Visibility threshold in sharpness for people with different regional backgrounds

Lu Liu
Jun Xia
Ingrid Heynderickx
Hanchun Yin

Abstract — The influence of regional background on the visibility of sharpness differences has been investigated by blurring various still images to different extents. The assessment of sharpness has been performed both in China by Chinese people and in the Netherlands by European people. The results showed that both Chinese characters and Roman text were clearly more critical image material for judging sharpness than natural images. Independent on whether the image contained Chinese characters or Roman text, the visibility threshold for a difference in sharpness was the same for both the Chinese and European people. When related to a diagonal step response, the threshold on average equaled an angular resolution of 5 arcsec.

Keywords — *Sharpness, perception, visibility threshold, step response.*

1 Introduction

Developments and innovations in display technology no longer only focus on improving the technical performance or reducing costs, but also on the perceived image quality which is considered an important aspect in satisfying consumers. Hence, improvements in the front-of-screen performance are directed towards a better "perceived image quality," which refers to the degree of excellence of a displayed image as experienced by the viewer. Because of its importance, image quality has already been a topic of research for quite some time. Sharpness has been demonstrated to be an important attribute of image quality.[1,2] When varying display resolution, picture size, or viewing distance, it has been shown that image quality is dominated by the sharpness attribute. Hence, from a display design point of view, it is important to understand which differences in sharpness are visible to the viewer, and how they are related to the physical characteristics of the display. In the past, various physical measures have been used to describe perceived sharpness in terms of physical display characteristics (see, *e.g.*, references in Ref. 3). One of these measures, *i.e.*, the diagonal step response, has been used to express the visibility threshold for differences in sharpness.[3] But, despite its importance for the entire display industry, regional or cultural differences in perceived sharpness have not been addressed in the literature. It is the main topic of this paper.

2 Considerations on the evaluation of perceived sharpness

To evaluate perceived sharpness, one needs to blur images in a controlled way. In an experimental environment, this can be done in two different ways. The first way is by sending intrinsically sharp images to a blurred display. For a CRT, *e.g.*, this can be done by changing the focus voltage of the tube. Since this corresponds to the normal defocusing in CRTs, this way of working closely reflects reality. The resulting perceived sharpness, however, is more difficult when it is interpreted as a number of physical characteristic changes simultaneously and in an uncontrolled manner (*e.g.*, to a different degree at different positions of the screen). The second way is by sending blurred images generated, *e.g.*, by means of a software filter to an intrinsically sharp display (or a display that is coming as close to it as possible). This method has the advantage that the level of blurring is well defined and exhibits no loss in averaged luminance or contrast. The disadvantage, however, is that this better way of blurring does not correspond to reality. But, to have full control on the degree of blurring in our experimental study, we have chosen the second option.

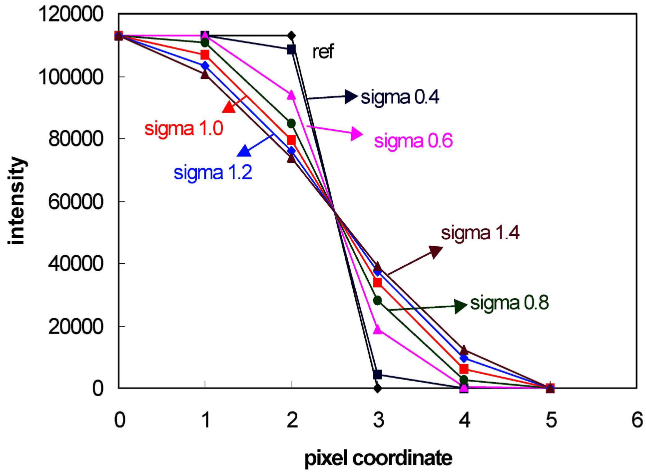

FIGURE 1 — Illustration of the effect of a Gaussian blurring filter with different σ-values on a sharp luminance transition from white to black.

Revised version of a paper presented at the 8th Asian Symposium on Information Display held February 14–17, 2004, in Nanjing, China.
L. Liu, J. Xia, and H. Yin, Southeast University, 2 Si Pai Lou, Nanjing 210096, P.R. China; telephone/fax +86-25-833-63222, e-mail: liulu@seu.edu.cn.
I. Heynderickx is with Philips Research Laboratories, Eindhoven, The Netherlands.

