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# Perceptibility and Acceptability of Surface Gloss Variation Under Different Illuminants

RS Rocha • VG de Carvalho • MNC Galvão • MY de Souza • TMF Caneppele • E Bresciani



### Clinical Relevance

The influence of different illuminants on the perception and acceptance of surface gloss variation in composite resins remains unclear but is important if restorations are to mimic natural teeth.

## SUMMARY

**Objective: The purpose of this study was to evaluate the influence of different illuminants on the perceptibility and acceptability of surface gloss variations and to determine limiting values.**

**Methods: Eight composite resin specimens and one human tooth specimen were polished to obtain composite resin specimens with different gloss units (GU) of 10, 20, 30, 40, 50, 60, 70, and 80 and a human tooth specimen of 80 GU. Sixty observers compared the surface gloss of the specimens in a light booth. For perceptibility testing, the specimens were randomly positioned two at a time. The acceptability of the gloss variation was determined by comparing the composite resin specimens with the tooth specimen. The observers answered specific questions to determine the**

Rafael Santos Rocha, MS, PhD student, Department of Restorative Dentistry, São Paulo State University (UNESP), Institute of Science and Technology, São José dos Campos, SP, Brazil

Victoria Garcia de Carvalho, master student, Department of Restorative Dentistry, São Paulo State University (UNESP), Institute of Science and Technology, São José dos Campos, SP, Brazil

Marina Nogueira de Castro Galvão, graduate student, Department of Restorative Dentistry, São Paulo State University (UNESP), Institute of Science and Technology, São José dos Campos, SP, Brazil

Maurício Yugo de Souza, PhD, Department of Restorative Dentistry, São Paulo State University (UNESP), Institute of Science and Technology, São José dos Campos, SP, Brazil

Taciana Marco Ferraz Caneppele, PhD, associate professor, Department of Restorative Dentistry, São Paulo State University (UNESP), Institute of Science and Technology, São José dos Campos, SP, Brazil

*Eduardo Brescianie, PhD, associate professor, Department of Restorative Dentistry, São Paulo State University (UNESP), Institute of Science and Technology, São José dos Campos, SP, Brazil

*Corresponding author: Instituto de Ciência e Tecnologia, UNESP, Departamento de Odontologia Restauradora, Av Eng Francisco José Longo, 777, São Jose dos Campos, SP, Brasil, 12245-000; e-mail: eduardo.bresciani@ict.unesp.br

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**level and perceptibility and acceptability limits of gloss variations. All analysis was done with two illuminants (D65 and fluorescent light) used randomly. Data were submitted to a nonlinear probit model and nonlinear probit regression estimation (α=0.05).**

**Results: Significant differences in illuminants were observed for perceptibility (*p*<0.001) and acceptability (*p*=0.045). The perceptibility limit for D65 was 7.0 GU and 6.8 GU for fluorescent illuminant. The acceptability limit for D65 was 34.2 GU and 37.1 GU for fluorescent illuminant.**

**Conclusions: More accurate perceptibility and acceptability judgments of the surface gloss of composite resin were made when the specimens were illuminated with D65 light.**

## INTRODUCTION

In addition to the expected degradation of resin restorations and clinical failures, many patients seek the replacement of anterior restorations for improved esthetics.[1] Therefore, understanding the optical properties of restorative materials is required to provide restorations that accurately mimic natural teeth.

The type of light in dental offices is a determinant factor for optimal esthetic treatment, since illuminants directly influence the optical perception of restorative materials, including metamerism and translucency.[2-7] If the color of a composite resin or ceramic restoration is chosen under poor lighting, esthetic problems might be perceived subsequently.

