Metrological capture of visual reaction

Authors:
Prof. Dr. Roland Greule, Dipl.-Ing. Markus Felsch, Dipl.-Ing. Thomas Lemke
Griegstraße 75 / Haus 3.2 22763 Hamburg

Before starting a precise analysis of the visual perception it is important to examine the characteristics of the eye without any disruption. This preliminary consideration is part of every testing method in order to allocate the evaluation of measured data of the field enquiry to the different visual effects.

The pre-formulated requirements for the “Eye-Tracking” test shall ensure that clear parameter could be determined. The results shall be time- and location-independently reproducible. Furthermore the whole test procedure should be financially affordable.

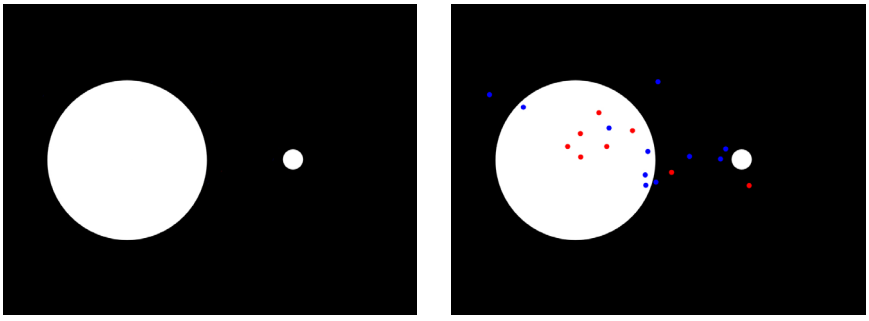
These requirements resulted in a monitoring of the visual parameters by using defined test boards. Outer disruption was nearly eliminated by using the light laboratory. To realize a prompt informative analysis, the entire scope has been limited. The experimental set-up contains three main parts:

1) Test person with “Eye-Tracking System”
2) One HD projector
3) A light-technical measured projection screenTotal time of a test sequence was 30 minutes.

5 minutes	Introduction and Explanation of the system
8 minutes	Adjustment of Instrumentation
12 minutes	Test
2 minutes	Disassembly of the Instrumentation

Of the given light impulses, the luminance and the chromaticity coordinate have been measured. Altogether 20 test persons (12 male and 8 female) have taken the test. The average age was 28.8 years.

Test board 1.0	Task: Two light beams with the same luminance, but different sizes.
Test board 1.1	Measurement: First sight



Result

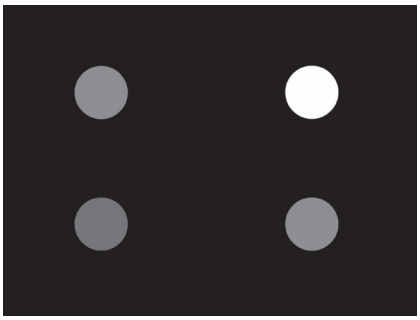
The visual perception of the two circles with the same luminance is the same. The different sizes do not have a significant effect on the “First sight”.

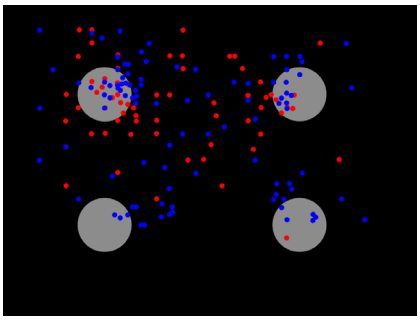
Test board 2.0

Task: Four light beams with the same luminance are given. After 5 seconds a dynamic movement began.

Test board 2.1

Measurement: First sight in relation to the starting dynamic movement





Result

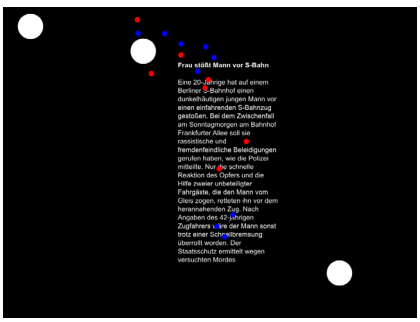
The dynamic changes were perceived very quickly. Male test persons scanned the whole projection screen. In contrast to this, the female test persons concentrated on one area.

Test board 3.0

Task: The test person’s attention should be attracted with a text. While reading the text three different light beams are displayed next to it.

Test board 3.1

Measurement: How does the visual behaviour change if an additional appeal appears?



