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Standard Guide for Designing and Conducting Visual Experiments[1]

This standard is issued under the fixed designation E1808; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is intended to help the user decide on the type of viewing conditions, visual scaling methods, and analysis that should be used to obtain reliable visual data.

1.2 This guide is intended to illustrate the techniques that lead to visual observations that can be correlated with objective instrumental measurements of appearance attributes of objects. The establishment of both parts of such correlations is an objective of Committee E12.

1.3 Among ASTM standards making use of visual observations are Practices D1535, D1729, D3134, D4086, and E1478; Test Methods D2616, D3928, and D4449; and Guide E1499.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1535 Practice for Specifying Color by the Munsell System
D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale
D3134 Practice for Establishing Color and Gloss Tolerances
D3928 Test Method for Evaluation of Gloss or Sheen Uniformity
D4086 Practice for Visual Evaluation of Metamerism
D4449 Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearance
E284 Terminology of Appearance
E1478 Practice for Visual Color Evaluation of Transparent Sheet Materials
E1499 Guide for Selection, Evaluation, and Training of Observers

3. Terminology

3.1 The terms and definitions in Terminology E284 are applicable to this guide.

3.2 *Definitions:*

3.2.1 *appearance, n—in psychophysical studies*, perception in which the spectral and geometric aspects of a visual stimulus are integrated with its illuminating and viewing environment.

3.2.2 *observer, n*—one who judges visually, qualitatively or quantitatively, the content of one or more appearance attributes in each member of a set of stimuli.

3.2.3 *sample, n*—a small part or portion of a material or product intended to be representative of the whole.

3.2.4 *scale, v*—to assess the content of one or more appearance attributes in the members of a set of stimuli.

3.2.4.1 *Discussion*—Alternatively, scales may be determined by assessing the difference in content of an attribute with respect to the differences in that attribute among the members of the set.

3.2.5 *specimen, n*—a piece or portion of a sample used to make a test.

3.2.6 *stimulus, n*—any action or condition that has the potential for evoking a response.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *anchor, n*—the stimulus from which a just-perceptible difference is measured.

3.3.2 *anchor pair, n*—a pair of stimuli differing by a defined amount, to which the difference between two test stimuli is compared.

3.3.3 *interval scale, n*—a scale having equal intervals between elements.

3.3.3.1 *Discussion*—Logical operations such as greater-than, less-than, equal-to, and addition and subtraction can be performed with interval-scale data.

[1] This guide is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.11 on Visual Methods.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.3.4 *law of comparative judgments*—an equation relating the proportion of times any stimulus is judged greater, according to some attribute, than any other stimulus in terms of just-perceptible differences.

3.3.5 *nominal scale, n*—scale in which items are scaled simply by name.

3.3.5.1 *Discussion*—Only naming can be performed with nominal-scale data.

3.3.6 *ordinal scale, n*—a scale in which elements are sorted in order based on more or less of a particular attribute.

3.3.6.1 *Discussion*—Logical operations such as greater-than, less-than, or equal-to can be performed with ordinal-scale data.

3.3.7 *psychometric function, n*—the function, typically sigmoidal, relating the probability of detecting a stimulus to the stimulus intensity.

3.3.8 *psychophysics, n*—the study of the functions relating the physical measurements of stimuli and the sensations and perceptions the stimuli evoke.

3.3.9 *ratio scale, n*—a scale which, in addition to the properties of other scales, has a meaningfully defined zero point.

3.3.9.1 *Discussion*—In addition to the logical operations performable with other types of data, multiplication and division can be performed with ratio-scale data.

3.3.10 *scale, n*—a defined arrangement of the elements of a set of stimuli or responses.

4. Summary of Guide

4.1 This guide provides an overview of experimental design and data analysis techniques for visual experiments. Carefully conducted visual experiments allow accurate quantitative evaluation of perceptual phenomena that are often thought of as being completely subjective. Such results can be of immense value in a wide variety of fields, including the formulation of colored materials and the evaluation of the perceived quality of products.

4.2 This guide includes a review of issues regarding the choice and design of viewing environments, an overview of various classes of visual experiments, and a review of experimental techniques for threshold, matching, and scaling experiments. It also reviews data reduction and analysis procedures. Three different threshold and matching techniques are explained, the methods of adjustment, limits, and constant stimuli. Perceptual scaling techniques reviewed include ranking, graphical rating, category scaling, paired comparisons, triadic combinations, partitioning, and magnitude estimation or production. Brief descriptions and examples, along with references to more detailed literature, are given on the appropriate types of data analysis for each experimental technique.

4.3 For reviews of topics in other than visual sensory testing within ASTM, see Refs (**1, 2**).[3]

[3] The boldface numbers in parentheses refer to a list of references at the end of this guide.

5. Viewing Conditions

5.1 *Light Source*—The illumination of the specimens in scaling experiments must be reproducible over the course of the experiments. To achieve this, it is essential to control both the spectral character and the amount of illumination closely in both space and time. Failure to accomplish this can seriously undermine the integrity of the experiments. The spectral power distribution of the illumination should be known or, if this is not possible, the light source should be identified as to type and manufacturer. Information such as daylight-corrected fluorescent light, warm-white fluorescent light, daylight-filtered incandescent light, incandescent light, etc., together with parameters such as correlated color temperature and color rendering index, if available, should be noted in the report of the experiment.

5.2 *Viewing Geometry*—Almost all specimens exhibit some degree of gonioapparent or goniochromatic variation; therefore the illuminating and viewing angles must be controlled and specified. This is particularly important in the study of specimens exhibiting gloss variations, textiles showing directionality, or gonioapparent (containing metallic or pearlescent pigments) or retroreflective specimens, among others. This control and specification can range from correct positioning of the source and observer and the elimination of any secondary light sources visible in the specimens, for the judgment of gloss specimens at and near the specular angle, to more elaborate procedures specifying a range of angles and aperture angles of illumination and viewing for gonioapparent and retroreflective specimens. When fluorescent specimens are studied, the spectral power distribution of the source must closely match that of a designated standard source.

5.3 *Surround and Ambient Field*—For critical visual scaling work, the surround, the portion of the visual field immediately surrounding the specimens, should have a color similar to that of the specimens. The ambient field, the field of view when the observer glances away from the specimens, should have a neutral color (Munsell Chroma less than 0.2) and a Munsell Value of N6 to N7 (luminous reflectance 29 to 42); see Practice D1729).

5.4 *Observers*—Guide E1499 describes the selection, evaluation, and training of observers for visual scaling work. Of particular importance is the testing of the observers' color vision and their color discrimination for normality. Color vision tests for this purpose are described in Guide E1499.

6. Categories of Visual Experiments

6.1 Visual experiments tend to fall into two broad classes: (*1*) threshold and matching experiments designed to measure visual sensitivity to small changes in stimuli (or perceptual equality), and (*2*) scaling experiments intended to generate a psychophysical relationship between the perceptual and physical magnitudes of a stimulus. It is critical to determine first which class of experiment is appropriate for a given application.

6.1.1 *Threshold and Matching Experiments*—Threshold experiments are designed to determine the just-perceptible difference in a stimulus, or JPD. Threshold techniques are used to