Different illuminants also influence surface gloss perception[3.] The surface gloss of restorations should match the natural tooth structures to obtain an acceptable to excellent restoration, and esthetics are compromised if such a match is not achieved.[8] The type of clinical illumination might influence the mimicking of a restoration outside the clinical setting under different lighting, as gloss perception under incandescent light is higher than under a fluorescent source.[3]

In a study that evaluated the limits of perceptibility and acceptability (endpoints in which 50% of observers perceived differences) of the surface gloss of composite resins, the authors concluded that small differences in gloss variations were perceptible but that observers accepted almost five times that difference in a clinical situation.[8] The referenced study assessed the overall perceptibility and acceptability of surface gloss with no comparison of different light sources. Moreover, the authors are only aware of a single study evaluating the influence of different illuminants on surface gloss,[3] which had few observers and a larger variation in surface gloss between specimens, indicating that studies with more participants and more observations are required for more robust results.

Thus, the purpose of this study was to evaluate the influence of different illuminants (D65 and fluorescent light) on the perceptibility and acceptability of the surface gloss variations of composite resins. The null hypothesis was that illuminants would not influence the perceptibility and acceptability of the surface gloss of resins. Additionally, the limits of perceptibility and acceptability of gloss variations under the two tested illuminants were determined.

## METHODS AND MATERIALS

This study was approved by the local institutional review board (IRB) under protocol no. 1.824.169 and initiated only after IRB approval. Sixty observers were enrolled: 20 lay people (unrelated to dental practice), 20 predoctoral dental students in Dentistry (fifth and sixth semester students who had started clinical practice), and 20 dentists (more than two years after graduation). The observers were between ages 18 and 50 years and signed an informed consent. The Snellen visual graph was administered to exclude participants with defective vision (corrected below near to 10/10 or 10/3 on the metric scale). Stereoscopic vision was also tested for discrepancies.[3,8,9]

Eight 6-mm diameter and 1.5-mm thick (1.0 mm with dentin resin and 0.5 enamel resin) specimens were fabricated incrementally with an A2 shade nanofilled composite resin (Filtek Z350 XT, 3M ESPE, St Paul, MN, USA) in a stainless-steel mold. Each increment was light activated for 40 seconds (Radii-Cal, SDI, Victoria, Australia) at 900 mW/cm² as determined by a radiometer.

An anterior human tooth, assessed with a shade guide (Vita Classical, Vita Zahnfabrik, Bad Säckingen, Germany) to be A2 shade, was cut into an enamel and dentin disk with a 6.0 mm diameter with a diamond trephine drill (Serra copo 6 mm; Geral utilidades) connected to a drill press (HiTorque Micro Mill; 2MT Spindle, Pasadena, CA, USA). The enamel surface was planed with a #800 abrasive disk grit (Fepa-P, Extec, Enfieild, CT, USA) mounted in a polishing machine (DP-10, Panambra, Sao Paulo, SP, Brazil) at 300 rpm with a load of approximately 1 N under distilled water irrigation. The thickness of the enamel was reduced to 0.5 mm to the dentin junction. The specimen was then placed in a 1.5-mm deep metal device to remove dentin, resulting in a specimen with 1-mm dentin and 0.5-mm enamel thickness.

The enamel surfaces of the composite resin specimens were polished for 30 seconds each with abrasive disk grits #1200 and #2400 (Fepa-P; Extec) in a polishing machine (DP-10; Panambra) at 300 rpm at an approximately 1-N load under distilled water irrigation. Subsequently, they were polished using abrasive disk grits #1200, #2400, and/or #4000 fixed to a flat surface and under water irrigation to obtain specimens with 10, 20, 30, 40, 50, 60, 70, and 80 gloss unit (GU). Polishing was performed with a figure eight circular motion holding the specimen by the thumb with no pressure, following a previously described protocol.[3,8]

