# Influence of the Effect Pigment Size on the Sparkle Detection Distance

***Omar Gómez[1*], Esther Perales[1], Elísabet Chorro[1], Valentín Viqueira[1], Francisco M. Martínez-Verdú[1], Alejandro Ferrero[2], Joaquín Campos[2]***

***[1] Color & Vision Group, Department of Optics, Pharmacology and Anatomy, University of Alicante, Alicante, Spain***

***[2] Instituto de Óptica, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain***

## Abstract

*In an effort to create more dynamic looking automobiles, there is an ever increasing trend among automobile manufacturers towards the use of gonio-apparent coatings in car bodies. These coatings consist of transparent pigments mixed with metallic or interference flakes. The flakes in the coating cause a change in color and brightness of the finish with viewing and illumination direction. This change in appearance accentuates the 3D shading of a car body, making it visually more attractive. Besides this angular dependence on viewing/illumination direction, the metallic finishes also exhibit a visually complex texture. Depending on the properties of the finish and the viewing and illumination conditions, the flakes exhibit a sparkle like texture, while the glossy clear coat may show a rough or smooth surface. As a result of these complex visual attributes, capturing the appearance and finding a perfect color match for an automotive coating is a non trivial task.*

*The main objective of this work is to evaluate the relationship between the special-effect pigments size, and the maximum distance which is detectable the sparkle texture effect. For this, two different sets of samples with different structural features were evaluated in a lighting booth specifically designed for the visual experiment. The booth allows to vary the lighting conditions, the viewing geometry and the distance at which the sample is perceived.*

*The visual experiment was applied to evaluate the high correlation between a structural parameter (i.e. pigment size) and the visual appearance attribute related with texture (sparkle detection distance). Under some fixed environmental conditions, as light intensity, color temperature and geometry of the light source, the sparkle detection distance was evaluated by applying the adjustment psychophysical method for two panel sets (metallic grays and blues), with known pigment sizes and colorimetry, with a small set of observers. The visual results show that a greater the pigment size, a greater the sparkle detection, but with some considerations.*

*In future, we will extend this method, even reinforced applying the statistical design of experiments (DOE), for understanding the relevance and interplay of structural (size, shape, concentration, orientation, etc.), environmental (illuminance level, color rendering, geometry, etc.) and colorimetric (dark vs. light background, chroma, etc.) factors on the sparkle detection distance.*

## Introduction

In the modern automotive industry, more and more manufacturers recognize that the paint appearance of cars makes an important contribution to customer product satisfaction. Attractive appearance has become one of the important factors for customers to make a decision when purchasing a car.

In general, objects or materials seen by humans are characterized by their shape, size, contrast and visual appearance. The visual experience induced in the eye and interpreted in the brain is called visual perception as defined in the standard practices as ASTM E284 [1]. According to this standard and the standard practice ASTM E2616 [2], visual appearance concerns the spectral and spatial perception of a visual stimulus in an environment specified by the geometric configuration of illumination and observation. According to the technical report CIE TC1-65 [3], the visual perception is subdivided in appearance components for color, gloss, texture and translucency. In addition to color and gloss, texture is one of the fundamental appearance components [3, 4]. Texture describes the location-dependent properties of a surface or its structure, pattern or topography. But, moreover, in the automotive industry, and in future in other industries (cosmetics, plastics, printing, etc.), and specifically in daily visual appearance quality control procedures in this industry, there is a growing challenge and a relevant need to know and predict better the interaction among color and texture differences in cars by a total or integral visual appearance model [5, 6]. However, in parallel, there are other fundamental challenges related to the detection, and even grading, of these new visual texture attributes as sparkle (glitter or glint). This work is only focused on the sparkle detection task which also implies to evaluate the visual and (current) instrumental correlation.

The appearance attributes of gonio-apparent automotive coatings depends on the viewing distance and illumination conditions. At larger distances of a few meters we observe macro appearance features such as color travel and luster [7]. On the other hand at a closer distance micro features such as the texture or the spatial distribution of color of the finish become more apparent [8].

