# COLOUR RENDERING OF LED SOURCES: VISUAL EXPERIMENT ON DIFFERENCE, FIDELITY AND PREFERENCE.

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## Introduction

This study looks at the perceived colour rendering quality of LED-based lighting. The objective was to present a new approach to quantifying the visual colour rendering of light sources. We investigate, with a paired comparison method, the quality of lighting in terms of colour difference, natural appearance and attractiveness. 45 subjects were asked to compare nine light sources at 3000K.

## Description of the experiment

In order to study these questions, a triple booth was designed. The central compartment and the one on the left were lit by 5 different types of LED (white, cyan, green, amber and red), the one on the right by halogen or fluorescence. The experimental setup was located in a room with no daylight and no ambient light. As targets, we selected fruits and vegetables and Macbeth ColorChecker.

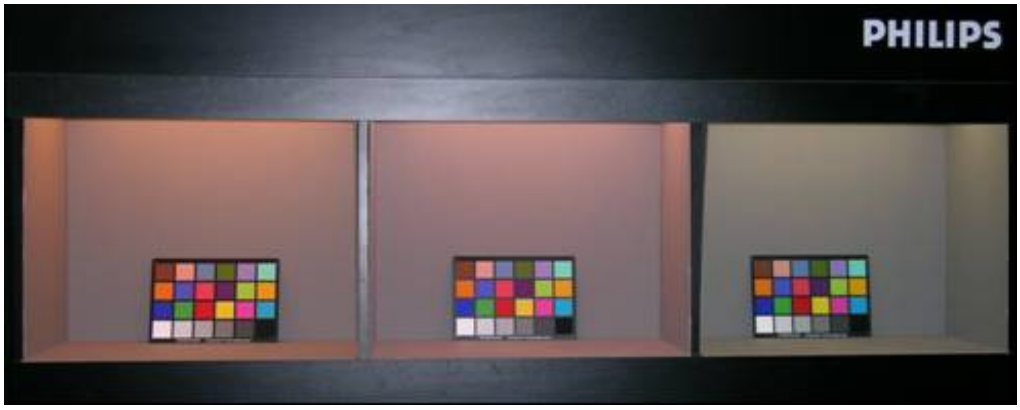


*Figure 1. Test setup for chromatic comparison (developed by Philips/ENTPE).*

Nine light sources were compared during the experiment: halogen, fluorescence and 7 clusters of LEDs:

"WA" cluster, with white and amber LEDs

"WR" cluster, with white and red LEDs

"WCR" cluster, with white, cyan and red LEDs

"WGR" cluster, with white, green and red LEDs

"WAR" cluster, with white, amber and red LEDs

"CRI" cluster with white, cyan, green, amber and red LEDs which optimise CIE CRI

"Spectra" cluster with white, cyan, green, amber and red LEDs which approximate the spectra of the reference light source (Planckian radiator at 3000K)

Relative intensities of each LED in every cluster were set in order to provide about the same illuminance (230 ± 6 lux) and the same colour temperature (3020 ± 80 K), as well as

to optimise the CIE CRI or to approximate the spectra of the reference light source (Planckian radiator at 3000K) whenever more than three types of LED light were mixed. During each experiment, the subjects viewed 2 side by side boxes (central-left or central-right depending on which pair is judge), and had to compare every pair of lighting. For each pair, they were asked to:

Estimate the colour difference between both lighting in a 0-6 scale

Select which lighting produces the most attractive colour rendering on fruit and vegetable or on charter (preference).

Estimate under which lighting fruit and vegetables appear most natural (colour fidelity)

or

Estimate under which lighting the colourfulness of the charter is highest.

45 subjects took part in the experiments. They were all screened for colour deficiency prior to start the experiment.

Results

The results obtained for the perception of LED-based lighting were quite positive.

It appears that it is possible to find mixtures of LEDs with lighting situations preferred in colour rendering. Indeed, in general, subject found that the colour rendering is more attractive with LEDs mixing than with standard light sources. Concerning the natural aspect, the standard light sources are chosen.

The paired comparison models of Bradley-Terry or Thurstone permit to map a scale of preference. Both statistical model yield nearly identical scales: the visual scale of attractiveness seems to be highly correlated with the gamut area while the scale of visual naturalness is highly correlated with CRI. But, neither CRI nor Gamut area, seem to describe completely the perceived naturalness or attractiveness.

Concerning the judgement of difference, none of the colorimetric formula (CIE13.3, CIELAB, CIECAM02) describe well the visual colour difference. But the colour difference from CIECAM02 is better than the one used in the calculation of the colour rendering index.

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Keywords: LED, colour rendering, colour perception.