The specimens were immersed in an ultrasonic bath for 5 minutes before the surface gloss was measured (Novo-Curve, Rhopoint TM, St Leonards-on-Sea, East Sussex, England) on a 2 mm × 2 mm area and with a 60-degree light incidence.[10-12] A metal device was used to block and eliminate interference from environmental light.[12] Three measurements were made on each specimen on the enamel resin surface, and the average obtained was used as the final gloss value providing the values fell within an acceptable variation of ±0.9 GU. If the specimen did not match the predetermined average of the surface gloss of the group, the polishing procedure was repeated.[8] The sequence of the polishing procedure was similar for the human tooth specimen. After the three measurements, the average surface gloss was 80 ± 0.9 GU. The specimens were arranged in the light booth (MM-4E, Gti, Newburgh, NY, USA), two at a time, with the combination and order of specimens randomly determined (sealedenvelope.com), and positioned to allow light incidence of different illuminants (D65 and fluorescent light) on the specimen's surface at an angle of 60 degrees. Those illuminants were chosen to represent a daylight range (D65), which individuals are most exposed to, and the light most used in dental offices (fluorescent).

Of the observers, 50% first observed the specimens at a nonfixed angle of observation during gloss qualification.[9,13] After those observations, the booth was closed, and observers performed gloss qualifications at a fixed 60-degree angle of observation. The illuminant sequence was determined randomly for both assessments.

The other half of the observers began gloss assessment with a fixed angle of 60 degrees, with the sequence of the types of illuminant defined randomly. The booth was then opened, and the observers evaluated the surface gloss at a nonfixed angle.

All observers evaluated at both angulations and under the two types of illuminants (D65 and fluorescent light). Therefore, a specific randomization was done for each observer and each observation condition. To avoid eyestrain, observers were provided with 5-minute breaks after 30 minutes of analysis.[14] For perceptibility, the resin specimens were randomly evaluated against each other. For acceptability, the resin specimens were randomly compared with the human tooth specimen. Randomization considered possible specimen combinations, and it was determined using a website tool.

The observers ranked the specimens under analysis by answering the following questions for perceptibility: Do both specimens present the same surface gloss? If not, which one presents the greater surface gloss? For acceptability, do both specimens have the same surface gloss? If so, the questioning stopped, and the nondetected surface gloss difference was considered clinically acceptable. However, if the answer was no, a second question was asked: Would this difference be clinically acceptable in a restored anterior tooth?[8]

The data were submitted to a nonlinear generalized model with the probit nonlinear regression test ($\alpha$=0.05). The binary responses represented by the correct or incorrect answers on gloss differences by observers were considered as a dependent variable, and the frequency of accepted and perceived variations was considered as a frequency variable. Independent variables (types of illuminants and variations in surface gloss between specimens and the human tooth) were also set for the analysis.

The nonlinear estimation function was used in the probit model to determine the limit of acceptability and perceptibility of the gloss. This limit has been defined as the point at which more than 50% of observers accept or perceive brightness variation.[8]

## RESULTS

The mean perceptibility and acceptability values and the frequency of correct responses are presented in Figures 1 and 2, respectively. For the perceptibility assessment, each of the 60 observers evaluated 112 combinations (n=6720). The type of illuminant resulted in a statistically significant difference ($p$<0.001). Differences among gloss variations ($\Delta$GU) were also detected for perceptibility, and the patterns of perception were 10 < 20 < 30 < 40 < 50 < 60 < 70 for D65 and 10 < 20 < 30 < 40 = 50 = 60, 50 = 60 = 70 and 40 < 70 for the fluorescent illuminant. The perceptibility limit was 7.0 GU for the D65 and 6.8 GU for the fluorescent illuminant. Although the perceptibility limits were close (0.2 GU of difference), when the $\Delta$GU equaled zero and the point at which 95% of the observers detected differences among the specimens, the observers were more discerning with D65 (Figures 3 and 4).

