ISO Standards for Accessible Design
-Development of Common Basic Standards-

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***Abstract*—Accessible design is a design with a concept for increasing the number of users of products, services, and environments, including older people and people with disabilities. ISO (International Organization for Standardization) is establishing the concept in its development of international standards by taking care of the needs of those people. In this paper, recent activities of ISO/TC159 "Ergonomics" on accessible design are reviewed with a focus on the development of *common basic standards* which are fundamental design methods based on ergonomic principles and human data and are to be used in every design field horizontally.**

I. INTRODUCTION

THE accessible design is a design with a concept for increasing the range of users of products, services and environments as wide as possible, including older people and people with disabilities in particular. As shown in Figure 1, every product or environment has been originally designed for a certain population: usually for younger to middle-aged adults, but not for older adults and other people who have any disabilities. With some modifications or additional designs, however, the products or environments can be easily made available for older people, for example, providing tactile information for blind people. Then, the range of users can be expanded to the those people who have such special requirements. The critical point is that the users who are originally intended for, for example younger generation etc., are not excluded by the modifications or additional designs, but still should be included. This is the basic concept of accessible design, the heart of which being the increase of users step by step.

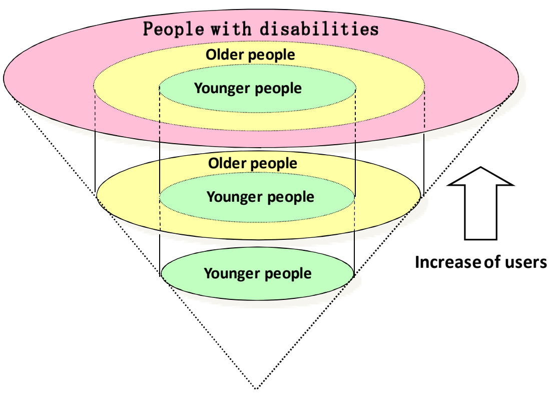

Figure 1 Concept of accessible design to increase users

The concept was launched by ISO/IEC Guide 71 in 2001 and has been shared widely among standards organizations worldwide, such as IEC, ITU and CEN [1]. Since the Guide addressed only conceptual points of accessible design, we need further develop technical guidance or individual standards for each design field to implement the concept.

ISO Technical Committee, TC159 "Ergonomics", has been working for providing technical information that is necessary for realizing accessible design from an ergonomic point of view. A Technical Report, ISO/TR22411, to support the Guide 71 will soon be published [2]. Currently, some of the contents of this TR are being standardized separately for horizontal use across various design fields. In this paper, the activities in ISO/TC159 for accessible design are reported, showing some examples of basic design methods for accessible design.

II. COMMON BASIC STANDARDS

Every product, service, and environment is composed of some basic design components: for example, a grip for ease of holding, visible buttons or switches for controls, auditory signals for warning, visible letters and conspicuous color combination for signs, and so on. If these design components were developed to meet the needs of older persons and persons with disabilities and if they were already standardized separately for the general use in every design fields, the accessible design in products in our daily lives would be greatly facilitated. Standards that specify those designs are called "common basic standards" for accessible design. ISO/TC159 "Ergonomics" is now trying to develop this kind of standards systematically, based on the ergonomic principle and data of human sensory, physical and cognitive abilities for wide and horizontal use in ISO and other standardization organizations.

III. EXAMPLES OF COMMON BASIC STANDARDS

The following are work items currently discussed or to be discussed in the near future in ISO/TC159 to be International Standards of accessible design.

A. Hearing threshold and auditory signals

Auditory signals are widely used in home appliances to provide the user a feedback of the operation of "on/off", or a warning of unusual situations. The temporal patterns of signals should be easily identified and discriminated, and their sound level and frequency should also be appropriately designed so that older people, who are usually less sensitive to high-frequency sounds, could hear them clearly. This is particularly important when we design emergency signals to avoid any confusions and accidents.