Result

First of all, the test persons searched for the beginning of the text. Thereby the female test persons searched more precisely then the male ones. There is a significant attachment to the text in relation to the disturbance of the light beams. Again the female test persons read and followed the text more concentrated than the male test persons.

Test board 4.0

Task: A picture and a text are shown simultaneously. While watching the projection screen the picture changes.

Test board 4.1

Measurement: How does the visual behaviour change when a given theme (the picture) changes?

Result

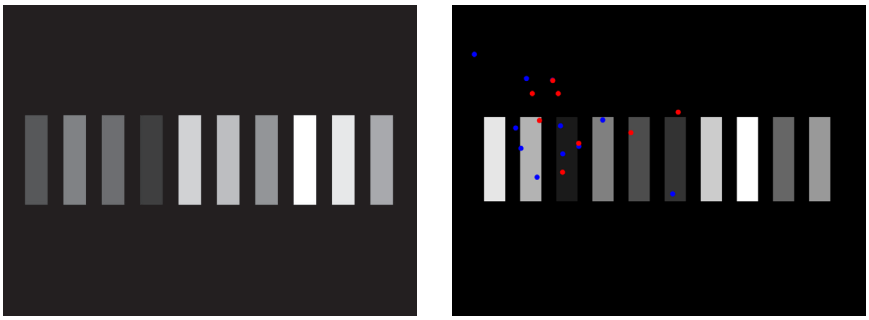
At first the test persons searched for the beginning of the text. The male test persons concentrated on watching the picture.
This test shows that the picture produced twice as much attraction for all test persons as the text. The change of the picture has been perceived over-proportionally by the male test persons.

Test board 5.0

Task: Graduations of White – divided in steps of 10% - are shown. To avoid a falsification of the results by favoured approach four different arrangements have been measured.

Test board 5.1

Measurement: Which areas, levels of brightness are favoured?



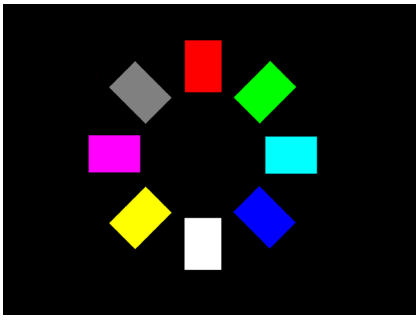
Result

Contrary to the common expectation, the test persons focussed on the darkest area of the test screen. Especially the “contrast-borders” have been fixed visually. Primarily, the interest lays on the “contrast-change” instead of the absolute brightest beam.

This test series has been executed with five additional test boards which came all to the same conclusions.

Test board 6.0

Measurement: Which colours are preferred?



Result	The test results show that there are no colour preferences. The scheme of watching this test board was noticeable, because some test persons watched in circular movements and others concentrated on watching the opposite colours.

Realization in praxis

Based on the test results it is possible to gain “practical” planning aids for the “Anthropogenic Lighting Design” (ALD).

Test No.1 showed that circles with the same luminance but different sizes are perceived equally. This effect builds the foundation for the “Light Intensity Levels Rule”.
By using distinct luminance differences in a preferably small room, it is possible to design a scene/lighting concept in an interesting and diversified way.
Luminaires with a narrow beam angle (for example 10°) are most suitable to realize these Light Intensity Level steps. Especially in combination with a reduced general lighting can significant steps be achieved.

Here is an example to explain the over-proportional visual rating of a small Light Intensity Level step in a “dark” surrounding: If a candle in a dark room is inflamed, it illuminates the room and it produces relatively high brightness levels. When the same candle burns in aroom that is illuminated with daylight, the lighting effect of the candle is nearly invisible. With increasing surrounding brightness our ability to perceive different brightness levels lessens.

The survey about “dynamic” effects offers a great variety for impressive lighting design concepts. Four parts of these dynamic effects are:

1) Colour Dynamic
2) Direction Dynamic
3) Characteristic Dynamic (soft or hard light)
4) Brightness Dynamic

“555-Rule“
To highlight a certain area the light has to have a wavelength of 555nm. The human eye perceives light at 555nm (yellow) as a lot more intense than blue (380nm) or red (780nm). This effect is supposed to lead a
spectator towards the product even though it is not the product itself but the display platform or an area close by that should be illuminated by yellow light. If a dynamic utilization of colour is desired the yellow light is only employed for a short period of time alternating with different shades of blue and red.