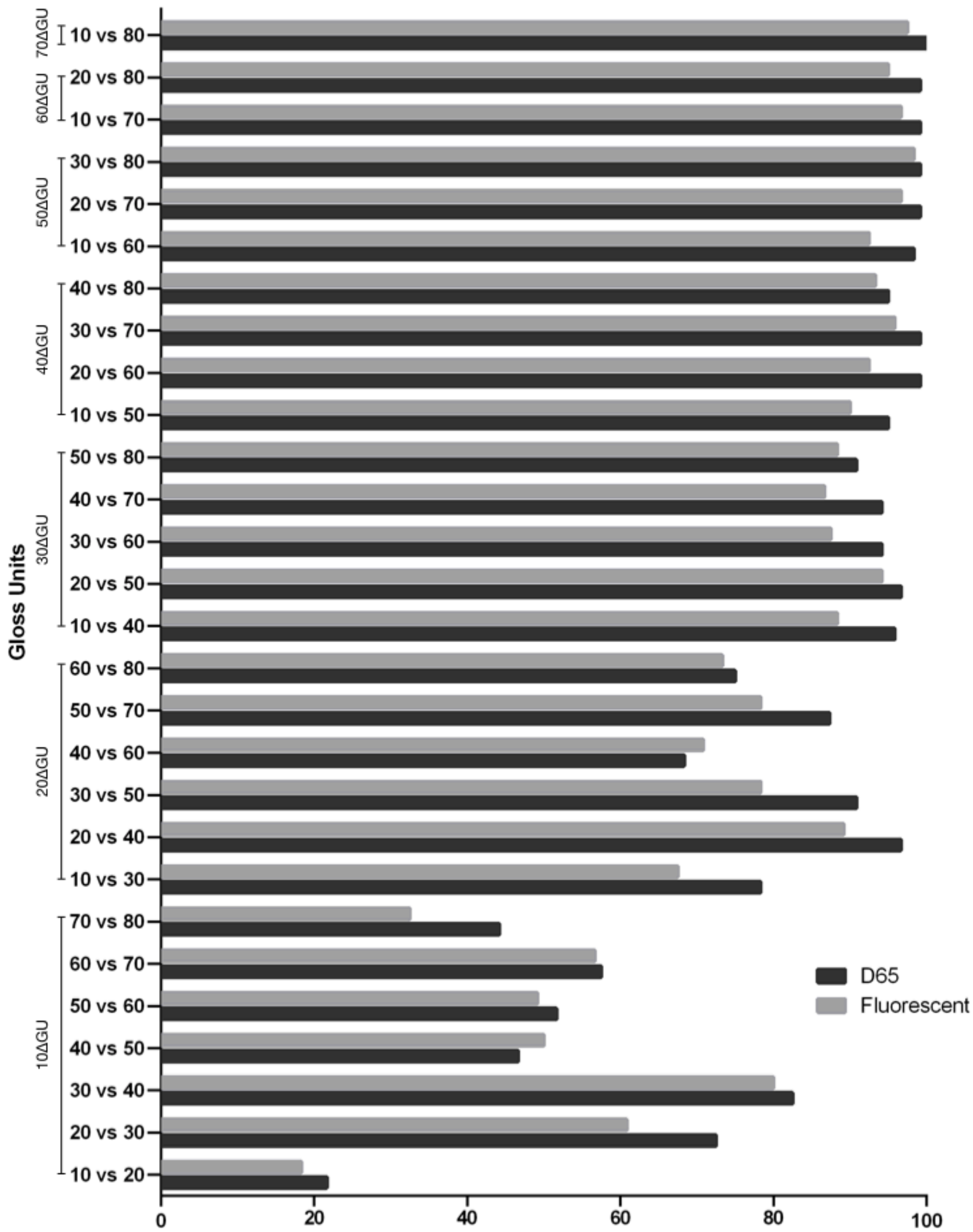


*Figure 1. Percentage of perceptibility of gloss variation with D65 and fluorescent illuminants.*

For acceptability, each observer evaluated 32 combinations. A statistically significant difference was obtained for the type of illuminant ($p$=0.045). Differences among ΔGUs were detected and the patterns of acceptability were similar for both illuminants: 0 = 10 > 20 > 30 > 40 > 50 > 60 = 70. The acceptability limit was 34.2 GU for D65 and 37.1 GU for fluorescent light. The characteristics of both curves showed that the observers were more discerning when the analysis occurred under the D65 illuminant (Figures 5 and 6).