Sparkle concept has been widely used by different authors [9 - 20], which can be defined according to standards ASTM E12.01 and ASTM E430 [21, 22]. It is a texture attribute for the perception of very small highlights in a surrounding. The tiny light spots are brighter than the surrounding.

Perception-related parameters for the perceived sparkle can be determined on the basis of bidirectional imaging measurements with instruments such as the multi-angle spectrophotometer BYK-mac [23], and some other theoretical models [20, 24]. The perception-related sparkle parameters are the sparkle area $S_a$, the sparkle intensity $S_i$ and the sparkle grade $S_G$. The total size of the small and bright areas per unit area are called sparkle area. The sparkle intensity is specified as the intensity of the small and bright light spots in relation to the intensity of the less bright surrounding [25]. The sparkle area and the sparkle intensity are combined in the representative sparkle attribute called sparkle grade [26].

$$S_G = 0.35 * \sqrt{(S_i * S_a)} - 0.8 \qquad (1)$$

The main objective of this work is to evaluate the relationship between the special-effect pigments size, and the maximum distance which is detectable the sparkle texture effect. For this, two different sets of samples with different structural features were evaluated in a lighting booth specifically designed for this experiment. This booth also allows to vary the lighting conditions, the viewing geometry and the distance at which the sample is perceived.

## Materials and Methods

For this work, a new lighting booth was used, specially designed to detect, scale and even discriminate sparkle at different distances, with different lighting geometries and with different light sources. The cabin has an adjustable arm to select the illumination geometry, to change the light source and to modify the intensity as required at each time (Figure 1).

For sparkle detection the booth was provided with a matt black environment and by sliding a chair we can obtain the distance which the sparkle is detected according to the sample in the booth. For this experiment we used a lighting level of 800 lux and a correlated color temperature of 2700K. The arm was placed at 30 cm from the sample and the illumination geometry was set at 15 degrees (Figure 1). We also used a black mask with a square of 7x7 cm to limit the viewing area of the sample

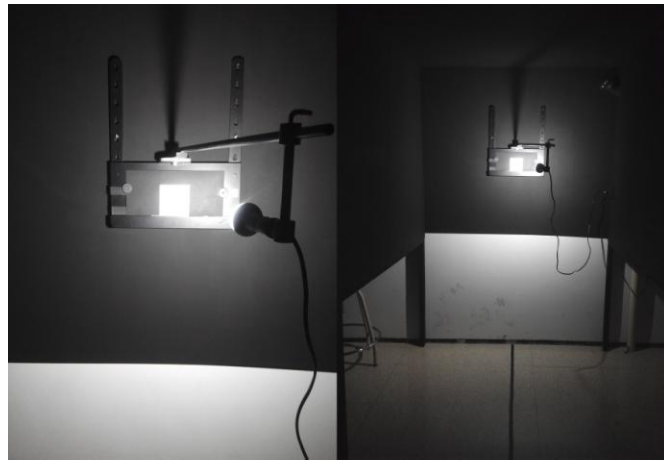

*Figure 1. Design of the lighting booth used in the experiment.*

We selected 12 samples with measures of 15x7 cm divided into two sets, basically differentiated by their chroma, six chromatic metallic samples (blue) and six achromatic metallic samples (gray). Both groups have the same type of pigment (Silverdollar) and different average sizes ($D_{50}$) between 10 and 55 μm.