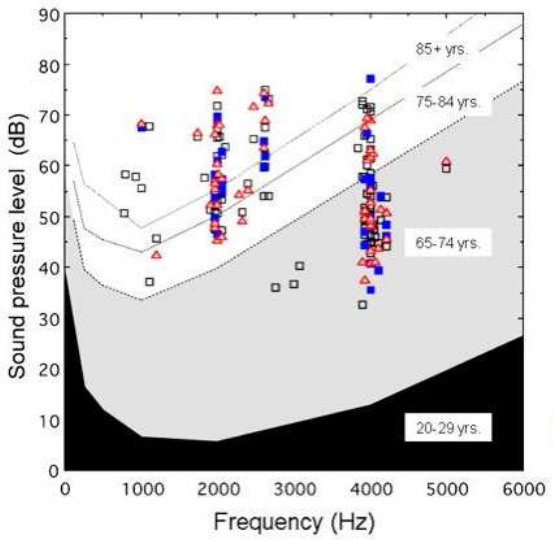

Figure 2 Sound level and frequency of auditory signals used in electric appliances in Japan (symbols of different shapes and colors) and average hearing thresholds of different age groups (curves).

Figure 2 shows the distribution of sound levels and frequencies of auditory signals used in electric home appliances in Japan (plotted as symbols of squares or triangles with a different color according to their functions), together with average hearing-threshold curves for different age groups (shown as lines to separate the areas)[3].

As shown in the Figure, many signals had a frequency of 4000Hz and a sound level lower than the threshold curve of the age group of 65-74 years. If we focus people above 85 years old, almost all the signals of 4000 Hz or even about half of the 2000 Hz signals are expected to be inaudible for them. To resolve this undesirable situation, we should shift the frequency of signals to a lower frequency region or to increase the sound level by a certain amount. Quantitative design approach can be taken by referring to Figure 2. This is an example of accessible design in the field of acoustics and hearing.

B. Visual sensitivity and contrast

Visual signs are composed of a variety of colors and sometime those colors have difficulty to be seen clearly by older people due to their age-related sensitivity loss. Blue light, in particular, has a problem of visibility for older people as our eye becomes less and less sensitive to short-wave stimuli with aging.

Figure 3 shows the data of spectral sensitivity data of the eye taken from people with different age groups from 10 years old up to 80 years old [4]. It is clear from the figure that visual sensitivity to short-wave stimuli gradually decreases with age. This means a light colored purple or blue looks darker to older people than to the younger. Care for visual signs that use blue color is necessary not to be invisible to older people.

For practical use of the data of spectral sensitivity we may need further arrangement. Being based on the data shown in Figure 3, a quantitative design guideline for estimating contrast of a visual sign can be given. This is demonstrated in Figure 4, where visual contrast for a given sign composed by a blue color is estimated for a younger and older person respectively.

As shown in Figure 4, basic idea is to calculate first relative visual efficacy of the symbol (blue) and background (dark brown) respectively using spectral radiance data ($L_{e,\lambda}$) of those parts of a sign as shown in the figure and visual sensitivity data, $V_{(a)}(\lambda)$, also shown in the Figure. Then, the contrast of the sign relative to the background can be obtained according to the contrast formula usually used. When we used the sensitivity data of a person in their age of 20s, a value of 0.51 was obtained as visual contrast for a younger person, which means the sign is clearly visible, The same calculation applied using the sensitivity curve of 70s and the quite low value of 0.11 in this case was obtained meaning the sign is very hard to see for an older person in 70s.

This example clearly demonstrates that even physically the same sign generates a large difference in apperance between a younger and an older person when blue color is involved.

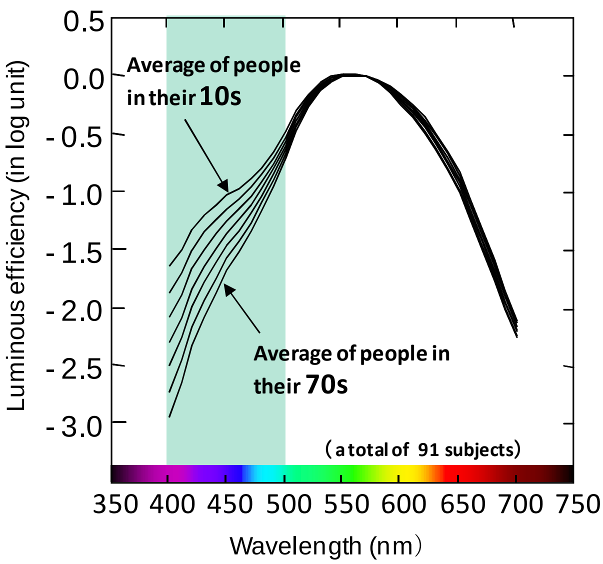

Figure 3 Spectral sensitivity curves of the human eye for 7 age groups from 10 years old to 70 years.

