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TECHNICAL REPORT

Guidance towards Best Practice in Psychophysical Procedures Used when Measuring Relative Spatial Brightness

CIE 212:2014

UDC: 612.84
159.931

Descriptor: Physiological optics. vision
Vision, psychology

THE INTERNATIONAL COMMISSION ON ILLUMINATION

The International Commission on Illumination (CIE) is an organization devoted to international co-operation and exchange of information among its member countries on all matters relating to the art and science of lighting. Its membership consists of the National Committees in about 40 countries.

The objectives of the CIE are:

1. To provide an international forum for the discussion of all matters relating to the science, technology and art in the fields of light and lighting and for the interchange of information in these fields between countries.
2. To develop basic standards and procedures of metrology in the fields of light and lighting.
3. To provide guidance in the application of principles and procedures in the development of international and national standards in the fields of light and lighting.
4. To prepare and publish standards, reports and other publications concerned with all matters relating to the science, technology and art in the fields of light and lighting.
5. To maintain liaison and technical interaction with other international organizations concerned with matters related to the science, technology, standardization and art in the fields of light and lighting.

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La Commission Internationale de l'Eclairage (CIE) est une organisation qui se donne pour but la coopération internationale et l'échange d'informations entre les Pays membres sur toutes les questions relatives à l'art et à la science de l'éclairage. Elle est composée de Comités Nationaux représentant environ 40 pays.

Les objectifs de la CIE sont :

1. De constituer un centre d'étude international pour toute matière relevant de la science, de la technologie et de l'art de la lumière et de l'éclairage et pour l'échange entre pays d'informations dans ces domaines.
2. D'élaborer des normes et des méthodes de base pour la métrologie dans les domaines de la lumière et de l'éclairage.
3. De donner des directives pour l'application des principes et des méthodes d'élaboration de normes internationales et nationales dans les domaines de la lumière et de l'éclairage.
4. De préparer et publier des normes, rapports et autres textes, concernant toutes matières relatives à la science, la technologie et l'art dans les domaines de la lumière et de l'éclairage.
5. De maintenir une liaison et une collaboration technique avec les autres organisations internationales concernées par des sujets relatifs à la science, la technologie, la normalisation et l'art dans les domaines de la lumière et de l'éclairage.

Les travaux de la CIE sont effectués par sept Divisions, ayant chacune environ 20 Comités Techniques. Les sujets d'études s'étendent des questions fondamentales, à tous les types d'applications de l'éclairage. Les normes et les rapports techniques élaborés par ces Divisions Internationales de la CIE sont reconnus dans le monde entier.

Tous les quatre ans, une Session plénière passe en revue le travail des Divisions et des Comités Techniques, en fait rapport et établit les projets de travaux pour l'avenir. La CIE est reconnue comme la plus haute autorité en ce qui concerne tous les aspects de la lumière et de l'éclairage. Elle occupe comme telle une position importante parmi les organisations internationales.

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Die Internationale Beleuchtungskommission (CIE) ist eine Organisation, die sich der internationalen Zusammenarbeit und dem Austausch von Informationen zwischen ihren Mitgliedsländern bezüglich der Kunst und Wissenschaft der Lichttechnik widmet. Die Mitgliedschaft besteht aus den Nationalen Komitees in rund 40 Ländern.

Die Ziele der CIE sind :

1. Ein internationales Forum für Diskussionen aller Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik und für den Informationsaustausch auf diesen Gebieten zwischen den einzelnen Ländern zu sein.
2. Grundnormen und Verfahren der Messtechnik auf dem Gebiet der Lichttechnik zu entwickeln.
3. Richtlinien für die Anwendung von Prinzipien und Vorgängen in der Entwicklung internationaler und nationaler Normen auf dem Gebiet der Lichttechnik zu erstellen.
4. Normen, Berichte und andere Publikationen zu erstellen und zu veröffentlichen, die alle Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik betreffen.
5. Liaison und technische Zusammenarbeit mit anderen internationalen Organisationen zu unterhalten, die mit Fragen der Wissenschaft, Technik, Normung und Kunst auf dem Gebiet der Lichttechnik zu tun haben.

Die Arbeit der CIE wird in sieben Divisionen, jede mit etwa 20 Technischen Komitees, geleistet. Diese Arbeit betrifft Gebiete mit grundlegendem Inhalt bis zu allen Arten der Lichtenwendung. Die Normen und Technischen Berichte, die von diesen international zusammengesetzten Divisionen ausgearbeitet werden, sind auf der ganzen Welt anerkannt.

Alle vier Jahre findet eine Session statt, in der die Arbeiten der Divisionen berichtet und überprüft werden, sowie neue Pläne für die Zukunft ausgearbeitet werden. Die CIE wird als höchste Autorität für alle Aspekte des Lichtes und der Beleuchtung angesehen. Auf diese Weise unterhält sie eine bedeutende Stellung unter den internationalen Organisationen.