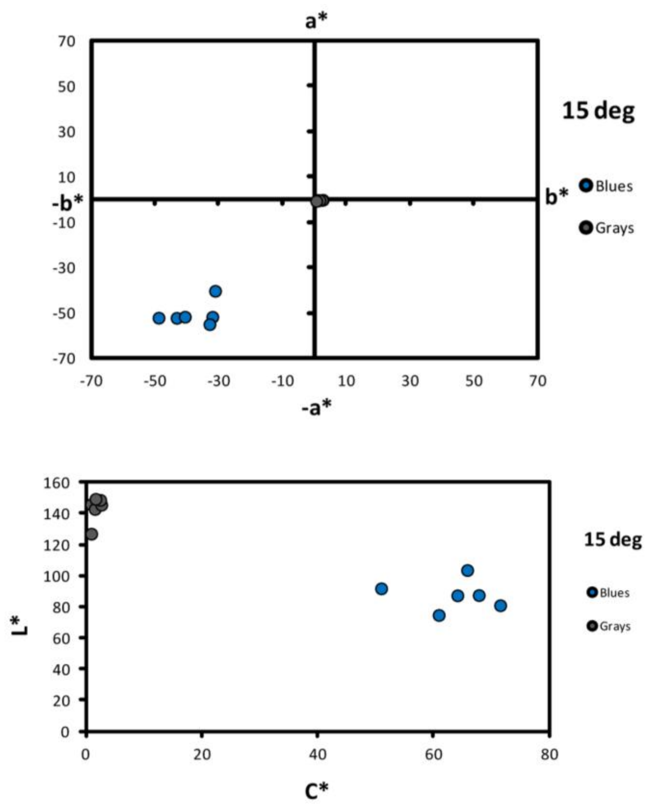


*Figure 2. Colorimetry of the studied panel sets under D65 illuminant and the measurement geometry 15as15 by a X-Rite MA98 multi-angle spectrophotometer, or CIE nomenclature 75x90, such as they are perceived in the visual experiment.*

Five observers, with normal color vision and visual acuity, participated in this experiment (3 men and 2 women). They made six evaluations per sample, three replications in which the observer was moving away from the sample and three in which the observer approached the sample to detect sparkle. Therefore, each observer performed 72 visual judgments between both subsets of samples, for a total of 360 visual judgments. The method used for the visual assessment was the method of adjustment, which is one of the oldest and most fundamentals of the psychophysics: the subject must adjust or manipulate freely the intensity of the stimulus (sparkle), until it is able to perceive it or to stop perceiving it, by adjusting the distance at which the sparkle is detected.

Previously, all observers received clear explanation about the sparkle concept. Moreover the height of the eyes was adjusted to the same height as the light source and sample, and before starting they spent some minutes for adapting the lighting conditions of this visual experiment.

## Results

### *Average Distance vs $D_{50}$*

After analyzing the results for both subsets, a clear tendency is observed: a greater pigment size, a greater detection distance for sparkle. However, there is no a lineal relationship between both parameters, in fact for the subset of blue samples, observers detected further away the sample with a particle size of 34 µm that for the particle size of 55 µm, and in a very similar way for the gray samples (Figure 3). This may be due to limitations in the human visual acuity, so in the automotive industry the maximum size found is 30 µm [25]. It would be desirable to have more samples in a range between 30 µm and 60 µm to verify this behavior.

Similarly, the instrumental value of sparkle ($S_G$) of the blue sample with a pigment size of 34 µm is larger than the sample with pigment size of 55 µm, what means that there is a correlation between the BYK-mac and the observer prediction, that is, at instrumental and visual level.