C. Visual acuity and estimation of legible font size

Letters have been so widely used in information and communication and legible font size is a critical problem of designing signs and printings. In our daily life we see signs that contain too small fonts not legible for older people or people with low vision. Accessible design needs a method to design better visibility of characters to older people and people with low vision.

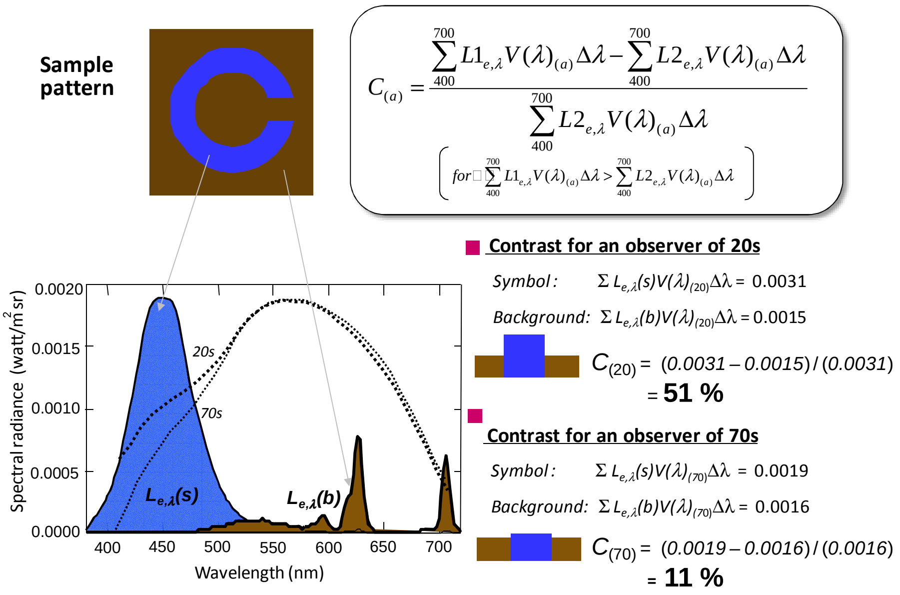

Figure 4 An example of how to calculate contrast using visual sensitivity data of different age and how the contrast differs with age. Persons in their 20s and 70s are shown as examples.

It is reasonable to consider that visual acuity is one of the most critically influencing factors on legible font size, but the problem is that the visual acuity changes in our daily condition according to the luminance level, viewing distance, as well as age of the observer, which makes it difficult to simply estimate the legible font size

Figures 5 (a) and 5(b) are the data of visual acuity as a function of viewing distance and luminance level respectively measured for 7 age groups [5]. The effect of viewing distance (Fig. 5(a)) shows a clear reduction of visual acuity at near distance (at less than about 1m) for people over 40 years old while the acuity remains almost constant for younger people even at short distance. The font size for older people, therefore, should be larger when they are seen at near distance. Note that in the measurement of visual acuity, all the subjects wore a lens best corrected at 5 m viewing distance.

As for the effect of luminance, all the 7 curves in Figure 5(b) show the same trend along with the luminance and no aging effect can be seen though the absolute level of the acuity is different among the age groups. One template to estimate the relative change of visual acuity is enough to apply to any age group.

In order to find a quantitative relationship between visual acuity and a legible font size, an experiment was carried out under several different viewing conditions [5], and as a consequence the following equation was derived with a new factor called "size factor, *S*". The size factor is simply defined as the viewing distance, *D* in m, divided by visual acuity V. The equation to estimate minimum legible font size, *P*, is;

$$P = aS + b \qquad (1)$$
$$S = D/V \qquad (D \text{ in m})$$

Where *a* and *b* are parameters depending on the kind of characters and font type. Those values are tabulated in Table 1.

