Relationships between Neuroscience and visual perception model Sens-Org-Int contributing to Design practices

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Design / Visual Perception / Neuroscience / Model Sens-Org-Int

The aim of this article is to present the results of an analysis of findings from neuroscience, done with a design point of view, using Model Sens-Org-Int. Results indicate that there are several concepts in neuroscientific studies, especially the ones called visual illusions, that enhance design studies as the ones obtained from Gestalt School, which contribute significantly to design practices.

1. Introduction

The aim of this article is to present findings in neuroscience that may contribute to design practices. As noted by neuroscientists Spillman & Ehrenstein (2004), recent studies from neuroscience may be considered as the updated study of Gestalt. This brings quite a contribution to design practice since findings in the area may determine new concepts to be used in design, such as Watercolour Effect (Pinna et al, 2001), determining figure-background perceptions using colours.

Not all studies from neuroscience may help design so directly, only those related to Org portion of Model Sens-Org-Int. This model was devised by the present author, published and awarded in IVLA's (International Visual Literacy Association) 2007 Book of Selected Readings (Csillag, 2008). The model differentiates the three processes that occur in human perception: sensory impressions, organizing processes, and interpretive processes of visual perception.

2. Visual Perception Model Sens-Org-Int

Sens-Org-Int Model differentiates three processes that occur in human perception: sensory impressions, organizing processes, and interpretive processes of visual perception. The model was devised in an attempt to differentiate which principles or laws of design and art are common to all human beings with normal eyesight from the concepts that are not common to everyone. Those that are not common therefore are learned or otherwise acquired.

In the 19th century, perception was studied as a passive stamping done by exterior stimuli on the retina. It would then reach the visual cortex, the zone of the occipital cortex that receives stimuli generated in the retina, resulting in an identical image (isomorphic) as the primary stimulus.

Modern psychology refutes this notion and views perception as an active process that involves the search for corresponding information, the differentiation of essential aspects of an image, the comparison of these aspects with each other, the formulation of appropriate hypotheses and the comparison of these hypotheses with the original data (Bruner, 1957; Leontiev, 1959; Luria, 1981). Familiar and non-familiar images can be differentiated by longer or more contracted paths of perception (Luria, 1981).

Telford (1970) differentiated sensation from perception in that the first comprises a simple conscience of the dimensions of experience, whilst perception implies the sensation and the meanings that are attributed to the experience. Thus, for this author, the determinants of perception are: context, constancy, distance, perspective, interposition, brightness, position, direction, accommodation, convergence motivation, emotion, and personality.

Theories about perception tend to emphasize the role of either sensory data or knowledge in the process. Some theorists have adopt a data-driven or bottom-up stance, or synthetic approach, according to which perception is direct: visual data are immediately structured in the optical array prior to any selectivity on the part of the perceiver proposed by Hering (1878), Gestalt theories, and Gibson (1979). Others adopt a constructivist, top-down or analytical approach emphasizing the importance of prior knowledge and hypotheses, defended by Berkeley (1709), Helmholtz (1925), and Bruce, Green & Georgeson (2003).

Visual Perception In Neuroscience

The human brain has been studied in many details, and one way of organizing the study of different functions of the brain, was to divide it in areas. Thus, in terms of visual perception, the most important area is the visual cortex, consisting of the primary visual cortex (also called striate cortex or V1) and the extrastriate visual cortical areas, containing areas V2, V3, V4 and V5.

Visual analysis primarily takes place in the visual cortex, which is performed by specialized neurons (Hubel & Wiesel, 1962; 1963). It has the influence of secondary zones of the visual cortex forming mobile syntheses of visually perceived elements under the modulating and regulating influence of other non-visual zones of the cortex (Luria, 1981).

Before synthesis can occur, the visual cortex must stabilize the image, because when the image reaches the retina, it lasts no longer than 1 to 1.5 seconds if the eye is not moving (Yarbus, 1965). Stabilization occurs by the formation of an after-image in the occipital zone that can last up to 20 to 30 seconds (Zimkina, 1957; Kaplan, 1949). Zeki (1999) identified a small area of cells on each side of the brain that seemed specialized in responding to colour, named V4.

