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Conspicuity index – looking for a possible objective measurement of visibility taking context into account

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Abstract

An emergency exit sign can be more or less visible. Something has to do with the sign itself: with bright colors it might be more visible than with faint colors. But also the context plays a role: alone on a white wall it will most likely become more visible than on a wall full of brightly colored posters. There is also a subjective side to the matter; you will more likely see the sign in an emergency situation than in an everyday situation. In the field of Information Design there is a need for an objective and easily administered measurement of conspicuity. Today a time measurement using visual search is possible, but often difficult and unpractical to use in real life.

In a small pilot study I have tested a new method of conspicuity index, a measurement method where the subject starts by looking at the target whose conspicuity is to be measured, then gradually looks away while attending to the target in the corner of his or her eyes until detection no longer is possible. The angle where detection ends is the conspicuity angle. Previous studies show a high correlation between the conspicuity index and traditional search time measurements. Results from this study show good accordance with intuitive impression of saliency.

Key Words: conspicuity, visibility, saliency, information design
Topic Cognitive ergonomics

1. Introduction

The saliency of signs and messages can be of large importance. Sometimes lives will depend on it. In Figure 1 two identical traffic signs are seen in two widely different environments. It is immediately obvious that the bottom sign is less visible than the top one. But how much less? Can its saliency be measured in some way? Within the field of information design it would be of great value if a simple measuring tool was found. This paper suggests investigating a method of *conspicuity* developed by Alexander Wertheim at Netherlands Organisation for Applied Scientific Research- TNO in Holland (1989).

Figure 1. Two identical traffic signs against two widely different backgrounds. How does the background affect the visibility of the sign? It is obvious that the top sign is more visible than the bottom sign, but can the difference be quantified?

Do a Conspicuity Test

Try a conspicuity measurement yourself and compare with the experimental results presented at the end of this paper. Place a printed color version of this page on the table. Take an ordinary A4-binder and use it as a forehead rest. Place it standing up on top of the Introduction section. Rest your forehead on the binder (which will give a distance of approximately 32 cm between your eyes and the paper) with your right eye vertically over the top traffic sign. Take a pen in your left hand and point it at the top traffic sign. Slowly move the pen to the left while continuously fixating the pen point with both eyes but attending the traffic sign in the corner of your eyes. Move the pen back and forward until you find the point when you no longer can detect that there is a sign in the middle of the green forest (this should be a point well off to the side of the paper). Repeat the same procedure with the bottom picture. The results should be different this time. Make a mark on the paper when you no longer can detect the bottom traffic sign (the one with the car falling off a dock side). Do this test also on the two panels in Figure 2. The predicted results are presented at the end of this paper.

2. Vision and Perception

Sensors in the human eye detect incoming rays of light which carry information of the world outside. This information is processed by different pathways in the brain. We call this bottom-up processing. Simultaneously, a top-down process governed by experience, expectations and knowledge helps interpret the sensory information until perception is reached, i.e. an understanding of what we just have seen.

Our intake of information through the eyes is limited to a number of fixations per second. Between the *fixations* the gaze moves rapidly over the scene in *saccades* during which information intake is suppressed. In each fixation we only see sharply in a narrow cone of about 1-2 degrees. The extent of the human peripheral sight amounts to an impressive 180 degrees but the quality is rapidly decreasing with increasing angle from the line of sight, both due to decreasing density of photo receptors and increasing convergence onto retinal ganglion cells. In just 6 degrees of eccentricity the visual acuity is reduced with 75 % (Purves et al., 2001). Still the amount of visual information gathered is estimated to be in the range of 10^8 bits per second (Itti & Koch, 2000). Of the massive amount of information that each second travels up the optic nerve from our eyes to the visual cortex only small fractions reach our conscious level. We sometimes believe that we see everything around us but phenomena like *change blindness* (e.g. Simons & Levin, 1997) dramatically reminds us that we are wrong. So how does perception pick out what objects to attend to and process up to our conscious level? How come that the traffic mark is so much easier to see against the green forest than against the cluttered wall?

The prevailing *feature integration theory* (Treisman & Gelade, 1980) states that perception picks up objects in a two step process where a first, fast, unattended, automatic, and parallel process codes a number of *separable dimensions* of the visual scene such as color, orientation, spatial frequency, brightness and direction of movement. These features are then processed in different areas of the brain and then in a second stage "glued" together to coherent objects by the focal attention in a slow serial process. If in a visual search process we want to detect a target based on just one of these separable features, such as looking for a red line among black lines (Figure 2 left), this could be automatically conducted by the first parallel process and the number of distracters will have little influence of the search time. The target immediately "pops-out".