## DISCUSSION

Incident light on an object surface, if not absorbed or transmitted by the object, is reflected either in a specular or diffuse form. Gloss may be perceived through specular reflection.[15] The influence of the illuminant on the perception of optical properties, including the material's gloss,[13,16] as found in this study, led to the rejection of the null hypothesis that no difference would be found between the illuminants in relation to perceptibility and acceptability.

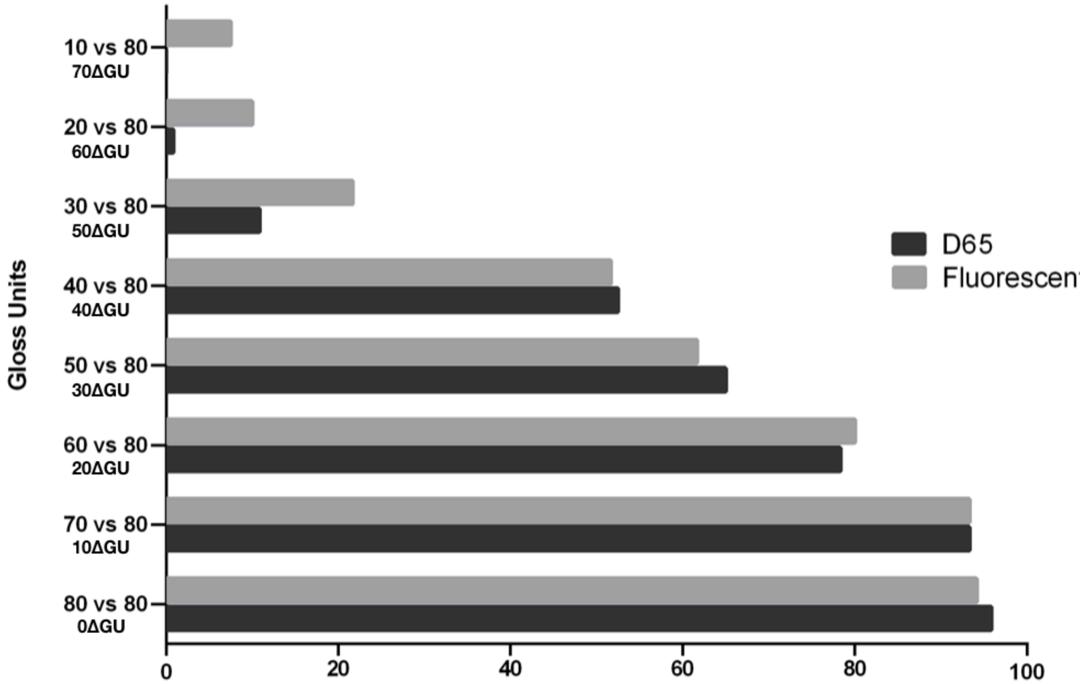


*Figure 2. Percentage of acceptability of gloss variation with D65 and fluorescent illuminants.*

Light reflection has been described as one of the most important optical attributes,[15] since it allows the observer to perceive the material's surface. The direction of light incidence on an object affects the perception of gloss and the texture of the material.[13] Marlow and Anderson[2] evaluated the influence of different illuminants that simulated real-world lighting in the "kitchen," "grove," and "campus" (light probes obtained from Debevec Light Probe Image Gallery; Debevec, 1998). The lights were focused on different spheres made of the same material. Between the spheres, the surface curvature of the materials was increased and, consequently, the sharpness of the reflections. Spheres containing higher curvatures had larger reflection areas with increased gloss perception. The type of illuminant influenced this observation, with the kitchen light being superior to the others. Similarly, another study reported increased gloss perception in curved compared with flat surfaces, since elevated areas tend to produce points of specular