CSILLAG, Paula 2012. Relationships between Neuroscience and visual perception model Sens-Org- Int contributing to Design practices. In Farias, Priscila Lena; Calvera, Anna; Braga, Marcos da Costa & Schincariol, Zuleica (Eds.). **Design frontiers: territories, concepts, technologies** [=ICDHS 2012 - 8th Conference of the International Committee for Design History & Design Studies]. São Paulo: Blucher, 2012. ISBN 978-85-212-0692-7. DOI 10.5151/design-icdhs-073

Processes of Primitive Vision considered bottom-up by neuroscientists, which are processes that do not require previous knowledge and are not determined by learning or experience, are the perceptions of movement, depth, form and colour vision. Colour can even be produced experimentally by a magnetic stimulus on V4 causing the "vision" of coloured rings and halos, the so-called cromatophens (Sacks, 2003).

Findings in neuroscience have mapped the visual pathways (Knoblauch & Shevell, 2004; Zeki, 2000) and have determined that perception occurs through a neural cascade, activating areas of the brain that are often very far apart. Thus, perception does not occur through isolated processes in the brain.

Proposed Model And Involved Variables

With the support of scientific evidence, the present model was devised in an attempt to differentiate which principles or laws of design and art are common to all human beings with normal eyesight from the concepts that are not common to everyone. These that are not common therefore are learned or otherwise acquired. Therefore, this model unites the synthetic and the analytical approaches to psychology as well as neuroscientific and physiological explanations on how the brain works, and relates these to classical art and design principles. With this framework, we are then able to tell, from the classical art and design "laws," which ones can truly be considered a principle valid for all human beings from those that cannot.

The term law sometimes carries the connotation of something that was decided by someone or a group of people. Therefore, it is natural to want to question these for the sake of creativity, like my students always have done. Now, when we consider the model, we can differentiate what truly is a law that cannot be questioned simply because it was not decided by someone. We are talking about the nature of the human eye and the human brain and not about someone's decision that could be questioned.

The proposed model of Visual Perception is shown in Figure 1. The variables intrinsic to the model are Sens (Sensory Impressions), Org (Organizing Processes) and Int (Interpretive Processes), respectively explained below.

Sens variable is related to the sensory information received through the pupil in our visual sensory organ. This aspect of perception is a phenomenon that occurs in the eye only, still in the form of light, before it becomes neural signs in the retina.

Org variable is related to organizing aspects of perception that occur starting in the retina, including what is considered the primary visual cortex, mostly in area V1 of the striate cortex. Org is related to the bottom-up approaches of visual perception in psychology. The phenomena of perception that occur as Org are what can be considered as laws or principles of design.

Int variable refers to the elaboration of Org in the extrastriate visual cortex, including approximately areas V2, V3, V4 and V5 of the brain, and moving on to other areas of the brain. This variable refers to the top-down approaches to visual perception in psychology. It is in this moment of perception, that neural cascades occur, which undergo the interference of motivation, emotion, personality, culture, knowledge, etc. This aspect of perception causes variation and interpretation in art and design and in the proposed model, is called interpretive processes.

Common Visual Literacy Mistake

The confusion between Org and Int is very common in the production of images, exposing frail visual literacy from the designer and bringing the risk of not communicating the intended message. To demonstrate, let's consider the following example.

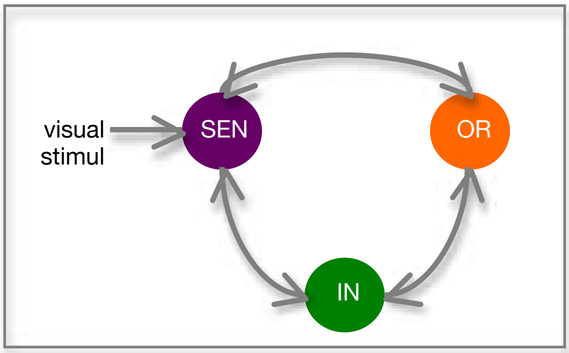


Figure 1. Proposed Model of Visual Perception

If we were to look for images that have visual movement, we may choose the image in Figure 2, which is a photograph of Ronaldinho, one of Brazil's key soccer players. As we can see, Ronaldinho is in the air, his colleague is looking up at him, and the ball is not touching him. These visual cues not only indicate that he is moving, but also serve as semiotic signs related to the understanding of this image. To understand movement, in terms of these hints, is to see the semiotic meaning in each of the elements, that belong to Int.