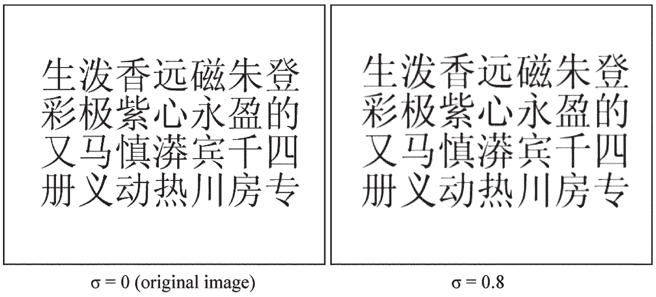

FIGURE 2 — The comparison of the image blurred at σ = 0.8 by applying a Gaussian filter with the original image.

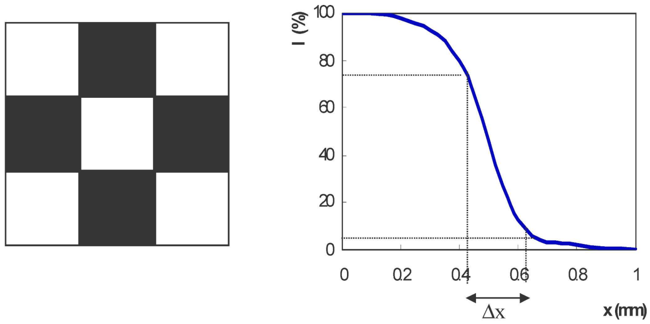

FIGURE 3 — Illustration of the definition of the step response.

Software filters that create a blurring effect generally replace the intensity of a given pixel by the (weighted) averaged intensity of a square of neighboring pixels. For the filters used in our study, we have chosen a Gaussian redistribution of the intensity of each pixel. This filter then is characterized by its σ-value, which is the width at half-height of the Gaussian distribution. The larger the value, the more the image becomes blurred. The effect of a Gaussian blurring filter on a one-dimensional intrinsically sharp black-white transition is illustrated for different σ-values in Fig. 1. For one image, blurring at $\sigma = 0.8$ is compared to the original image ($\sigma = 0$) in Fig. 2.

In earlier work,[3] the visibility threshold for differences in sharpness was determined for natural images, which were isotropically blurred using Gaussian filters. This study was performed at four institutes in Europe. Subjects were requested to score the perceived sharpness of images blurred to different extents (*i.e.*, with σ-values ranging from 0.4 to 1.4 in steps of 0.2 when expressed in pixel units) with respect to the original image on a six-point numerical scale ranging from 0 (no difference with reference) to 5 (large difference with reference). To investigate whether there is any difference in perceived sharpness between people of different regional or cultural backgrounds, this experiment was repeated in a slightly different set-up at one institute in China. For the experiment in China, only the lower blurring levels were used (*i.e.*, σ = 0.3, 0.4, 0.6, and 0.8), and subjects were requested to score the difference in sharpness between each pair of blurred images (*i.e.*, in a type of paired-comparison set-up) on an 11-point numerical scale from –5 (left image much more blurred than right image) to +5 (left image much sharper than right image). These differences in approach do not limit the comparison of the results of both experiments, which are summarized in Table 1. From these results, it can be concluded that for natural images, the visibility threshold for perceiving differences in sharpness is the same for Chinese and European people; for both groups there is no statistically significant difference in perceived sharpness between the original image and the one blurred with a $\sigma = 0.4$ Gaussian filter, but they do see differences in sharpness between higher blurring levels.

TABLE 1 — Summary of results of former experiments.

	Chinese characters	Natural image
China	σ=0 = σ=0.3 > σ=0.4 > σ=0.6 > σ=0.8	σ=0 = σ=0.3 = σ=0.4 > σ=0.6 > σ=0.8
Europe		σ=0 = σ=0.3 = σ=0.4 > σ=0.6 > σ=0.8

>: the image with left σ-value is sharper than the image with right σ-value.
=: the difference in sharpness is not perceived.

