Measuring visual form discrimination with blur thresholds

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A method is described for gauging the discriminability of spatial forms. Rather than challenging form discrimination by size reduction as is done in testing visual acuity, the maximum image degradation by blurring is determined that still allows shape recognition. The procedure has the advantage that tests are substantially independent of optical (resolution) and retinal (light-processing) stages of vision and concentrate on the perceptual demands of distinguishing form. Candidate spread functions are analyzed with respect to both their spatial and spatial-frequency properties and compared with dioptric defocus. Form discrimination thresholds, in terms of the parameter of the imposed Gaussian spread, were determined for several classes of patterns and compared with contrast reduction, where target size can also be kept constant but retinal sensitivity issues predominate. The technique has utility for experiments in ordering shape difference hierarchies, in examining rules of Gestalt properties, and in identifying progress in perceptual learning. Diagnostic potential in patients with spatial visual dysfunction such as amblyopia remains to be explored.

Introduction

Differentiating forms or shapes is arguably the single most important visual facility, as evidenced by the fact that when a vision check is pared down to a single test—e.g., for driver’s licenses or in a first once-over in a professional eye examination—it is invariably for visual acuity.

In the traditional visual acuity test, e.g., the Snellen chart, letters are diminished in size to the recognition limit. The challenge to the observer’s spatial sense is twofold. One is resolution, the ability to distinguish two closely-adjacent contours as separate, best exemplified by the ability to differentiate the letters O and C. But in addition, there is the task of correctly identifying the relative disposition of fully-articulated components of configurations, for example those involved in distinguishing between the shapes of the letters X and V, or H and N.

Visual acuity is a psychophysical thresholds measurement, in which the task of identifying the individual letters is made progressively harder until it can only barely be performed, the difficulty increasing along a dimension capable of numerical scoring. In Snellen acuity it is size compression. But there are ways of carrying out a stress test on form discrimination other than making the tokens smaller.

When form is being probed by minimally detectable discrimination procedures, visual spatial signals are rearranged or modified. For example, there are procedures involving perturbation of the geometrical disposition (relative location, orientation, angle, curvature, etc.) of target or target component contours. They fall into the domain of hyperacuity. Other procedures leave the targets themselves unchanged, but subject their contours to loss of definition. To examine them, it must be understood that edges or borders, on which the recognition of shapes depend, are created by differential activation of immediately adjacent elements in the apparatus encoding spatial location and one would be looking for means of reducing border conspicuity. A well-known way of accomplishing this is by diminished brightness contrast (Figure 1): this is the basis of the Pelli-Robson chart (Pelli, Robson, & Wilkins, 1988), an idea that could be extended into the heterochromatic brightness domain and indeed into the more general realm of chromaticity.

The purpose of this communication is to lay out the case for another stress test of probing form discrimination. Instead of diminishing their size, sharply-delineated targets have their borders subjected to a flattening in contrast gradients (Figure 2). This may be called blur threshold. How much blur can be imposed on shapes before they can no longer be distinguished?

It should be noted that image sharpness degradation and its subjective counterpart, blur, are here used as a measuring tool to aid investigation into the perception of shapes and not as perceptual variables in their own rights for threshold determination (for example, Hamerly & Dvorak, 1981; Westheimer, 1991), difference discrimination experiments (for example, Watt & Morgan, 1983; Mather & Smith, 2002), or theoretical
analyses (for example, Watson & Ahumada, 2011; McIlhagga & May, 2012).

**Principles of method**

The aim is to test the limit of an observer’s form discrimination ability by reducing the sharpness of target edges. As in traditional visual acuity, the observer’s task is to report on shape; thresholds are reached when the contrast gradient of edge light distributions is so shallow that the form-distinguishing characteristics of the feature are obscured and no longer allow correct responses. Hence in all its essentials the procedure is similar to standard visual acuity tests in that targets, belonging to a class whose members are few and well known to the observer, have to be deciphered against a progressively increasing handicap, which in this case is fuzziness (Figure 2). The present implementation utilizes a series of progressively wider spread functions, characterized by a single parameter whose value signifies increasing spatial extent and therefore poorer target definition. The original targets remain constant in size throughout but, with increasing convolved spread, the covered area increases.

In addition to the spread function used to degrade the targets, specifics of the implementation also include questions of the nature of the target set and hence the observer’s perceptual decision.

**Target set**

Even in the sketchiest application of a procedure for quantitatively assessing the relative discriminability of forms, the quandary has to be confronted of the categories within which shapes differ.

Form or shape discrimination obviously transcends the mere report of the presence or absence of nonuniformity of a field and also simple decisions relating to basic resolution (“Is the feature single or double?”), spatial extent (“Which of the two lines is longer?”), contour location (“Is the top line of the vernier target to the right or left of the bottom line?”), or orientation (“Is the picture frame vertical?”). One thinks of form or shape testing as discriminations more involved than simple yes/no answers to questions such as these, yet pattern design should as far as possible be decoupled from overall brightness and total contour length.

Some popular visual stimuli, such as gratings or Gabor patches, do not fit into the category of form discrimination if the observer’s task is detection of the presence of an inhomogeneity rather than the distinction between two different shapes of inhomogeneity.

On the other hand the rings with undulating circumference (Wilkinson, Wilson, & Habak, 1998), where the deformations are easily perceived and parameterized, conform well with the approach adopted here. In the experiments reported in this area (e.g., Bell & Badcock, 2008), the measurement parameter has been the minimum detectable shape deformation in features with moderate but constant blur, because such targets are difficult to generate with the image crispness that is demanded when, as is here the case, blur rather than deformation is the test parameter. Hence, in what follows, somewhat simpler shapes
are used differing among themselves only in outline and little or not all in area and total border length.