If we now look at this image in terms of Org, we can see that it is quite static indeed. To visualize this, we can just trace a line along the major elements, shown in Figure 3. As we know from design principles, horizontal and vertical lines are more static than diagonal and curved lines (Dondis, 1999; Kepes, 1944; Ostrower, 1983; Scott, 1979). So a better example of movement would be to use Figure 4. And to confirm the plastic forces indicated by a line, Figure 5 shows the main elements in the black diagonal line presented. In terms of Int forces, both pictures show movement, but in terms of Org forces, only picture 4 does.

3. Analysis of Neuroscientific Findings Using Model Sens-Org-Int from a Design Perspective

A bibliographical review of neuroscience authors revealed some interesting results from a design perspective. What neuroscientists call visual illusions, are intriguing for them in terms of how the brain works. Now for designers, some of these studies are

Figures 2, 3, 4, and 5. Photogragh Of Ronaldinho (Used With Permission Of Tasso Marcelo.)

in fact information to be used for the design practice. As noted by neuroscientists Spillman & Ehrenstein (2004), recent studies of neuroscience may be considered as the updated study of Gestalt. Analysing these studies, having in mind Model Sens-Org-Int, some of them fall into Org category of the model, which are those that occur primarily in the primary vision, therefore are common to human beings with normal eyesight.

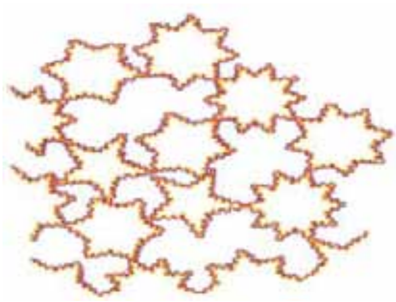
Pinna et al (2001) named one of these visual illusions as The Watercolour Effect. This illusion defines figure-ground background in a different way than Rubin's figure-ground Gestalt law did, for the Watercolour Effect is determined chromatically. This effect may be visualized in Figure 6 and may be defined as a shading of colour through an area that is larger than it actually occupies, as if an area were filled in with watercolour paint.

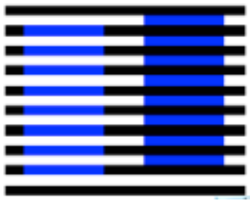
The neurological explanation for the Watercolour Effect is that the combination of a lighter contour combined with a darker contour, over an even lighter background, stimulates neurons that respond only to a contour that is lighter in the interior than on the exterior, or to a contour that is darker in the interior than the exterior, but not to both. The definition of the border is decoded in cerebral portions V1 and V2. Investigations showed that curved wavy lines produce a colour shading stronger than with straight lines probably because wavy lines activate neurons that respond to orientation. The colour that is signalized by these uneven margins should be conducted to other regions of the cortex that cover large areas of the visual camp, continuing the colour spreading until cells that are sensitive to borders on the other side of the closed area supply a barrier to the flux (Pinna, Brelstaff & Spillman, 2001).

Another important neuroscience finding that may be very useful for design practices is the Munker-White Effect (White, 2010). Figure 7 illustrates this illusion, where the blue stripes on the left side seem to be lighter than the blue stripes on the right side, but they are exactly the same shade. It is important to note that this effect is the opposite of what is known as simultaneous contrast, for the perception of the colour blue is altered in the direction of its context.

The neurological explanation for this effect is called chromatic assimilation (Kelly & Grossberg, 2003). Basically, it refers to the fact that neurons do not send to the brain a fixed, immutable image, like it is physically on paper. They only send to the brain some information like edges, and changes in light intensity. Ganglionary cells have center-surround receptors. An on ganglionary cell works more intensely when the center is lighter that the surround and less intensely when the receptor camp is uniformly illuminated. Off cells behave in an opposite way: they respond when the center is darker than the surround and almost don't send signals when center and surround are uniform. Frequently, light is received on both types of cells, on and off, which could also be called as light and dark photoreceptors. When this happens, both types of cells compete with each other; one part of the receptor wants to be active while the other part does not. This competition causes chromatic assimilation and the sensation of two colours that are the same seem different.