As mentioned above, earlier work[3] has related the size of this sharpness threshold to the diagonal step response, which is one of the physical sharpness measures often used for CRTs and proven to be correlated with perceived sharpness. How the step response is defined is illustrated in Fig. 3. It is usually measured by means of a checker-board pattern, consisting of white and black squares. The step response value equals the distance (expressed in mm) between the 75% and 5% luminance levels measured from the luminance profile across an edge between a white and black square. From its measurement in the horizontal and vertical directions we can determine the diagonal step response as the square root of the sum of the squares of the horizontal and vertical step response, *i.e.*,

$$\text{Diagonal step response} = \sqrt{(\Delta x)^2 + (\Delta y)^2}.$$

For the CRT used in the study reported in Ref. 3, the sharpness threshold for natural images corresponded to a difference in diagonal step response *dsr* of at least 0.3 mm. For a viewing distance *s*, this can be recalculated to an angular resolution α by

$$\alpha = tg^{-1}\left(\frac{dsr}{s}\right).$$

For a difference in *dsr* of 0.3 mm at a viewing distance of 2.25 m, this corresponds to a visibility threshold for differences in perceived sharpness of 14 arcsec. It should be noted that this number is much smaller than what is usually indicated as the resolving power of the human eye, which is said to be 1 arc min.[4]

The experiment in China included, apart from natural images, one image containing Chinese characters. The results for this image are given in Table 1 as well. They indicate that Chinese characters are more critical for judging differences in sharpness than natural images. Indeed, for this image, people already noticed a difference in sharpness between the original image and the one blurred with a $\sigma = 0.4$ Gaussian filter, where this was not the case for natural images.

This observation leads to the question of whether this higher sensitivity in perceiving sharpness differences is related to the image content (*i.e.,* Chinese characters) or to the regional or cultural background of the subjects (*i.e.,* Chinese people) or to a combination of both. In order to investigate this, we performed an experiment using only two images, *i.e.,* one containing Chinese characters and one existing of Roman text. One session of this experiment was done in the Netherlands and one in China. In this paper, we present the results of both sessions.

3 Experimental protocol

As indicated above, two still images, *i.e.*, "chinchar" containing Chinese characters and "textpage" containing Roman text, have been selected as the stimulus material for this experiment. Both images are shown in Fig. 4. They both contain nonsense text in a font size slightly smaller than the one commonly used for subtitles in the case of Roman text and comparable to the size used for subtitles in the case of the Chinese characters. The Roman characters were on average 10 mm high, whereas the Chinese characters were 30 mm high. Each image was blurred at four different levels using a Gaussian filter with σ = 0.3, 0.4, 0.6, and 0.8 as expressed in pixel units. A paired-comparison methodology[5] was used: subjects indicated the sharpest image out of a pair, randomly chosen out of all 10 possible combinations of two images based on five blurring levels (including the original image). When including the left-right repetition, the number of pairs increased to 20 per original image. Considering the two images, subjects had to judge 40 pairs of images in total.

Each pair of images was shown on two neighboring identical real-flat 32-in. CPTs. The brightness and contrast settings of the displays were adjusted to a peak-white luminance of 145 cd/m^2, measured on a 5×5-cm white square, and a black-state luminance less than 3 cd/m^2. The white point of the displays was set to (0.288, 0.299), which corresponds to a correlated color temperature of 8600K. The ambient illumination was adjusted to a level of 20 lux, measured with a Minolta lux meter in front of the screen in the direction of the viewer. The viewing distance between the subject and screen was 2.25 m, *i.e.,* six times the height of the screen (in line with the recommendations in Ref. 6). For these real-flat 32-in. CPTs with a spatial resolution of 1024 $\times$ 576 pixels, we can translate the width of the Gaussian filter σ in terms of an angular resolution. Since the size of the screen is 676×387 mm, the size of one pixel is 0.66 mm broad and 0.67 mm high, resulting in a diagonal size of 0.94 mm [*i.e.,* $(0.66^2 + 0.67^2)^{1/2}$]. Considering a viewing distance of 2.25 m, we found an angular resolution of