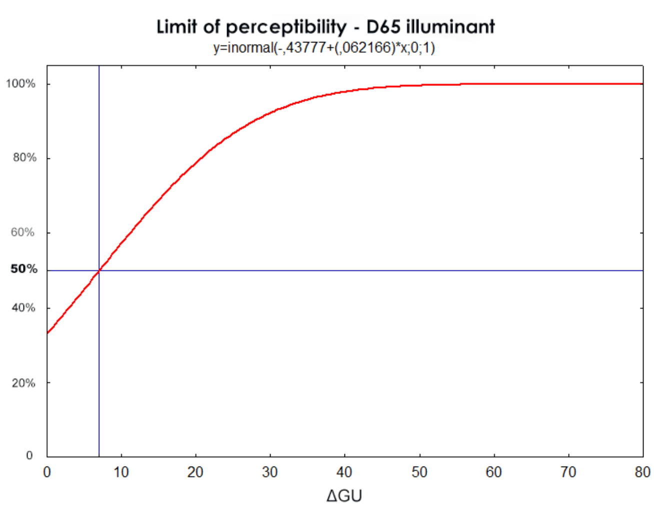


*Figure 3. Limit of perceptibility (50% observers) under D65 illuminant.*

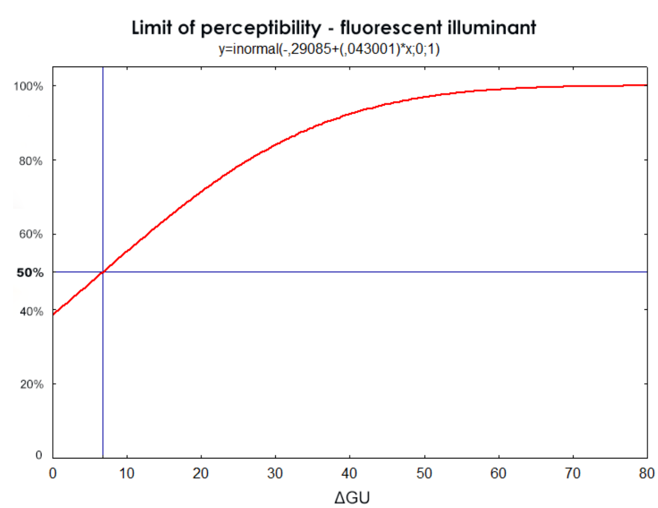


*Figure 4. Limit of perceptibility (50% observers) under fluorescent illuminant.*