Other illusions will be briefly mentioned here, due to length limitations, which are: De Valois Illusion (fig. 8), Sohmiya Illusion (fig. 9), neon colour spreading (fig. 10), and Anderson Illusion (fig. 11). The neurological explanations will be omitted since the visual explanation is more useful for the designer. In De Valois Illusion (fig. 8), the orange and magenta squares shown in the upper row are actually the same shade of red, and the yellowish-green and cyan squares displayed in the lower row are the same shade of green (De Valois, R. De Valois, 1988). In Sohmiya Illusion (fig. 9) the white background behind the orange waves appears to be tinted orange (Sohmiya, 2007). Neon colour spreading (fig. 10) occurs when crossing points of a black grating in front of a white background are replaced with coloured crosses, and colour appears to go out into the background (Van Tuijl, 1975). In Anderson Illusion (fig. 11), the circle surrounded by the bluish background on the left appears to be yellowish while the circle on the right surrounded by the yellowish background appears to





Figures 6 and 7. (from left fo right) Watercolour Effect and Munker-White Effect.

be bluish. But both circles are exactly the same colour and texture (Anderson & Winawer, 2005).

There are more illusions, but the ones presented here were selected as being significant for the designer. The illusions showed above may be adapted to other colours and variations, presenting a wider array of options for the designer. Also, it is important to note that this paper focused on recent illusions, considering that older ones like Hermann-Grid (1870), or simultaneous contrast (Itten,1979; Chevreul, 1854; Beck, 1972) are already well discussed and known.

Therefore, this paper presents the results of an analysis of findings from neuroscience done with a design point of view, using Model Sens-Org-Int, and selecting only Org findings. Results indicate that there are several concepts in neuroscientific studies, especially the ones called "visual illusions" that enhance design studies as the ones obtained from Gestalt School, which contribute significantly to design practices.

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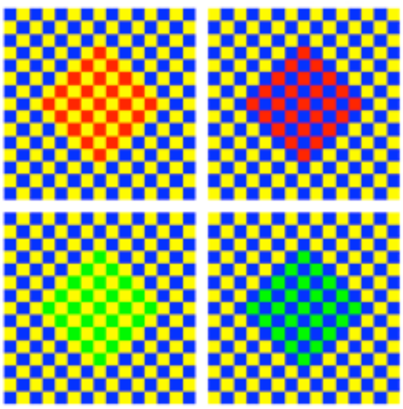

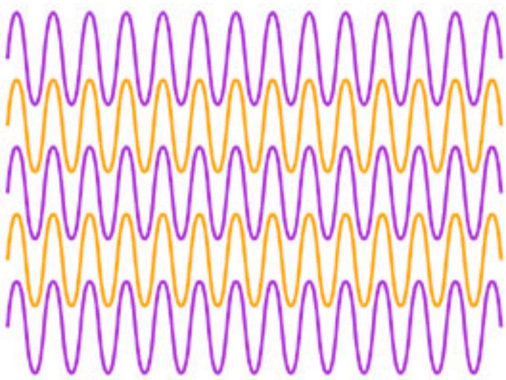

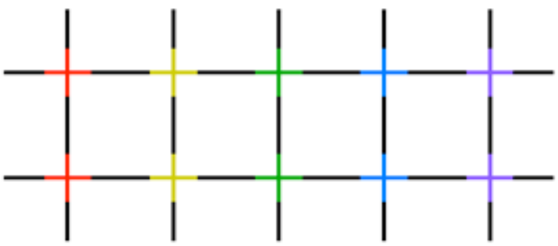

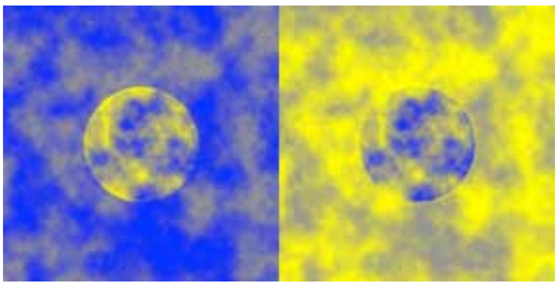

Figures 8, 9, 10, and 11. (from left to right and top to bottom) De Valois Illusion, Sohmiya Illusion, neon colour spreading, and Anderson Illusion.

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