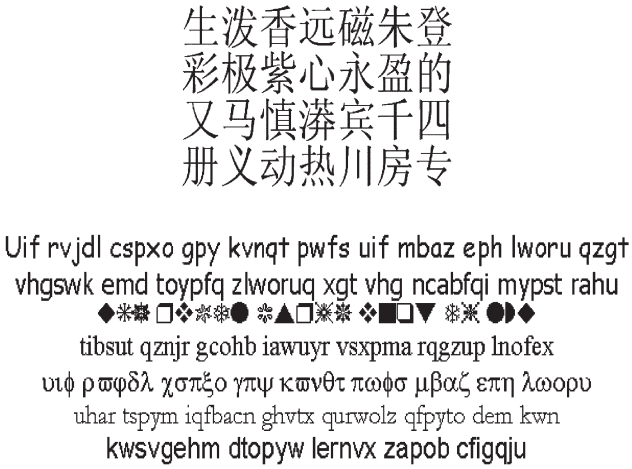

FIGURE 4 — Images "chinchar" (at the top) and "textpage" (at the bottom) as used in the subjective evaluation.

$$\alpha = \mathrm{tg}^{-1}\,(0.94 \times 10^{-3}/2.25) \times 60 = 1.20 \text{ arcmin}$$

for a width of the Gaussian filter σ corresponding to one pixel unit. For the other σ-values used in this study, their dimensions in terms of angular resolution were

$$\sigma = 0.8 \rightarrow \alpha = 0.96 \text{ arc min},$$

$$\sigma = 0.6 \rightarrow \alpha = 0.72 \text{ arc min},$$

$$\sigma = 0.4 \rightarrow \alpha = 0.48 \text{ arc min},$$

$$\sigma = 0.3 \rightarrow \alpha = 0.36 \text{ arc min}.$$

In total, 40 subjects joined the experiment. Twenty people, all with a European background, participated to the session in the Netherlands. Twenty people with a Chinese background participated in the session in China. All participants had a (corrected to) normal visual acuity of at least 1 as measured with the Landolt C-scale in the Netherlands and with the E-scale in China. They received as much time as needed for evaluating each pair of images.

4 Statistical analysis

Data from the paired-comparison experiment were first combined in a preference matrix as demonstrated in Table

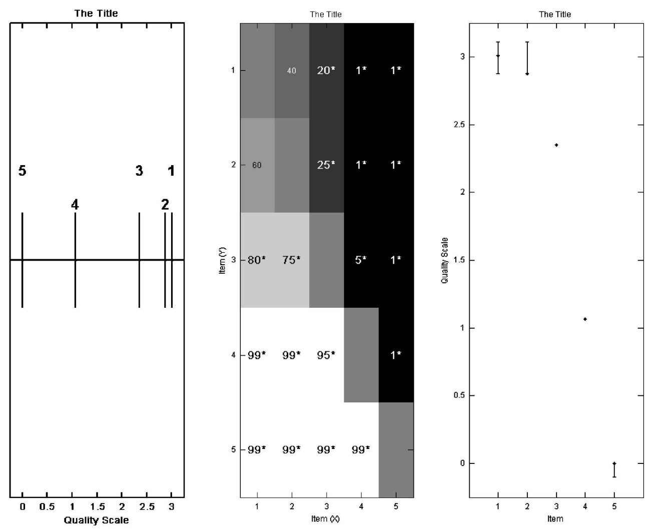

FIGURE 5 — Results for the image "chinchar" in Europe: 1: σ = 0; 2: σ = 0.3; 3: σ = 0.4, 4: σ = 0.6, 5: σ = 0.8.

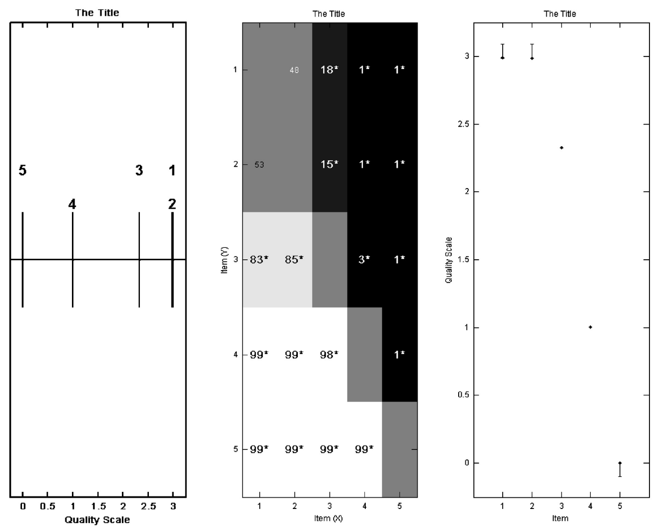

FIGURE 6 — Results for the image "textpage" in Europe: 1: σ = 0; 2: σ = 0.3; 3: σ = 0.4, 4: σ = 0.6, 5: σ = 0.8.

