TECHNICAL REPORT

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Ergonomics data for use in the application of ISO/IEC Guide 71:2014

Données ergonomiques destinées à être utilisées dans le cadre de l'application du Guide ISO/IEC 71:2014

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 122, *Ergonomics,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO/TR 22411:2008), which has been technically revised.

The main change compared to the previous edition is the replacement of ergonomics data on human abilities and capabilities with new or more elaborated data for use in the application of ISO/IEC Guide 71:2014.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is intended to help standards developers by providing ergonomics data related to human characteristics and capabilities to support ISO/IEC Guide 71:2014. This document is supposed to be used mainly by standards developers, but also by those responsible for design. The underlying idea is that products, services and environments encountered in all aspects of daily life and intended for the consumer market and the workplace should be designed to be accessible for people with a widest range of capabilities. This idea, called accessibility, has been spreading all over the world.

ISO/IEC Guide 71 was first published in 2001 to successfully address the importance of being aware of the needs of older persons and persons with disabilities and to direct the attention of standards developers to these needs when they draft or revise standards. In response to the publication of ISO/IEC Guide 71, ISO/TR 22411:2008 was developed to fulfil the gap between the concept and practice with offering ergonomic knowledge and data on human abilities.

After more than 10 years from the publication of ISO/IEC Guide 71 and ISO/TR 22411, together with new knowledge and experience in implementing these documents, ISO/IEC Guide 71 was revised into a more elaborated one and consequently the revision of ISO/TR 22411 was required.

This document provides updated ergonomics data as well as newly available data which are all publicly available and can be used to support standards developers in applying ISO/IEC Guide 71:2014 in their individual standards. These ergonomics data help standards developers to understand characteristics and capabilities of diverse users to be served by requirements and recommendations in a standard. The data provided in this document apply mainly to persons with disabilities and older persons. The intention in using these data is to formulate requirements and recommendations in standards that include the widest possible range of users. It can also be used by designers in order to increase accessibility as part of accessible design or universal design.

While the data covers a wide area of human abilities related to accessibility, data for some part of the area, for example cognitive abilities, is still missing. Furthermore, new data emerged or were updated during the development of this document, which is not included in this document either. This document, due to scientific reasons, does not necessarily adopt the ICF terminology but established terms in ergonomics.

Ergonomics data for use in the application of ISO/IEC Guide 71:2014

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This document provides ergonomics data for standard developers to use in applying ISO/IEC Guide 71:2014 to address accessibility in standards. These data can also be used by ergonomists and designers to support the development of more accessible products, systems, services, environments, and facilities.

The ergonomics data include quantitative data and knowledge about basic human characteristics and capabilities as well as context-specific and task-specific data, all being based on ergonomics research. The data focused on the effects of ageing and/or consequences of various types of human sensory, physical, and cognitive disabilities. It does not contain general ergonomics data that have no direct relation to ageing or disabilities.

The data presented in this document are not exhaustive due to no available data for some aspects of human characteristics and capabilities with regard to ageing and disabilities.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
accessibility
extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of user needs, characteristics and capabilities to achieve identified goals in identified contexts of use

Note 1 to entry: Context of use includes direct use or use supported by assistive technologies.

[SOURCE: ISO 9241-112:2017, 3.15]

3.2
accessible design
design focused on diverse users to maximize the number of potential users who can readily use a system in diverse contexts

Note 1 to entry: This aim can be achieved by (1) designing systems that are readily usable by most users without any modification, (2) making systems adaptable to different users (by providing adaptable user interfaces) and (3) having standardized interfaces to be compatible with assistive products and assistive technology.

Note 2 to entry: Terms such as universal design, accessible design, design for all, barrier-free design, inclusive design and transgenerational design are often used interchangeably with the same meaning.

[SOURCE: ISO/IEC Guide 71:2014, 2.19]

3.3
impairment
problem in body function or structure related to a significant deviation or loss

Note 1 to entry: Impairments can be temporary or permanent; progressive, regressive or static; intermittent or continuous.