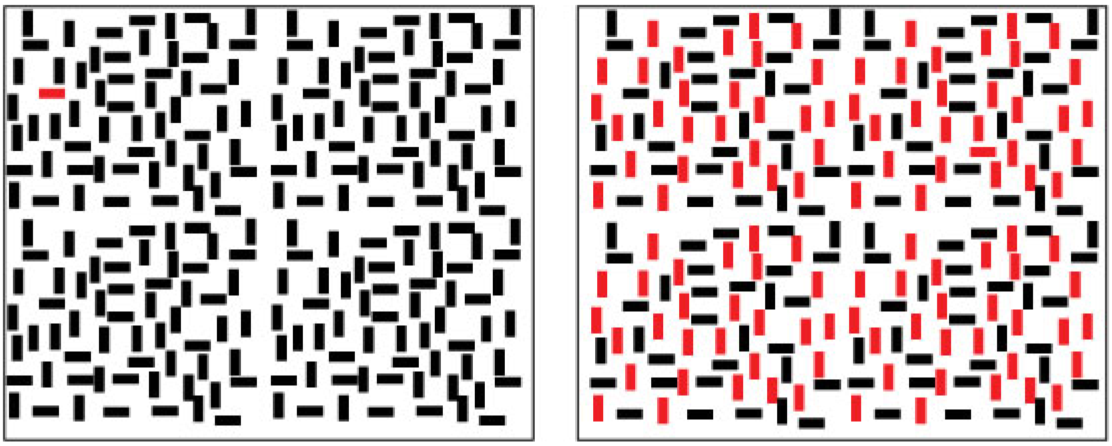

Figure 2. Try visual search for the red horizontal line (there is just one in each panel). In the left condition the distracters are all black which allows for rapid parallel search and the number of distracters has limited effect. In the right condition the distracters are both red, vertical lines and black horizontal, forcing the second stage of feature integration to kick in and conduct a slow serial search where the number of distracters influences search time in a linear way.

If on the other hand a search process involves integrating separable features the second focused attention mechanism needs to be called in, which involves slow serial search. This can be intuitively demonstrated by searching for the red horizontal line among the red vertical and black horizontal and vertical distracters in the right panel of Figure 2.

In the discussion of what accomplishes the early pre-attentive selection Koch and Ullman (1985) introduced the idea of *saliency maps* as a concept of mental two-dimensional maps that encodes the saliency of the visual environment based on the aforementioned features. The most salient feature would get the attention first and so on. It would then be the saliency of the red horizontal line in the left panel of Figure 2 that makes it pop-out in the fast pre-attentative stage. Predictions based on computed saliency maps would then be possible to make.

On the other hand in the second stage, selective attention and visual strategies based on top-down knowledge of the scene, such as searching for traffic signs along road sides makes prediction of search patterns impossible.

Based on the feature integration theory we can in Figure 1 understand why we so easily detect the yellow sign against the green wood and not against the cluttered wall. In the first case we could conduct disjunctive parallel search based on one feature (e.g. color or shape), in the second case we need to conduct slow serial conjunctive search. The established way to measure this difference in saliency is using search time. The method is cumbersome, the subjects cannot know in advance where the target is but has to know what to look for and each one can then only be used once. Furthermore chance plays a role (subjects might happen to look right at the target at once) so a large number of subjects need to be used to reach significance. But a simpler method has been suggested.

3. Conspicuity

Conspicuity is a concept defined as the extent to which the target object, when viewed peripherally is visually masked by its embedding surrounding (Wertheim et al., 2006). As such it is different from the concept of visibility, which refers to the properties of the object itself, such as color, brightness, size etc. The method can be used both in the physical setting and on photographs of the scene. The subject fixates a point well to the side (or in any radial direction) of the target and then successively moves the gaze towards the target until it can be detected (*detection conspicuity*) or identified (*identification conspicuity*). The process is repeated three times and can also be repeated the other way, from the target and out until it is no longer seen. The mean value of the angle can then be used as an index of conspicuity.

It is not self-evident that a measure of how well an object can be seen at different positions in the periphery of our vision can be applied to its visibility in the scene, but the correlation between conspicuity angle and traditional search times in natural scenes has been shown to be high (in the range of 0.74 – 0.89, Toet et al., 1998; Kooi & Toet, 1999). The logic is that during a search process, the larger the conspicuity index the greater the chance that a target is spotted when a fixation is within the radius of the conspicuity angle.

Theoretically conspicuity is explained as based on a sensory phenomenon called *lateral masking.* This theory is somewhat in opposition to the feature integration theory and suggests that the slow search in conjunctive condition is due to lateral masking and not to focal attention. This paper is not taking a stand in the question of the neurophysiology behind the method of conspicuity and for a deeper explanation and experimental evidence see Wertheim et al., 2006. From a pragmatic point of view the important thing here is if the method can be used in practical situations and show reliability. An investigation from an information design point of view has been commenced.