2. Each cell gives the fraction of time the image corresponding to the σ-value mentioned in the column head is preferred above the image corresponding to the σ-value mentioned in the row head. This fraction is calculated by dividing the actual counts of preference for a given image over the number of times a pair is judged (which is twice per subject, hence 40 times in total). The cells at the diagonal of the preference matrix have not been measured (in order to limit experimental time for a subject), but are assumed to have a value of 0.5, which would result from randomly choosing one image as the best out of a pair of equal images.

From the preference matrix, a Quality Scale can be deduced by first transforming all values into *z*-values (assuming a normal distribution of the data), and then averaging all *z*-values within a column (see, *e.g.*, Ref. 7).

The results of the analysis are shown in the figures, consisting of three graphs (see, *e.g.*, Fig. 5). The left graph represents the Quality Scale values. In this graph, lines 1, 2, 3, 4, 5 correspond to the blurring levels with σ = 0, 0.3, 0.4, 0.6, and 0.8, respectively. The middle graph is a representation of the preference matrix, similar to Table 2. Each cell gives the percentage of subjects that prefer the σ-value mentioned in the column above the σ-value mentioned in the row. The color of the cell gives some indication of the percentages:

- the black cells: 1–20%
- the dark grey cells: 21–40%
- the mid grey cells: 41–60%
- the light grey cells: 61–80%
- the white cells: 81–100%.

The * sign indicates whether the given percentage is statistically significantly different from 50%, *i.e.*, from randomly choosing between two options. The right graph gives the 95% confidence interval of the Quality Scale values, and thus can be used to see which values are statistically significantly different from each other (*i.e.*, when the *z*-value of one blurring filter lies outside the confidence interval of the other blurring filter).

TABLE 2 — Preference matrix.

	σ = 0	σ = 0.3	σ = 0.4	σ = 0.6	σ = 0.8
σ = 0	0.5	0.475	0.175	0	0
σ = 0.3	0.525	0.5	0.15	0	0
σ = 0.4	0.825	0.85	0.5	0.025	0
σ = 0.6	1	1	0.975	0.5	0
σ = 0.8	1	1	1	1	0.5

5 Results

For the session performed in the Netherlands, the results for the image "chinchar" are given in Fig. 5, and the results for the image "textpage" in Fig. 6. The left graphs of both Figs. 5 and 6 illustrate that when judging perceived sharpness, subjects assessed the various blurring filters as follows:

$$\sigma = 0.8 < \sigma = 0.6 < \sigma = 0.4 < \sigma = 0.3 \approx \sigma = 0,$$

where < refers to less sharpness. The middle graphs show that the images with σ = 0.8 and σ = 0.6 are almost never preferred above the images with a lower σ-value. The images with σ = 0.4 are only preferred about 20% of the time when compared to the images with σ = 0 and σ = 0.3. For the images with σ = 0 and σ = 0.3, the preference of one above the other is almost 50%, which is close to randomly picking one out of two. In other words, the difference in preference between the images with σ = 0 and σ = 0.3 is very small. The right graphs illustrate that there is no statistically significant difference in perceived sharpness between

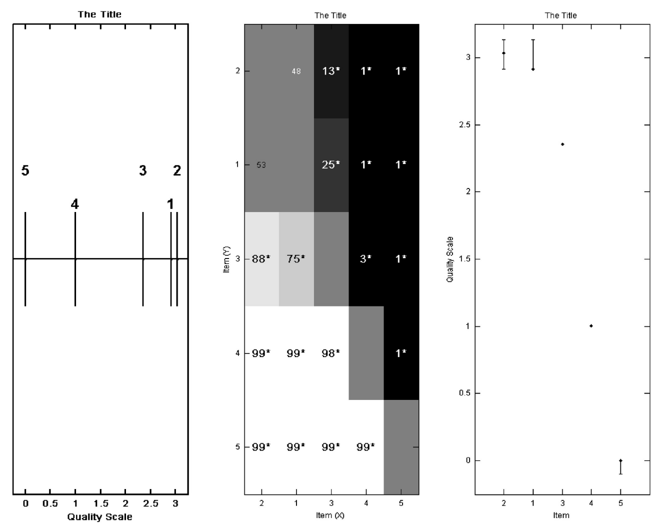

FIGURE 7 — Results for the image "chinchar" in China: 1: $\sigma = 0$; 2: $\sigma = 0.3$; 3: $\sigma = 0.4$, 4: $\sigma = 0.6$, 5: $\sigma = 0.8$.