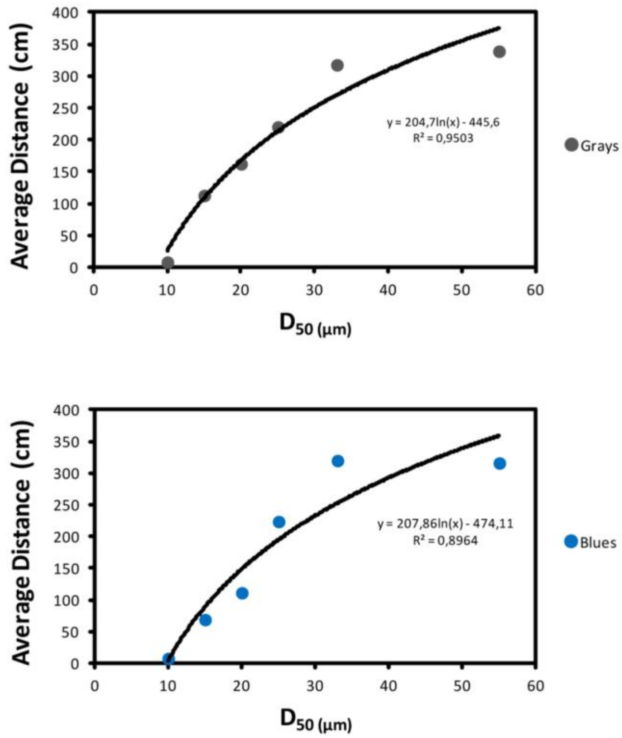


*Figure 3. Average Distance vs Pigment Size ($D_{50}$).*

### *Average Distance vs $S_G$*

One of the main objectives of this work is to verify that the instrumental measurement ($S_i$, $S_a$, $S_G$) of the BYK-mac correlates with the visual measurements made by observers. Figure 4 shows the relationship between the value of sparke ($S_G$) measured by the BYK-mac and the average distance obtained from the visual experiment. As it can checked, there is a good correlation. The results obtained for $S_i$ and $S_a$ values, is that, for $S_i$ against visual measurement, there is very good correlation, however against $S_a$ we found a very similar behavior with the pigment size ($D_{50}$), i.e. reached a certain area ($S_a$) the increased detection distance is nonlinear.