4. Results of the self test

A small pilot study on 19 subjects using the stimuli shown in Figures 1 and 2 has so far been conducted. From a distance of 32 cm between the eyes and the stimuli the conspicuity index (a distance recalculated to an angle) was measured. In the top picture (traffic sign in wood) the conspicuity angle was well outside of the paper to the left. For the lower sign the mean detection angle was 12° (66 mm, SD=24 mm) to the left of the sign. The results for Figure 2 are also shown below.

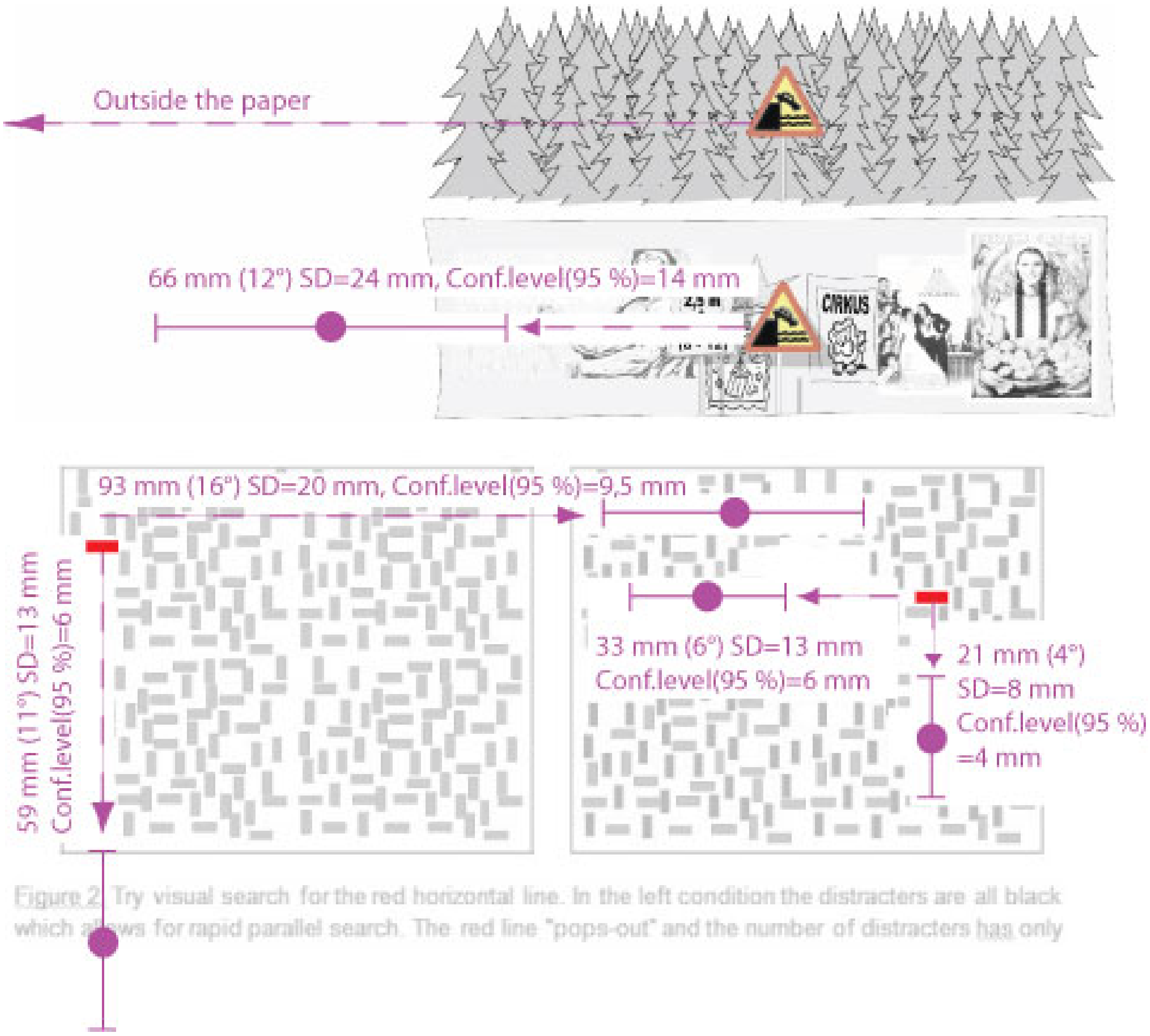

Figure 3. The results of the pilot study on 19 subjects. Compare these values with your own.

5. Conclusion

The results of the pilot study agrees well with the intuitive feeling of the visibility of the traffic signs against the two different backgrounds in Figure 1 and the red horizontal line segment in Figure 2. Together with results of experiments conducted in the referred studies I think that conspicuity index can be a very interesting candidate for an objective measurement of salience which can be used in traffic and control room environments, emergency signage, in printed an on-line environments, etc. The reliability of the conspicuity index as a tool will need further studies to determine its reliability and validity in different types of environments.

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