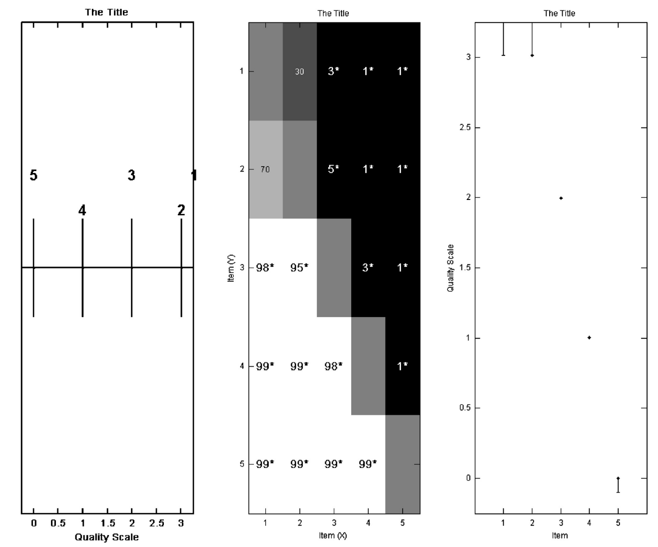

FIGURE 8 — Results for the image "textpage" in China: 1: $\sigma = 0$; 2: $\sigma = 0.3$; 3: $\sigma = 0.4$, 4: $\sigma = 0.6$, 5: $\sigma = 0.8$.

the original image and the one blurred with $\sigma = 0.3$. Both levels, however, are statistically significantly sharper than all other levels. These higher blurring levels (*i.e.*, $\sigma = 0.4$, 0.6, and 0.8) also are mutually statistically significantly different. So, the perceived differences in sharpness for both images can be summarized as given in Table 3, in which for each image and each blurring level the resulting QS value is given and whether it is statistically significantly different from the next one is indicated.

For the experiment in China, the results are shown in Fig. 7 for the image "chinchar" and in Fig. 8 for the image "textpage." Both figures show more or less the same trends as found before for the results in Europe. The left graphs illustrate that when judging perceived sharpness, subjects assessed the various blurring filters as follows:

$$\sigma = 0.8 < \sigma = 0.6 < \sigma = 0.4 < \sigma = 0.3 \approx \sigma = 0.$$

The middle graphs of Figs. 7 and 8 illustrate that the images with $\sigma = 0.8$ and $\sigma = 0.6$ are almost never preferred over the images with other σ-values. The image "chinchar" blurred with $\sigma = 0.4$ is only preferred about 20% of the time with respect to the images blurred with $\sigma = 0$ and $\sigma = 0.3$. For the image "textpage" the percentage is lower. The images with $\sigma = 0$ and $\sigma = 0.3$ have a preference percentage slightly deviating from 50% when compared to each other. The right graphs of Figs. 7 and 8 show that there is no statistically significant difference between the original image and the one blurred with $\sigma = 0.3$. Both levels are statistically significantly sharper than all other levels. The $\sigma = 0.4$, 0.6, and 0.8 levels are mutually statistically significantly different. So, the differences in perceived sharpness for both images can be summarized as given in Table 4.

TABLE 3 — Quality Scales (QS) for both images as resulting from the experiment in Europe.

σ-value	Chinchar	Textpage
$\sigma = 0$	QS=3	QS=3
$\sigma = 0.3$	=QS=2.85	=QS=3
$\sigma = 0.4$	>QS=2.35	>QS=2.3
$\sigma = 0.6$	>QS=1.05	>QS=1
$\sigma = 0.8$	>QS=0	>QS=0

=: no statistically significant difference.

$>$: sharper.