With this effect, the customer shall be lead to the products. Thereby the product itself is not illuminated, but the product carrier or an area next to the product carrier. If coloured effects are used in dynamic sequences a highlight arises by a limited use of the yellow light in contrast to the colour gradient in the blue/red part of the spectrum.

„Reversion Rule“
To directly target the attention of a spectator light and shade areas can be reversed. By rule people expect the light to come from overhead. This creates a normal direction of

shadowing. Reversion of this setting leads to prolonged attention and increases the duration of view and a longer
staying spectator.

„Characteristics Rule“
Indistinct changes between zones of directed light (defined shadows) and diffuse light (hazy shadows) can be used to channel attention. Direct light not only illuminates an article it also generates a shadow with very distinct boundaries. Changing the illumination to a diffuse lighting causes the shadow to be a bit blurred and showing less contrast. A constant change between these settings is an additional dynamic means. Neither direction nor intensity or colour need to be changed.

„Median Rule“
Fluctuating lights have to be timed within a median time-frame. The human eye does not want to be bored or overstrained. To avoid this changes in lighting have to be adjusted to the psychology of human perception and not to the technical potential. Lighting changes of very high or very low frequency can not be dealt with by a spectator. The mean duration of viewing a given product should be the upper limit of frequency. The mean duration of staying in the shop should be the lower limit for a sequence.
A dynamic lighting concept offers besides the effects of psychological perception also a huge energy-saving potential. The lighting can be presence-controlled which means, thatthe illumance levels are decreased when a customer is coming. In addition, a well-designed presence-controlled lighting concept can fulfil different functions: on the one hand a “serving” light, an ambient light that allows seeing. On the other hand a “focal glow” and a “play of brilliance”, light that leads the attention and attracts interest. These columns of lighting – ambient light, focal glow and play of brilliance – are based on the ideas of an American, called Richard Kelly (1910-1977).

Through the contemporary knowledge about the visual perception and the technical progress it is possible to design more functional lighting scenarios regarding optical and energetic topics.

It is essential for all light scenes: “Through the interaction of light and shadow appears the contrast that reveals the message.”

Lighting Design based on psychology of perception
Visual perception in shops

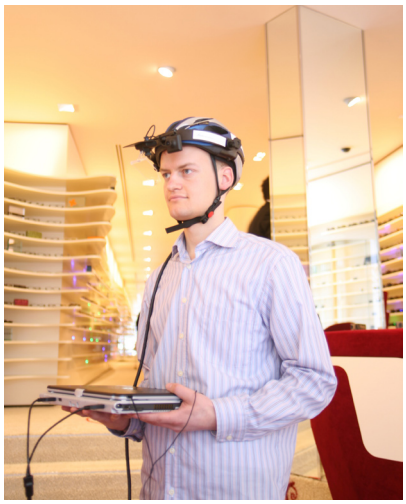
The amount of the visual perception of our overall cognition is 80%. The rest disperses on the perception of sounds, smells, tastes and the sense of touch.
The over proportional part of the visual perception shows impressively how important and necessary the professional handling for this part of our perception is.

Designing spaces means to make rooms perceptible and visible for the human being. The most important medium for this performance is light. It reveals various information about size, surfaces, materials and colours. Simultaneously, it allows for an orientation in the room.

As lighting designers we have the opportunity to show things passively (static) which means to illuminate things and highlight their characteristics. Therefore colours, characteristics, directions and intensities of light can be varied and combined.

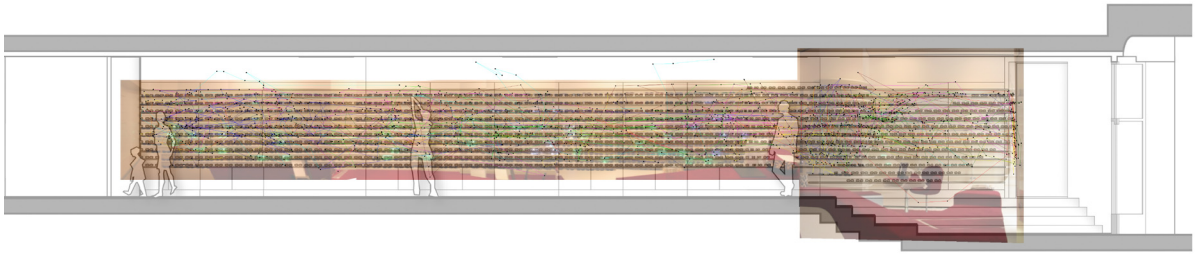
The opposite of the “passive” lighting design is the “active” (dynamic) illumination. The light itself gains more importance and its role changes from a representative medium to a self-contained medium that determines the message of the room and its atmosphere. Active illumination gains constantly more importance in the field of shop displaying. The image of shops changed from a passive sales area to an active world of new experiences. The image of a brand as well as the active guidance of the customer’s perception becomes more important in the contemporary lighting concepts.