[SOURCE: ICF 2001, WHO]

3.4
system
product, service, or built environment or any combination of them with which the user interacts

[SOURCE: ISO/IEC Guide 71:2014, 2.1]

3.5
universal design
design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design

Note 1 to entry: Universal design shall not exclude assistive devices for particular groups or persons with disabilities where this is needed.

Note 2 to entry: Terms such as universal design, accessible design, design for all, barrier-free design, inclusive design and transgenerational design are often used interchangeably with the same meaning.

[SOURCE: ISO/IEC Guide 71:2014, 2.18]

3.6
user
individual who accesses or interacts with a system

[SOURCE: ISO 9241-11:2018, 3.1.5, modified — In the definition, "person" has been changed to "individual", "accesses or" has been added, and "product or service" has been removed.]

4 Supporting ISO/IEC Guide 71 with human data

ISO/IEC Guide 71:2014 provides standards developers with guidance on addressing accessibility in standards through two approaches, as shown in Figure 1:

1) the first approach defines accessibility goals for the product or system under development and the user accessibility needs associated with fulfilling those goals (denoted by Clause 6 in Figure 1);

2) the second approach provides accessibility-related design considerations, based on an understanding of human abilities and characteristics (denoted by Clause 7 in Figure 1).

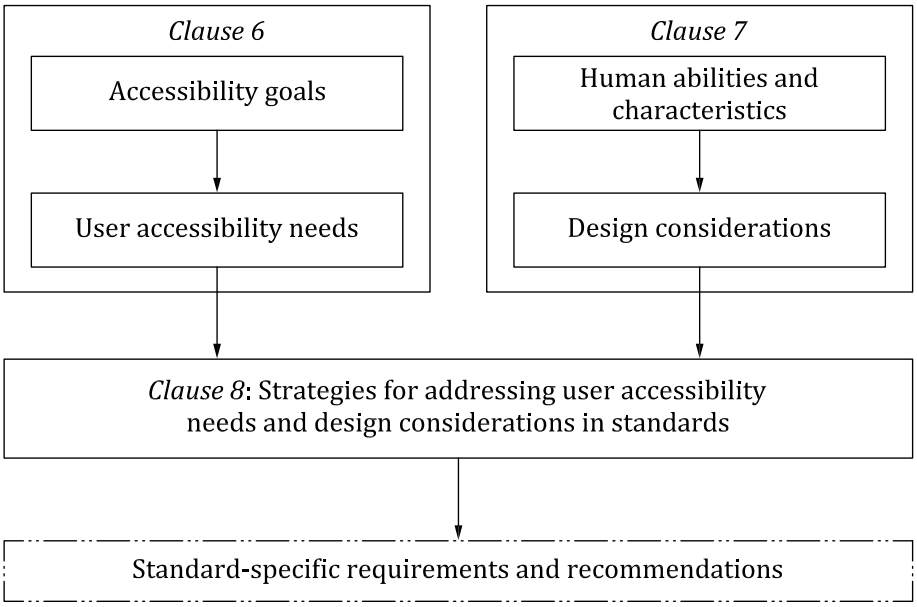


Figure 1 — Two approaches to address accessibility in standards described in ISO/IEC Guide 71:2014

The user accessibility needs (first approach) or design considerations (second approach) can serve as the basis for accessibility requirements and recommendations in standards. Regardless of which approach is used, the accessibility requirements and recommendations in the standards are derived through the appropriate selection of strategies (denoted by Clause 8 in Figure 1) that can meet the accessibility needs or address the design considerations.

Ergonomics data are relevant throughout both approaches and especially important in determining which strategies are the most effective in a situation. In some cases, the data can provide a source of nominal values or numerical specifications which can be included in the requirements and recommendations of standards. In other cases (especially with respect to cognitive variables), the available data are qualitative in nature and/or reflect small sample sizes, but can still be used to evaluate the feasibility of applying particular strategies to meet accessibility needs or to address design considerations.

In addition to the role that ergonomics data play in standards development, these data are directly relevant to the product and system designers, who are attempting to fulfil accessibility requirements and recommendations by developing and implementing technical solutions that make use of the existing data.