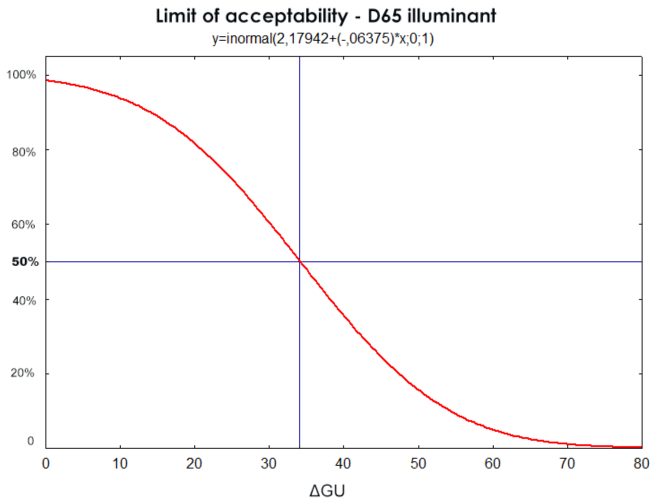


*Figure 5. Limit of acceptability (50% observers) under D65 illuminant.*

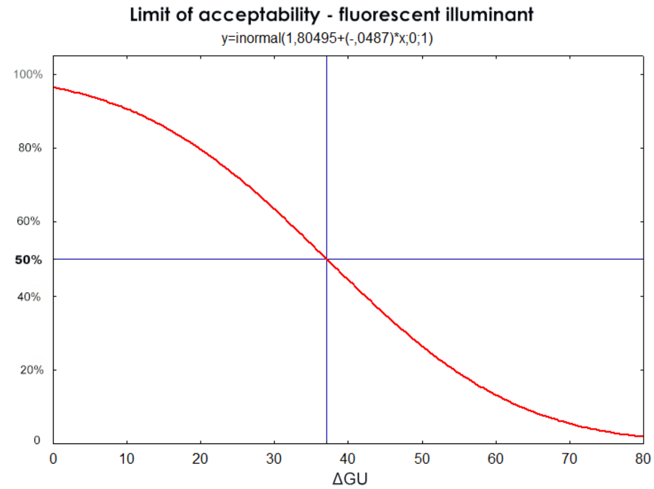


*Figure 6. Limit of acceptability (50% observers) under fluorescent illuminant.*

reflection.[17] Therefore, different illuminants interact with object surfaces in different ways because of different spectra and/or light energies. In the present study, significant difference was found between D65 and fluorescent light, both for perceptibility and acceptability, although the perceptibility limit for fluorescent light was close to that of D65 light (Figures 3 and 4). A higher GU variation is required for 95% of the observers to perceive a difference between two specimens under fluorescent light.

Regarding acceptability, where 95% of the observers would not accept the differences between two specimens in a restorative treatment, a difference of 10.8 GU was found between the illuminants, with the judgment being more discerning under D65 light. This illuminant has a color temperature close to 6500 K and represents daylight.[18]

Similar dental studies are sparse. Tessarin and others[3] evaluated the influence of illuminants and different observers in relation to the perception of the surface gloss of the composite resins, comparing D65, fluorescent, and incandescent lights. They found no difference for illuminant D65 in relation to the others; however, the incandescent and fluorescent lights differed, with the fluorescent light being the illuminant under which the observers perceived less difference. Also, Tessarin and others[3] reported a perceptibility limit of about 17.6 GU. The low number of observers and the greater ΔGU interval among specimens in that study may have resulted in the not statistically significant differences between the D65 and fluorescent illuminants. Their perceptibility limit was more than 10 GU above that in the present study.

Rocha and others[8] evaluated the perceptibility and acceptability of the surface gloss of composite resins, with factors that could influence clinical gloss perception (illuminant, viewing angle, and instructions to the observer). Their perceptibility and acceptability results were similar to the present study. However, their conclusions were based on the interaction of all factors and not on the conditions analyzed individually.

Fluorescent light might be the illuminant most used in dental offices. However, as the patient will be exposed to a variety of illuminants, the dentist must ensure that the finishing and polishing protocol provides the optimal gloss match under all conditions. Based on the results of this study, fluorescent light is not the best illuminant for perceiving surface gloss variations. However, as the acceptability of gloss presents a broader variation in comparison to the perceptibility, the before-mentioned statement might not be a clinical concern.

Limitations in the present study include that the illuminants were evaluated independently, and specimens were assessed dry. Other factors (light incidence, type of background, and the presence of saliva) might influence the perception of gloss. Moreover, future research should consider the aging of restorations and the gloss of dental ceramics.

## CONCLUSIONS

Based on the findings of this study, the following conclusions were drawn:

1. Observers perceived more gloss variations with less acceptability of such variations in surface gloss when illuminated by D65 light.

2. A variation of 7.0 GU was needed for 50% of the observers to perceive surface gloss differences under D65 light and 6.8 GU under fluorescent light.
3. For acceptability, a variation of 34.2 GU for D65 light and 37.1 GU for fluorescent light was needed for observers not to accept surface gloss differences.

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## Regulatory Statement

This study was conducted in accordance with all the provisions of the human subjects oversight committee guidelines and policies of the institutional review board of the Institute of Science and Technology of Sao Jose dos Campos–UNESP. The approval code issued for the study is 1.824.169.

## Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or companythat is presented in this article.

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