Unfortunately many lighting concepts are developed without scientific research on the illuminations’ sales-promotional qualities. To expand this knowledge the University of Applied Science in Hamburg started a scientific research project about the visual room experience, examining the evaluation of static impulses of contrast in brightness and colour as well as dynamic changes in brightness and colour by using an “Eye-Tracking System”.



The analysis of a shop revealed information on how the different areas are experienced by customers – some attracted all attention and others have not even been noticed.

The picture below shows the distribution of visual fixations on a wall with shelf units. The surface is been watched very evenly and in the right area of the wall a concentration of fixations can be identified, which can be explained with an optical contraction of the image. In this part of the shop the wall is shaped like a curve which is shown as a compression of fixation.



The physiology in correlation with the psychology of sight

Together the human eyes have a visual field of ca. 180° (horizontal) and 150° (vertical). The field in which we see defined is limited to 1-2°. At a degree of 8° we only have a residual acuity of 20%.

In the field up to 120°, we are able to see and divide colours. In the field after 120°, we still perceive changes in brightness and contrast.
The process of perception takes place in three steps. The fastest adaptation is achieved by opening and closing the pupil. The sensitization of the biologic sensors (rods and cones) takes much longer. For a while we know that there is an additional receptor in our eyes which regulates the circadian rhythm (i.e. Sleep-Wake-Cycle) by being sensitive for blue frequencies in light (daylight as well as artificial light). This information describes the physiology of the visual perception.

As important as the physiology are the psychological rating and also the cultural area based rating of illumination and the personal relation to the colours of light.
In northern countries, light colours with high colour temperatures and a high proportion of blue in the spectrum are judged to be uncomfortable and cold, whereas in southern countries the same colour of light is highly appreciated because of its cooling effect.

The Asian culture has a long history in the usage of colours for interior spaces (for example Feng Shui). The composition of spaces and the use of colour are the results of different rules which aim to create a harmonic surrounding.
It is interesting to see that evaluation and hence the emotional effect of colours on the viewer differs according to his cultural and geographic origin. White for example stands for youth and purity in Europe; in Japan on the contrary it symbolizes sorrow.
In Germany the colour blue stands for loyalty and masculinity, whereas in France it is a symbol for anger and fear.

Consequently, for the use of colour in interior spaces we need to take into account influencing variables such as the cultural area, the age of the target audience, the surrounding brightness, the colour sequence, the brightness of luminous and coloured luminous areas.

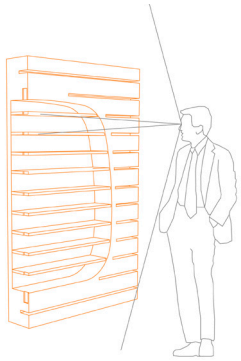
In addition to this, the location where highlights in brightness are set, the time in which dynamic processes take place, the light direction and the light characteristics, have to be considered.

The lighting design concept for the “Opticon Shop” in Hamburg is based on a diploma thesis which has been written in 2004 at the University of Applied Science in Hildesheim. This category of lighting design, which is aligned to the human perception, is called “Anthropogenic Lighting Design” (ALD).

The objective of shop lighting concepts, based on ALD, is to guide the customer’s attention and show him as many areas of the shop displays as possible, to extend the duration of his stay in the shop.
Passive illumination (see introduction) is used for orientation in the room and presenting the goods whereas active illumination constantly leads the visual focus around the shop. A colour dynamic light installation creates a visual appeal which captures the attention.

According to the research on the eye movement, we know that the upper part of a field, for example a shelf, is seen much better (more visual focus) than lower parts. This can be explained by our need to look into people’s faces to get more information about their mood. Therefore we are “scanning” our environment at eye level more intensely than above or below.

The consequence for the lighting design concepts is to “activate” the upper and lower parts of a shelf. If the customer is standing in a distance of 80cm in front of a shelf with a height of 2m, we would need to activate the area from the ground to 1m and above 1.7m to the ceiling.