One of the challenges for standards developers and designers is that ergonomics data relevant to specific populations is distributed across multiple standards and other guidance documents, as well as in published research reports, papers and books from a variety of academic disciplines. The purpose of this document is to bring the most valid and applicable data together in one document. This will assist standards developers to address accessibility and consider the widest range of user needs when formulating requirements and recommendations. Having a single source of information will also be of value to designers.

5 Data selection and format

5.1 Data selection

The data in this document were selected from various sources existing in scientific books and journals, standards, as well as databases of universities, research institutes or projects. They are all relevant for demonstrating effects of ageing and disabilities and the committee regards valid and worth citing in this document. Most of the data are well-supported in academia and related technical fields or based on

a sufficient number of samples to provide statistical meaningful results. Some of the data, especially in cognitive field, have a limited number of samples but the committee regards qualitatively relevant for application.

5.2 Data format of this document

Data in this document are presented in a common format for easy and correct understanding of the data. It contains following items. If no information is available for some items, they are left blank.

— **Title**

This item describes the title of the data. The title has an additional information on the type of data either for the effect of ageing or the effect of some specific disability.

— **General**

This item describes background and outline of data, implications in designing, as well as why the data is important and included in this document. Some scientific information necessary to understand the data is also included.

— **Sampled population**

This item describes samples from which the data have been obtained. Number of people who participated in the experiments or measurements, their age and gender distribution, and any other attributes of samples necessary for understanding the data are presented.

— **Methods and conditions of data collection**

This item describes methods and conditions of the measurement used for data collection. Technical information necessary for understanding the figures and tables in the data section is provided depending on the types of human characteristics and capabilities. Limitations associated with the methods or conditions are also provided.

— **Data**

This item describes typical data given in figures and tables picked up from the data source(s) that would be most suitable for understanding the human characteristics and capabilities expressed in the title of the data. The data is also selected as the most useful one for design considerations.

— **Limitations**

This item describes constrains or cautions for use of the data. As the human data largely depends on the methods and conditions of the measurement, it would be safe and useful to show the limitations in applying the data to actual situations.

— **Application examples**

This item gives a general idea for applying the data and implication of the data for design with some examples. This includes not only specific design examples but also how to use the data in general.

— **References**

This item provides a list of:

— Data sources: sources of information on the data presented in the data item, including relevant literature (standards, academic journals, books, other reports) and website;

— Cross-references: relevant sections in this document for cross-referencing and better understanding of the section;

— Other references: relevant literature and website, not directly related to the data but useful for understanding them.

5.3 How to use the data

This document provides data on a large variety of human characteristics and capabilities that can be applied to product design, as well as some aspects of the design of services and environments.

Clause 6 provides data items on sensory characteristics and capabilities covering modalities of vision, hearing, touch, and the thermal sense. No data is provided on smell and taste as no relevant data source was found, though ISO/IEC Guide 71 does address these senses in a general way.

Clause 7 provides data items on physical characteristics and capabilities, covering body size, fine motor coordination of the hand, movement of upper body structures, movement of lower body structures, and muscle power and muscle endurance. No data is provided on physical characteristics and capabilities related to speech production.

Clause 8 provides data items on cognitive characteristics and capabilities related to attention, information processing and memory. Although cognitive abilities are especially relevant to accessibility, little data of quantitative nature exists because cognitive disabilities vary markedly in their effects and can involve many unique combinations of attentional, information processing, memory, decision-making and affective impairments for any given individual.

The data provided in this document can be used, directly or indirectly, when standard developers and products designers consider accessibility in the context of developing standards or designing products, services or environments. Depending on the nature of experimental data provided, it may or may not be relevant to a specific design issue. Therefore, users of this document should consider whether the data provided in this document can be applied in their specific situation, given how it was collected (i.e. the population tested and the method used), as well as the limitations of the data, as described in subclauses.

In addition, much of the data related to physical and sensory capabilities can be directly applied because numerical values are provided in tables, charts, formulas and graphics. These data may be directly used to set limit values in standards (e.g. weight-lifting limit), or specifications of certain design parameters (e.g. the grip span for a tool). Alternatively, much of the data related to cognitive abilities simply is in the form of task-specific trends, as a function of age and/or disability, and cannot be applied directly. In these cases, designers and standards developers are limited to interpreting the implications of the trends in light of their particular design or standards development situation. It is also extremely important that users of the cognitive data maintain awareness of the significant variance in cognitive capabilities and limitations, generally, and the limited sample sizes involved for some populations for which data is provided.