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This Technical Report has been prepared by CIE Technical Committee 1-80 of Division 1 "Vision and Colour" and has been approved by the Board of Administration as well as by Division 1 of the Commission Internationale de l'Eclairage. The document reports on current knowledge and experience within the specific field of light and lighting described, and is intended to be used by the CIE membership and other interested parties. It should be noted, however, that the status of this document is advisory and not mandatory.

Ce rapport technique a été élaboré par le Comité Technique CIE 1-80 de la Division 1 "Vision et Couleur" et a été approuvé par le Bureau et Division 1 de la Commission Internationale de l'Eclairage. Le document expose les connaissances et l'expérience actuelles dans le domaine particulier de la lumière et de l'éclairage décrit ici. Il est destiné à être utilisé par les membres de la CIE et par tous les intéressés. Il faut cependant noter que ce document est indicatif et non obligatoire.

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The following members of TC 1-80 "Research Methods for Psychophysical Studies of Brightness Judgements" took part in the preparation of this Technical Report. The committee comes under Division 1 "Vision and Colour".

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GUIDANCE TOWARDS BEST PRACTICE IN PSYCHOPHYSICAL PROCEDURES USED WHEN MEASURING RELATIVE SPATIAL BRIGHTNESS

Summary

This report reviews evidence for the procedures and other factors of experiments carried out to investigate relative spatial brightness, making recommendations of those aspects that ought to be considered as essential, or at least desirable, for best practice. These factors include the size and complexity of the visual field employed in trials, evaluation mode (separate, simultaneous, sequential or successive) and experimental biases associated with selection of stimulus range and response mode. Some of the issues raised will be considered, by some, to be obvious and already standard practice: unfortunately such awareness is not widespread. This report hence serves as a guide for those planning experiments to investigate spatial brightness. The proposals are presented as recommendations and not as compulsory. The report identifies those issues for which further research is desirable.

GUIDE DE BONNES PRATIQUES CONCERNANT LES PROCEDURES PSYCHOPHYSIOLOGIQUES UTILISÉES LORS DE LA MESURE DE LA LUMINOSITÉ SPATIALE RELATIVE

Résumé

Ce rapport examine les procédures et autres facteurs expérimentaux pratiqués lors de l'investigation de la luminosité spatiale afin d'en tirer des recommandations quant aux aspects essentiels, ou tout du moins désirables, aptent à constituer la meilleure des pratiques. Ces facteurs incluent la taille et la complexité des champs de vision employés dans les items expérimentaux, les modes d'évaluation (séparé, simultané, séquentiel ou successif) et les biais expérimentaux associés à la sélection de l'étendue des stimuli et le mode de réponse. Certains des problèmes abordés pourront paraître triviaux, mais, malheureusement, ce savoir n'est pas encore diffusé de manière optimale. Ce rapport sert donc de guide à tous ceux qui projettent d'expérimenter dans le domaine de la luminosité spatiale. Il donne un ensemble de recommandations dont le caractère n'est pas obligatoire, et il identifie les problèmes qui mériteraient davantage de recherche.

LEITFADEN ZUR OPTIMALEN VORGEHENSWEISE BEI PSYCHOPHYSISCHEN VERFAHREN ZUR MESSUNG RELATIVER RÄUMLICHER HELLIGKEIT

Zusammenfassung

Dieser Bericht gibt Einsicht in Verfahren und andere Einflussgrößen bei Experimenten zur Untersuchung relativer räumlicher Helligkeit, und gibt Empfehlungen hinsichtlich jener Gesichtspunkte, die als wesentlich oder zumindest wünschenswert angesehen werden sollten. Diese Einflussgrößen schließen die Größe und Komplexität des in Versuchen verwendeten Sehfeldes, die Bewertungsmethode (separat, simultan, sequentiell oder sukzessiv), sowie experimentelle Tendenzen, die mit der Auswahl des Reizbereichs und der Antwortmethode zusammenhängen, ein. Einige der aufgeworfenen Sachverhalte werden von einigen Lesern als offensichtlich und als gegenwärtige Standardpraxis betrachtet werden, aber leider ist solche Erkenntnis nicht weit verbreitet. Dieser Bericht dient deshalb als Leitfaden für jene, die Experimente zur Untersuchung räumlicher Helligkeit planen. Die Vorschläge sind als Empfehlungen anzusehen und nicht verpflichtend. Der Bericht stellt die Themen heraus, für die weitere Forschung wünschenswert ist.