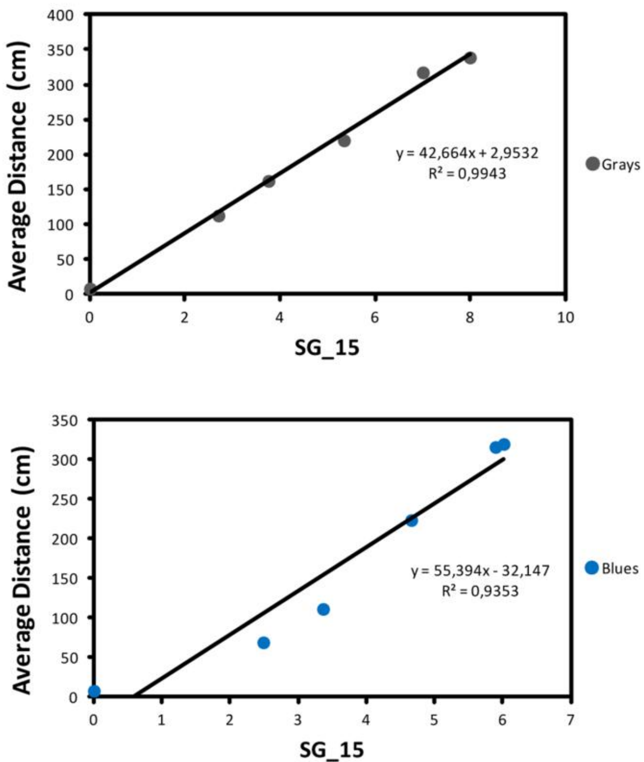


*Figure 4. Average Distance vs Sparkle Grade (15 deg).*

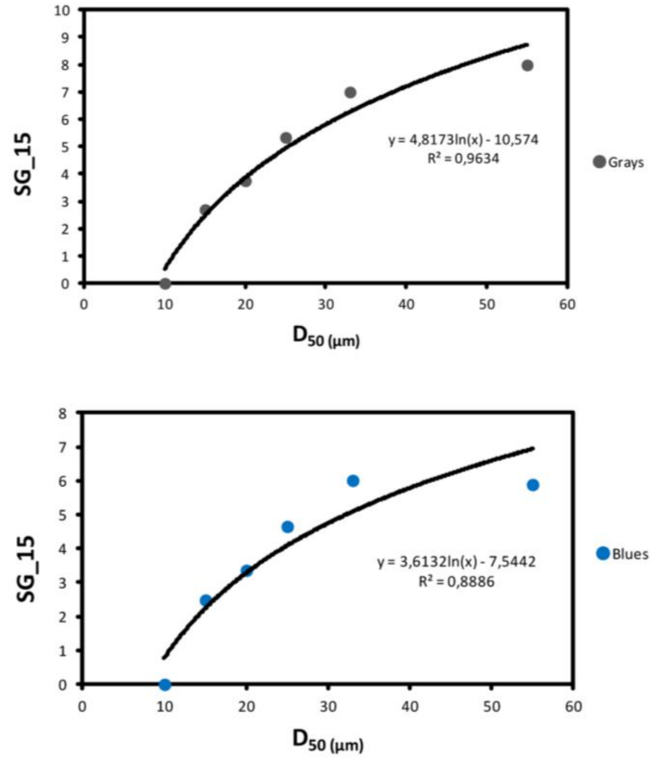


*Figure 5. Sparkle Grade (15 deg) vs Pigment Size ($D_{50}$).*

### $S_G$ vs $D_{50}$

With this comparison, we see again that the tendency between the value of sparkle against the size of the pigment is not linear, and it is observed that a greater the pigment size, a greater the sparkle detection distance (Figure 5).

## Conclusions

A visual experiment was applied to evaluate the high correlation between a structural parameter (i.e. pigment size) and the visual appearance attribute related with texture (sparkle detection distance). Under some environmental conditions, as light intensity, color temperature and geometry of the light source, the sparkle detection distance was evaluated by applying the adjustment psychophysical method for two panel sets (metallic grays and blues), with known pigment sizes and colorimetry, with a small set of observers. The visual results show that a greater the pigment size, a greater the sparkle detection, but with some considerations. Although the visual and instrumental correlation obtained is linear for the detection distance and sparkle grade ($S_G$), the relationship with pigment size ($D_{50}$) is not completely linear, showing a partial plateau or saturation level with bigger pigments, specifically with the area sparkle value ($S_a$), one of the two partial instrumental values ($S_a$ and $S_i$) for the sparkle grade value. Obviously, this psychophysical method and crossed analysis can be extended to other panel sets, with controlled structural, environmental and colorimetric features, but the fitting functions obtained here are only valid for these panel sets. In future, we will extend this method, even reinforced applying the statistical design of experiments (DOE), for understanding the relevance and interplay of structural (size, shape, concentration, orientation, etc.), environmental (illuminance level, color rendering, geometry, etc.) and colorimetric (dark vs. light background, chroma, etc.) factors on the sparkle detection distance.

There is very good instrumental and visual correlation of the sparkle, but it was described above, though a greater the pigment size, a greater the sparkle detection distance, this does not mean that the degree of instrumental sparkle ($S_G$) has to be higher as the observer is farther as he can detect sparkle. The reasoning for this is that, the instrumental measurement given by the BYK-mac is based on a fixed detection distance for the monochrome CCD camera, in fact, according to the equation described in the introduction (1), $S_G$ is a function of $S_i$ and $S_a$, so that a higher sparkle detection distance, we have a lower $S_i$, and hence a lower $S_G$.

The relationship between the size or area of pigment versus the detection distance is not a linear relationship, since with some bigger pigment sizes the observer does not dramatically increase the sparkle detection distance. Maybe, and difficult to be tested with the current panel sets, other structural variables, as the synthesis and/or coating processes, can influence on this.

### *Future Work*

Apply the statistical design of experiments (DOE) to study how they affect various structural and environment variables in the detection of sparkle. Several similar experiments will be carried out as described above but setting the variables we are interested to know, as the type of pigment (Silverdollar, Cornflake), the pigment size, density, contrast, illuminance level, measurement geometry, colorimetry of the sample, etc.

### *Acknowledgments*

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## Author Biography

Omar Gómez Lozano received his Materials Engineering from the Complutense University of Madrid in 2011, his master in Materials Science from the University of Alicante in 2012 and is doing his PhD in Physical Sciences and Technologies in the University of Alicante since 2012. His work has primarily focused on Color Science and Technology and Psychophysics and Visual Perception. He is current member of the Color & Vision Group (http://web.ua.es/en/gvc) of the University of Alicante. (omar.gomez@ua.es)