6 Sensory characteristics and capabilities

6.1 Overview of sensory characteristics and capabilities

Every sensory characteristic and capability can be affected by ageing: abilities to detect, discriminate or perceive sensory stimuli of vision, hearing, touch or thermal sense. How the change occurs varies depending on the sensory function.

Various types of disabilities in sensory characteristics and capabilities are caused by medical disorders or impairments in the structure or the function, which result in low vision, colour defect, hardness of hearing, etc. In addition, disabilities can be caused by environmental factors such as illumination, noise, temperature, etc.

Most of the sensory characteristics and capabilities do not vary depending on the gender or ethnicity. However, in the case of hearing, for example, a large gender difference can be found in the sensitivity of older ears although the reason for that is not known.

Table 1 shows a brief summary of sensory characteristics and capabilities with regard to ageing effects. Details are described in 6.2 to 6.5. The sense of taste and olfaction is missing in this document because of a lack of data useful for ergonomic design.

An online database can be used to investigate the ageing effects and effects of disabilities in sensory characteristics and capabilities (see Reference [77]). Some of the data referenced in this document have been taken from the database.

Overview of ageing effects on vision is also available in Reference [59].

Table 1 — List of major sensory functions and effects of aging

Sensory functions	Particular effects of age
Vision	
Spectral sensitivity	Declines at short-wave region (blue light)
Colour discrimination	Worsened
Colour identification/colour category	Span of colour category reduced
Contrast sensitivity	Declines at high spatial frequencies
Temporal sensitivity (flicker sensitivity)	Declines at high temporal frequencies
Visual acuity	Worsened at high spatial frequencies and at short viewing distance
Legibility (of symbols and letters)	Worsened for complex symbols and letters
Field of view	Narrowed
Dark/light adaptation	Slightly affected
Lighting level	Slightly affected
Glare	Increased
Hearing	
Hearing sensitivity	Declines especially at high frequencies
Sensitivity to extremely high frequency (above 10 000 Hz)	Declines or completely lost
Sensitivity to low frequency (below 100 Hz)	Moderately affected
Loudness	Becomes smaller especially at high frequencies; in some cases, accompanies abnormal growth called “recruitment”
Tone perception	Worsened especially in noisy conditions
Speech perception	Worsened especially in noisy conditions
Touch	
Tactile pressure sense	Sensitivity decreased
Spatial resolution	Declines at high spatial frequencies
Temporal sensitivity (for vibration)	Sensitivity decreased especially for high temporal frequencies
Legibility (for tactile symbols and characters)	Worsened
Thermal sense	
Sensitivity to surface temperature	Decreased
Sensitivity to air temperature	Decreased
Thermal sensation for comfort	Reduced

6.2 Vision

6.2.1 Visual sensitivity to colour (spectral sensitivity of the eye: ageing effect)

6.2.1.1 General

The human eye responds to electro-magnetic radiation of the wavelength range from about 380 nm to 780 nm. The overall sensitivity to the radiation throughout the range is called spectral sensitivity or spectral luminous efficiency. This spectral sensitivity changes with age so that it becomes less sensitive

to light in the short-wavelength region approximately from 400 nm to 500 nm (coloured purplish and bluish). Therefore, a bluish as well as a purplish light looks darker to older persons than it does to young persons. Taking account of this ageing effect can increase visibility of signs and displays for older people.

NOTE This ageing effect disappears if an older person has had his/her lens replaced with an artificial eye lens surgically implanted, as the effect is caused mainly by yellowing of the lens.

6.2.1.2 Sampled population

Data were collected from 91 participants ranged in age from 12 years to 78 years. The distribution of ages of the participants were 6 people in 10–19 years, 11 people in 20–29 years, 10 people in 30–39 years, 10 people 40–49 years, 10 people in 50–59 years, 28 people in 60–69 years, and 16 people in 70–79 years. The numbers of male and female participants were nearly equal.

