. 13).

![Fig. 13 - Visual diversity of ceramic glazed tiles on urban environments as an emotional value.](image)

Colour, texture, size, and quality surface are fundamental to the understanding of spatial context. Ceramic claddings, as visual and physical aspects of architecture, interact with the environment, changing with light, inviting to the Human contact, actively participating in the construction of a vital and stimulating urban space.

The sensory-perceptual and spatial features of this material, qualify it as an improving element in spatial legibility and readability, allowing us to characterize, organize, and rank objects and spaces.

Azulejos visual and haptic qualities - colour, texture and gloss – can be a reference in ergonomic features, functioning as an anchor point, supporting our visual memory construction, contributing to wayfinding and urban identity.

Contrary to most materials, which have an intrinsic colour and texture, in ceramic claddings visual characteristics may be defined by the project. The customisation of ceramics can alter perception of its visual and tactile appearance. This potential can be used as a tool in human centred design, improving products ergonomic quality and functionality.

Human reliability on visual, tactile and self perceptive information (Allen 1999) turns glazed tiles into a reference material in the environmental design process. By associating surface qualities to colour and brightness azulejos ergonomic potential is increased as a solution for cladding and signage; it's proved longevity (structural, chromatic and brightness) allows an environmentally responsible use, without losing visual or tactile qualities during its lifetime.

This study findings aim to be a contribution to a sustainable and meaningful (re)innovation of glazed tile's claddings, in their design process - from thinking to production and application, as well as a opportunity to establish perception features as an important element in colour planning methodologies.

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