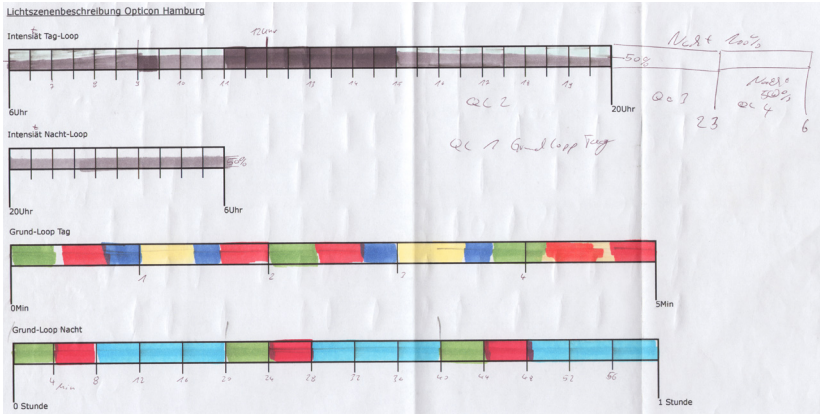
How does this type of lighting design looks like in praxis?

The activation in the “Opticon Shop” in Hamburg is realised with colour changing LED stripes, which create a “white wave” that wanders from the entrance to the end of the shop within 5 minutes at daytime. In addition, the intensity level of brightness increases according to the depth of the room. Therefore, the customer’s orientation is drawn into the shop. The “filling colours” within the loop (pre-programmed continuously recurring sequence) consist of the three main colours (Red, Green, and Blue) which produce less bright impressions.

The length of the single Loop-Times differs according to the customer’s time of residence. Moreover, the illumination’s intensities change. During lunch time the intensity reaches a climax to ensure that the artificial light effects are visible in contrast to daylight.

To create a highlight the light has to have a wavelength of 555 nm. The spectral perception of the eye evaluates this wavelength of 555nm (yellow) at daytime (photopic vision) stronger and brighter than the boundary areas of 380nm (blue) and 780nm (red).

This effect shall lead the customer to the products. Thereby the product itself is not illuminated, but the product carrier or an area next to the product carrier. If coloured effects are used in dynamic sequences a highlight arises by a limited use of the yellow light in contrast to the colour gradient in the blue/red part of the spectrum.



It is noticeable how the intensities are controlled in the course of a day. The outside impression of the shop is realised with the interior LED Illumination during night time. Based on the human perception (scotopic vision) at night time, this loop has a new concept that emphasizes the blue parts of the spectrum come to the fore. The illuminations' wave movement takes an overall time of 1 hour. Single segments are programmed with a loop time of 20 minutes. Occasionally short light flashes interrupt the calmness of the whole atmosphere. They produce confusion which prevents the adaption of the visual perception.

The chronology of the light changing processes takes place in a medial time frame. The medial exposure time at one product forms the upper limit of a sequence and the medial exposure time in the shop builds the lower limit for the cycle. The static light increases according to the spatial depth.

To attract the customers attention to the lower parts of a shelf the area at the bottom (three fifth) has to be accentuated with light. This rule is based on research of the eye movement, presenting the fact that human beings usually look at the upper parts of their surrounding or a shelf. However, this characteristic also depends on the target audience. Because of children's random observation behaviour the methods have to be increased. In "Opticon Shop", this is achieved by the positioning of LED stripes.

To create well directed attention points in the "Bo Concept Shop" the lighting concept uses punctual light focal points. To achieve huge differences in the visual sensation they have to be placed at the fore side of the human brightness perception. For example, a candle in a dark room (night time) produces a greater alteration in brightness, then the same candle at daylight, where no distinguishable change is visible.

It has turned out, that changes in the upper part of the brightness intensity provoke just substandard perceptions. In contrast, changes in the lower parts are experienced above average. This effect can be combined with the objective of presenting concentrated information. For a lighting design concept this means to reduce disturbance and the useage of new design elements On the contrary, single variations from this rule can create focal points of visual alertness.

So far, the results of the research project show, that the sight is controlled by light focal points. At the same time the relative size of a luminous field is crucial. A larger field with the same luminance is favoured.
If luminance is graded in steps of 10%, yet shown on a large field, the sight concentrates with 75% on the darkest part. In conclusion we know that the human perception concentrates on the area with the greatest viewing task. A direct comparison of contrasts has shown that the brightest parts are evaluated with 75% to be concisely.

These and other findings are required to increase the ecological and economical efficiency in lighting design for shops.