Recommendations

This report presents recommended guidance for procedures used to compare spatial brightness under different sources of light. Some of these items are essential, others may be considered desirable. The body of this report describes the reasons for making these recommendations.

i) Recommended requirements

Procedure	Recommended requirements
Matching	<ul style="list-style-type: none"> • counterbalance position of the visual scenes (e.g. left and right) • counterbalance application of luminance adjustment • commence luminance adjustment from high and low initial settings • include null-condition trials • present visual scenes in all-possible-pairs
Discrimination	<ul style="list-style-type: none"> • counterbalance position • present visual scenes in all-possible-pairs • include null-condition trials
Adjustment	<ul style="list-style-type: none"> • use multiple stimulus ranges • use high and low anchors (initial illuminance settings) • use repeated trials to check internal consistency <p>Note: further work is required to clarify best practice for using this procedure – see 7.2</p>
Rating	<ul style="list-style-type: none"> • consider the number of response points – two issues are the presence / absence of a neutral point (i.e. odd vs even ranges) and that the number of response points and number of stimulus magnitudes should be similar • use repeated trials to check internal consistency • present pre-experimental standards to anchor the response range

ii) Data to be collected and reported

Characteristics of test participants:

- Sample size and summary of age, gender and ethnicity.
- Normal colour vision (screened using the Ishihara Test under daylight or a daylight simulating source). If classification of colour deficiency is required then a further test is required such as the Farnsworth-Munsell 100 hue test.
- Whether the test participants were naïve or expert.

Apparatus characteristics:

- Procedure and apparatus.
- Lamp characteristics: spectral power distribution (SPD) in the form of numeric data or graphs, an indicator of the colour of the light source (e.g. correlated colour temperature (CCT) and/or chromaticity) and of the colour appearance of objects viewed under the light source (e.g. colour rendering index (CRI) or some other metric that may be proposed in the future), and other proposed metrics such as S/P-ratio.
- Characteristics of the visual scene (e.g. types and reflectances of surfaces and/or objects).
- Luminances in addition to illuminances where horizontal illuminance is the target variable.
- Luminance/illuminance uniformity if using homogeneous scenes. If using complex scenes (such as a room for example) report the highest contrast or luminance range or show pseudo colour scene luminance image.

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- Type of photometric meters used and confirmation of calibration to national standard.
- Practice trials (number of trials and scenes observed).
- Unintended variations of light settings during the experiment, e.g. the range of CCT variation or MacAdam ellipses. This may be particularly necessary when using LEDs.
- Instructions/information given to test subjects (verbal and/or written).
- Original language version of rating scales (i.e. if reported in English but experiment carried out using native language).

Results:

- Mean and standard deviation are reported (or median and inter-quartile range for non-normal distribution). If the raw data were made available (e.g. on a website) this would allow subsequent independent analysis.
- Results of null-condition trials.
- Statistical tests used to analyse data.
- Correlation: report the numbers of pairs of observations on which a correlation coefficient is based.

1 Introduction

1.1 Aim

The purpose of the TC 1-80 work was to provide guidance to aid the successful implementation of the experimental procedures commonly used to measure spatial brightness. This was done through a review of the procedures and conditions under which these experiments have been carried out.

Spatial Brightness describes a visual sensation to the magnitude of the ambient lighting within an environment, such as a room or lighted street. Generally the ambient lighting creates atmosphere and facilitates larger visual tasks such as safe circulation and visual communication. This brightness percept encompasses the overall sensation based on the response of a large part of the visual field extending beyond the fovea. It may be sensed or perceived while immersed within a space or when a space is observed remotely but fills a large part of the visual field. Spatial brightness does not necessarily relate to the brightness of any individual objects or surfaces in the environment, but may be influenced by the brightness of these individual items (Fotios & Atli, 2012).

Evaluation of spatial brightness is a subjective assessment and experimenters need to be aware of the limitations of such assessments as can be observed through two statements:

Quantitative subjective assessments are almost always biased, sometimes completely misleading.

[Source: Poulton, E.C., British Journal of Psychology, 1977; 68; 409-425]

In the study of perception, I think we get caught up a little in thinking that much has to do with what people see. Sometimes the procedural matter is more about influences on what people say, rather than what they see.

[Source: Niall, K., TC1-80 member, June 2011; feedback on an early draft]

1.2 Procedures For Brightness Measurement

This report deals with quantitative methods for investigating relative spatial brightness. For a single trial involving an explicit¹ measurement of a specific perceptual attribute of a given visual scene, there are four basic types of procedures: adjustment, matching, discrimination and category rating. All four procedures have been used in past studies of spatial brightness and are therefore discussed in this report. The relationship between these is shown in Figure 1.

Relative spatial brightness implies the brightness of one scene compared with that of another scene. The procedures may employ relative or absolute measurements. Relative measurement involves a direct comparison between two light settings. Absolute measurement involves comparison between an observed light setting and a reference – such as an internal standard or memory – of what that scene would look like when lit by a different light setting or how it should appear under ideal conditions.

¹ An *explicit* measurement indicates that observers are given a task in which they explicitly respond to the visual scene under investigation. *Implicit* measurements are also possible (e.g. physiological measurements such as skin conductance or brain activity, eye-movements, and behavioural measurements such as task performance or approach-avoidance tendencies) but these are not within the scope of this report.