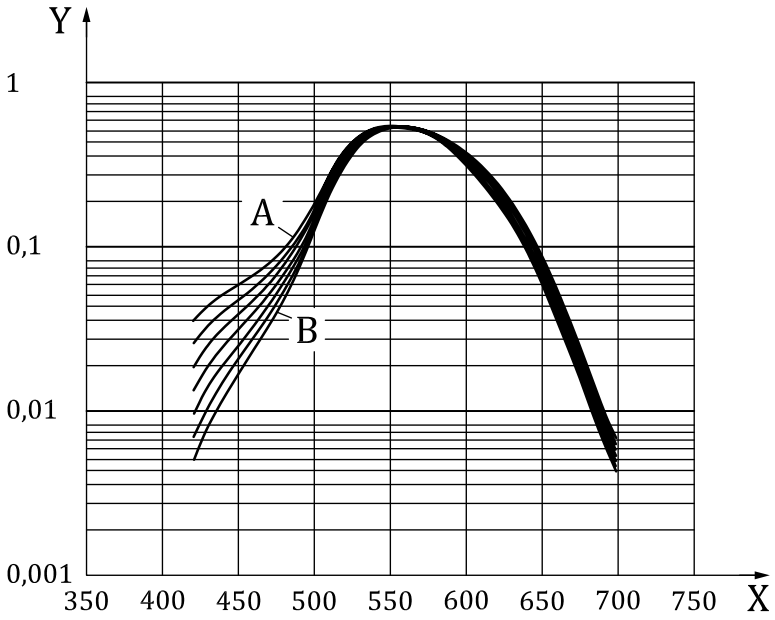
6.2.1.3 Methods and conditions of data collection

The data were measured by the conventional method for visual sensitivity called flicker photometry. In this measurement, a test light and a reference light, both of which were subtended at a visual angle of about 2° at the same location on the retina, were temporally alternated with a fixed frequency of 12 Hz. A non-flicker or a minimum flicker point was determined by adjusting the intensity of the test light, in most cases, while that of the reference light was fixed. The minimum flicker point was regarded as the equal luminance of the test and reference light to the eye. The test light was chosen from a range of 420 nm to 700 nm in 10 nm steps. The amount of each test light needed to reach to the equal luminance level gives the reciprocal of spectral sensitivity data.

6.2.1.4 Data

Figure 2 shows the spectral sensitivity data measured for 91 people by flicker photometry with a foveally fixed 2-degree target field at a photopic level. The data are classified into seven age groups in 10-year steps and the geometric average over all the participants in a decade is expressed as a solid line.

The data shows clear reductions of sensitivity in the short-wave region (blue light) with ageing, while there is almost no change at middle-wave (green light) and long-wave (red light) regions. This means that blue light, which contains a short-wave component, looks darker to older people than it does to young people. This age-related change occurs gradually and smoothly from the youngest age, and the maximum difference reaches about one tenth (or 10 times) when the data of 10–19 years old and 70–79 years old are compared.



Key

X wavelength (nm)
Y relative sensitivity
A average of people in their 10s
B average of people in their 70s

Figure 2 — Spectral sensitivity curves of the human eye for seven age groups from 11 to 78 years