6 Discussion

Combining the results of both sessions, we can directly compare the trends obtained in Europe and in China for the perceived differences in sharpness of both images used in this study. Tables 3 and 4 show that the Quality Scale values

TABLE 4 — Quality Scales (QS) for both images as resulting from the experiment in China.

σ-value	Chinchar	Textpage
$\sigma = 0$	QS=2.85	QS=3
$\sigma = 0.3$	=QS=3.05	=QS=3
$\sigma = 0.4$	>QS=2.35	>QS=2
$\sigma = 0.6$	>QS=1	>QS=1
$\sigma = 0.8$	>QS=0	>QS=0

=: no statistically significant difference.

$>$: sharper.

TABLE 5 — Comparison of the results in China and in Europe for all blurring levels and images.

	Chinese characters	Europe text page	Natural image
China	$\sigma=0$	$\sigma=0$	$\sigma=0$
	$=\sigma=0.3$	$=\sigma=0.3$	$=\sigma=0.3$
	$>\sigma=0.4$	$>\sigma=0.4$	$= \sigma=0.4$
	$>\sigma=0.6$	$>\sigma=0.6$	$>\sigma=0.6$
	$>\sigma=0.8$	$>\sigma=0.8$	$>\sigma=0.8$
Europe	$\sigma=0$	$\sigma=0$	$\sigma=0$
	$=\sigma=0.3$	$=\sigma=0.3$	$=\sigma=0.3$
	$>\sigma=0.4$	$>\sigma=0.4$	$= \sigma=0.4$
	$>\sigma=0.6$	$>\sigma=0.6$	$>\sigma=0.6$
	$>\sigma=0.8$	$>\sigma=0.8$	$>\sigma=0.8$

for the two images at different blurring levels are slightly different between the session in Europe and the one in China. But, these differences are not statistically significant, and thus, exactly the same trend is found in the results for China and Europe. These results are summarized in Table 5, together with the results of an earlier study using natural images.

Table 5 clearly illustrates that the same results are found in China and in Europe. Subjects cannot distinguish a difference in sharpness between the original image ($\sigma = 0$) and the one blurred with a Gaussian filter with $\sigma = 0.3$. They can, however, distinguish differences in sharpness between all images blurred with a Gaussian filter with a σ-value above 0.4 in case the difference in σ between two images is at least equal to 0.2. The threshold for perceiving a difference in sharpness is between the original image and the one blurred at $\sigma = 0.4$ for both Chinese characters and Roman text. This threshold is lower than what was found earlier for natural images.[3]

Since the same CPTs were used as in the study reported in Ref. 3, we can use the data presented there to relate the measured visibility threshold for perceived sharpness to a difference in diagonal step response. The threshold corresponding to a difference in sharpness between an original image and the one blurred to a level of $\sigma = 0.4$ is for the CPT used in this study related to a difference in diagonal step response of only 0.1 mm. Considering again the viewing distance of 2.25 m as used in this study, the visibility threshold for perceiving differences in sharpness in text images corresponds to a difference in diagonal step response with an angular resolution of 5 arcsec. Hence, assuming that we need pixel sizes of 0.1 mm to display all possible detail that (on average) can be observed by the human eye in text images at a distance of 2.25 m, we would need TV displays with a spatial resolution of about 250 dpi. Current commercially available TVs have a spatial resolution lower than 100 dpi.

As mentioned earlier, the Chinese characters and Roman text used in this study did not have the same character size. In both cases, font sizes more or less typical for a subtitle application were used. If the subjects would have assessed perceived sharpness as legibility, the difference in font size might be expected to have some effect on the results. But, since for both text images of nonsense text was used, legibility is not likely to play a role on the judgment of perceived sharpness. Moreover, especially for the assessment of the image containing the Chinese characters in the Netherlands, legibility could not have been played at role at all. Subjects were indicated to judge perceived sharpness as the visibility of clear edges on small strokes, and as such, as the related perceived level of details distinguishable in the characters. Hence, we are convinced that we would have found similar results for both text pages if the same character size would have been used.

7 Conclusions

Using exactly the same experimental protocol and the same experimental set-up, we have duplicated the experiment from China to Europe to investigate possible differences in perceived sharpness for different regional backgrounds. Having paid a lot of attention to the exact duplication of the experimental conditions, we are convinced that possible differences in the results of both experimental sessions can be directly attributed to differences between the two groups of subjects.