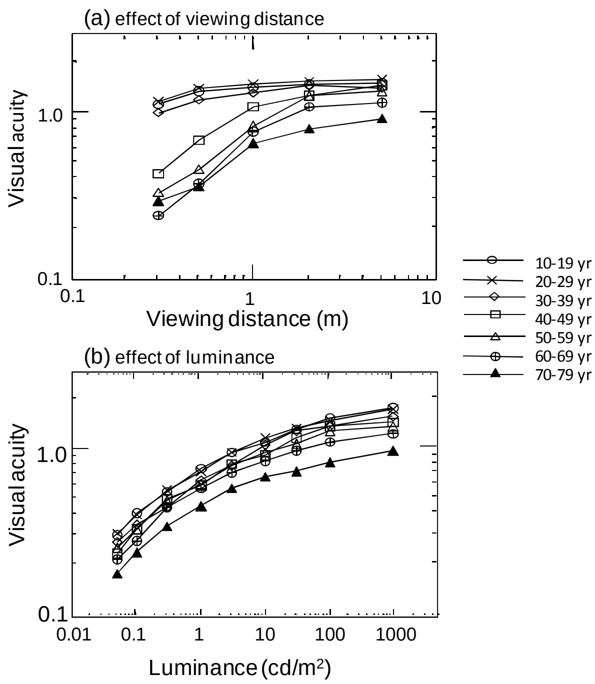

Figure 5. Visual acuity for different age groups as a function of; (a) viewing distance and (b) luminance level. A total of 111 people with different age were participated in the experiment.

For a person of 70 years old who reads Arabic numerals of the plain type at 50 cm under the 100 cd/m^2 luminance level, for example, the following calculation applies.

The visual acuity *V* of the person at this viewing condition can be obtained as 0.4 by referring the data in Figures 5 (a) and 5(b). This gives us a size factor *S* of 1.25 (= 0.5/0.4). From equation (1) and parameters given in Table 1, the minimum legible font size for this particular viewing condition is as follows:

$$P = 8.2 \times 1.25 + 2.6 = 12.9 \text{ (point)}$$

If this calculation is applied to the Gothic type of font, the minimum size is calculated to be 11.0 point, which is smaller than the plain font. This means the Gothic font is easier to read than the plain one as experienced in our daily life.

Minimum legible font size gives us a baseline of designing font size at a large variety of viewing conditions. This can be usefully used for accessible design of signs containing characters seen by older people. Scaling of legibility above threshold levels should be based on this design method [6].

Table 1. Parameters *a* and *b* used in equation (1)

Font type	Kind of Characters	a	b
Plain	Japanese Hiragana, Katakana and Numerals,	8.2	2.6
	Chinese with 5-10 strokes	9.6	2.8
	Chinese with 11-15 strokes	9.6	3.6
Gothic	Japanese Hiragana, Katakana and Numerals	6.4	3.0
	Chinese with 5-10 strokes	8.1	3.4
	Chinese with 11-15 strokes	8.6	4.1

IV. CONLCUSIONS

Accessible design is a newly introduced design concept in ISO to address the needs of older persons and persons with disabilities. Technical assistance is definitely necessary for implementing the concept into individual standards. Common basic standards will be a key technological concept for this issue and Gerontechnology could be a scientific and technological basis for developing those standards. ISO/TC159 is now trying to develop a series of those standards in its active working groups, TC159/WG2 "Ergonomics for people with special requirements" and TC159/SC5/WG5 "Physical environments for people with special requirements"

Acknowledgment

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REFERENCES

[1] International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), "Guidelines for standards developers to address the needs of older persons and persons with disabilities" ISO/IEC Guide 71, 1971.

[2] International Organization for Standardization (ISO), "Ergonomic data and ergonomic guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities" ISO TR22411 (in press).

[3] Kurakata K., Matsushita K., Kuba Y., and Y. Kuchinomachi Y. (1999). Audio signals in electric home appliances evaluated in terms of the hearing ability of older adults (Second report). The Japanese Journal of Ergonomics, Vol. 35, No. 4, pp.277-285.Kurakata.

[4] Sagawa, K., and Takahashi, Y. (1991). Spectral luminous efficiency as a function of age. J. Optical Society of America , A, Vol. 18, pp. 2659-2667.

[5] Sagawa K, Ujike H, Sasaki T: Legibility of Japanese characters and sentences as a function of age, Proc. IEA 2003, Vol. 7, pp.496-499 (2003),

[6] Sagawa, K and Itoh, N.: Legible font size of a Japanese single character for older people, Proceedings of the IEA 2006 (CD-ROM) (2006)