6.2.1.5 Limitations

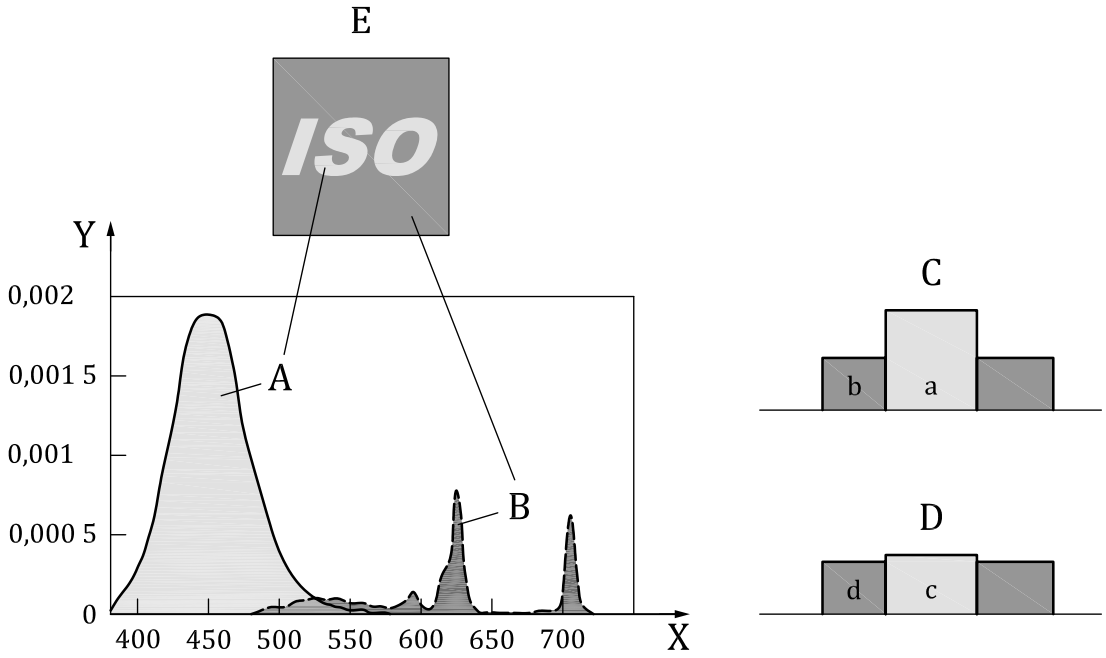
The data presented here are only for people with normal colour vision, and do not apply to people with defective colour vision nor with low vision.

6.2.1.6 Application examples

The main application of human spectral sensitivity is in the measurement of light in terms of visual sensation of lights or objects (photometry or visually meaningful measurement of light), i.e. brighter or darker. The sensitivity data for young people without any visual impairment has been standardized by the International Commission on Illumination (CIE) and has been traditionally used in the measurement of light which is visually meaningful. The age-related change in the sensitivity shown in Figure 2 has not been officially established yet in the field of photometry, but can be practically used in evaluating lights for people in any range of age, in particular for older people, in the same manner as it is used in photometry.

Evaluating the visibility of blue lights for older people in traffic signs, emergency signs and other critical displays, in particular, can increase the accessibility of those signs. Designers should increase light intensity when possible if they use blue lights (blue LEDs, for example) against dark backgrounds in signage used by older people.

Figure 3 shows an example of visual sign composed of blue letters on a dark yellow (brown) background. Using spectral sensitivity curves of people in their 20s and 70s respectively, the contrast ratio of this sign is much lower for older people (1,13 for those in their 70s) than for young people (2,07 for those in their 20s). Nearly twice as much luminance of blue light is needed for older people to achieve the same contrast as young people. This colour combination example is a typical one regarded as hard to see for older people but not to young people. For other colour combinations, this contrast difference may be smaller, but care should be taken for any colour combination when blue light is used in a sign.



Key

X wavelength (nm)
Y spectral radiance (watt/m^2)
A blue letter
B dark yellow background
C contrast for an observer in his/her 20s [2,07 (= 0,003 1 / 0,001 5)]
D contrast for an observer in his/her 70s [1,13 (= 0,001 8 / 0,001 6)]
E sample sign
a luminance of a blue letter to people in their 20s (0,003 1 relative unit)
b luminance of a dark yellow background to people in their 20s (0,001 5 relative unit)
c luminance of a blue letter to people in their 70s (0,001 8 rel. unit)
d luminance of a dark yellow background to people in their 70s (0,001 6 relative unit)

Figure 3 — An application of spectral sensitivity for calculating contrast of a coloured sign

More information on the implication and use of the spectral sensitivity data are presented in ISO 24502.

6.2.1.7 References

— Data source: Reference [31];

— Cross-references in this document: none;

— Other references: Reference [86].

6.2.2 Colour category (spans of fundamental colour, young people, older people, and people with low vision)

6.2.2.1 General

Colour is coded in the central brain, but not in the retina in the eye, as a number of groups of similar colours. This is called categorical colour perception or colour categories. Orangish-red and purplish-red, for example, are both perceived as a colour in the red category in the brain. There are a number of