The statistical analysis of the data, however, convincingly showed that there are no differences:

- The difference in sharpness between the original image and the one blurred at $\sigma = 0.4$ level is perceived for an image containing Chinese characters as well as for an image containing Roman text.
- This difference is perceived by Chinese people as well as by European people.

Furthermore, the results of this study confirmed an earlier observation,[8] namely, that people judge perceived sharpness differently on text than on natural images. This study combined with earlier results (only partly published in Ref. 3) indicate that text, whether it consists of Roman or Chinese characters, is more critical image material for judging sharpness than natural images.

With the results of this study, we now can invalidate the rumor often heard that Chinese people would be more sensitive to sharpness differences than European people. One should note, however, that determining visibility thresholds for different regional backgrounds does not say anything about possible differences in preference. Indeed, in an earlier study[9] indications were found that people in China prefer a high-contrast setting on a CRT when judging sharpness, whereas people in the Netherlands disliked this high contrast setting because of the related loss in sharpness due to spot broadening. Thus, although differences in sharpness are perceived equally between European and Chinese people, it still might be necessary for display manufacturers to optimize their display characteristics related to sharpness differently for the various markets spread over the world.

Acknowledgments

This project is supported by LG.Philips Displays. The authors would like to thank all the volunteers in the Netherlands and in China who joined the experiment.

References

1 K Teunissen and J Westerink, "A multidimensional evaluation of the perceptual quality of television sets," *J SMPTE* **105**, 31 (1996).
2 J H D M Westerink, "Perceived sharpness in static and moving images," Ph.D. Thesis, Eindhoven University of Technology (1991).
3 I Heynderickx, S Bech, E Mastenbroek, and M De Lameillieure, "The visibility of differences in perceived sharpness and its relationship to display characteristics," *SID Symposium Digest* **32**, 504 (2001).
4 L A Olzak and J P Thomas, "Seeing spatial patterns," in: *Handbook of Perception and Human Performance,* Vol. 1, eds. K. R. Boff, L. Kaufman, and J. P. Thomas (John Wiley & Sons, New York, 1986), pp. 7.1–7.56.
5 H A David, *The Method of Paired Comparisons* (Charles Griffin & Company, Ltd, London, 1963), Chap. 3.7.
6 Recommendation ITU-R. BT.500-10 "Methodology for the subjective assessment of the quality of television pictures" (2000).
7 P G Engeldrum, *Psychometric Scaling: A Toolkit for Imaging Systems Development* (Imcotek Press, Winchester, 2000), p. 65.
8 I Heynderickx, S Bech, and E Mastenbroek, "Sharpness As Perceived on a CRT," *Proc IDW '02,* 1267 (2002).
9 J Xia, L Liu, I Heynderickx, and H Yin, "Influence of white-point setting and contrast on perceived image quality," *SID Symposium Digest* **33**, 816 (2002).

Lu Liu graduated from the Automatic Control Department of Southeast University in 1985 and received her B.S. degree in computer science and technology at the same university in 2004. She is now working in the Display Technology Research Center of Southeast University. Her current interest is visual perception study.

Jun Xia received his M.S. and Ph.D. degrees from Southeast University, Nanjing, P.R. China in 1999 and 2004, respectively. His current research area is video processing and human visual perception.

Ingrid Heynderickx was born in Sint-Niklaas (Belgium) in 1961. She received her Ph.D. degree in physics at the University of Antwerp in December 1986. In 1987, she joined the Philips Research Laboratories in Eindhoven, and worked in different areas of research: optical design of displays, processing of liquid-crystalline polymers, and functionality of personal-care devices. Since 1999, she has been the principal scientist in the Video Processing and Visual Perception group, where she is heading the project on Visual Perception of Display Systems. She is member of the Society for Information Display (SID), and for the SID, she is chairman of the Applied Vision subcommittee.

Hanchun Yin graduated from Fudan University in 1970 and received her M.S. degree in engineering from Southeast University in 1982. In 1985–1986, she was a visiting scholar with Prof. T. Mulver at Aston University in Birmingham, U.K. She now works in the Department of Electron Engineering at Southeast University as a Professor and Ph.D. advisor. Her specialty is electron physics, the computation of electromagnetic fields.