As a general guide, the criteria to be applied in the experimental psychophysical exploration include that the individual exemplars of target sets should be (a) intermediate in size, say 10–20 arcmin when shown in the fovea, (b) well known to the testee so that familiarity is not an issue, (c) approximately equal in complexity, so that the recognition task is equivalent, and (d) limited in number to make the scoring procedure manageable.

### Spread functions

As candidate spread functions that are circularly symmetrical and defined by a single parameter, dioptric defocus would seem a natural especially since blur minimization is widely used as the end point in the determination of refractive errors. The diopter, as a single variable, unfortunately masks the complexity of the image situation in defocus, as is described below. Spread functions involving some sort of exponential decay are better candidates, the Gaussian $\exp(-(r/k)^2)$ as proposed by Fry and Cobb (1935), being the most well known. (A Gaussian with parameter $k$ degrees $[\exp(-(r/k)^2)]$ has the additional property that its spatial frequency analog is also a Gaussian falling to 37% of peak value at $f = 1/\pi k$ cycles/°.) For reasons of its mathematical properties, the Cauchy function has been proposed (Klein & Levi, 1985), see Figure 3. Also good candidates would be families of spread functions based on the fit of empirical measurements of retinal light distributions (see Table 1.) Which set of spread functions is preferable in practice is a question that remains to be explored.

It is of interest to examine spread function in parallel in both the space and spatial frequency domains. Because all functions to be considered are circularly symmetrical, transformation into the spatial frequency domain involves not the cosine but the Hankel transform, wherein the kernel function is the Bessel function of zero order. In symbols, if the spread function in the object or image plane is defined by $G(r)$, $r = \sqrt{x^2 + y^2}$, its representation in the domain of $s$, the spatial frequencies, is

$$H(s) = \sum_{r=0}^{r_{\text{max}}} G(r) J_0(2\pi rs/60) r dr,$$

where the constant 60 is predicated on the units being used: light spread in minutes of arc visual angles; spatial frequencies in cycles/° of visual angle. In general, image degradation is reflected in a high-spatial frequency deficit. In a thorough analysis of spatial visual processing one tries to disambiguate the contributions of component factors of optical spread, receptor compartmentalization, center/surround retinal neural processing, and so on. Being measured in units of retinal distance, their role becomes increasingly more significant as target size is reduced. That makes the essential difference between traditional visual acuity determination and the approach adopted here so important: target size is unchanged; rather, processing and filtering is confined to the low spatial-frequency region and hence the size relationship between target features, retinal structure, and the intrinsic optical spread of the particular eye remains invariant throughout the process of measurement. It is in this connection that defocus blur needs special consideration. Defocused optical transfer functions are difficult to calculate but fortunately it has been estimated that

![Figure 3. Gaussian spread functions (left) with three parameters $k = 3, 4$ and 5 and Cauchy spread functions (right) with parameters $k = 2, 3$ and 4.](https://jov.arvojournals.org/pdfaccess.ashx?url=data/journals/jov/932811/ on 12/30/2018)
the error in a geometrical optical over the full diffraction formulation is only about 10% (Hopkins, 1955). It follows that to a good approximation the retinal point spread function for a typical eye with pupil diameter $a$ and focus error $\Delta F$ is a top-hat function with diameter $a\Delta F$ radians visual angle. Conversion to visual angle in arcmins, focus error $\Delta F$ of 1 diopters, and pupil diameter $a$ of 3 mm yields a top-hat retinal point spread of 10 arcmins. Obviously, even neglecting aberrations and a possible influence of the Stiles-Crawford effect, defocus in diopters is not a unique measure of image degradation. An additional aspect of the situation emerges on transfer into the spatial frequency domain: High spatial-frequency components are never completely eliminated by defocus but are merely attenuated and may be subject to phase inversion, and thus occasionally emerge in spurious resolution, when a high spatial-frequency grating might suddenly appear as resolved in a field otherwise destitute of detail.

Figure 4 depicts some spatial-frequency spectra. Units are chosen to highlight properties as they relate to the diameter of retinal receptors, of the order of 1 arcmin visual angle, and the cut-off spatial frequency of ideal optical systems like the eye, of the order of $30a$ cycles/° where $a$ is the pupil diameter in millimeters.

In practice, targets are made up as pixel maps convolved with the circularly symmetrical and monotonically decreasing spread function and the results summed pixel by pixel. In other words, the convolution of the target pattern with the spread distribution is displayed.

For the purposes of these experiments, the convolution of the target with the spread is calculated for all pixels in an array of side length equal to the targets plus the distance at which the spread function decays to near zero, usually about 2% of the peak. When the background was at full brightness and the target before convolution is black on white, the display array is given a black surround to minimize glare. The display could also be shown in reverse contrast, bright against a full dark background.

**Contrast**

Convolving a graded spread function with a target whose luminance profile is sharp edged has an impact on the contrast of the resulting distribution, which will have maxima only in positions surrounded everywhere by full-contrast target regions because only in these is the convolution height equal to the integral of the spread function. For that reason attention has to be paid to the contrast values in the distribution presented to the observer lest the effects of image degradation and of contrast diminution be conflated. In the experiments described below, this problem is being dealt with by a fixed Michelson contrast value in all presentations.

**Experimental study**

**Methodology**

**Targets**

Almost universally, the individual letters in visual acuity charts, no matter what the alphabet, are not uniform in legibility. This objection and questions about the observer’s familiarity with the items in the set and the probability of their occurrence are met by the

<table>
<thead>
<tr>
<th>Spread function</th>
<th>Expression</th>
</tr>
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<tbody>
<tr>
<td>Top hat</td>
<td>$G(r) = 1$ for $r &lt; k$, $0$ elsewhere</td>
</tr>
<tr>
<td>Linear (tent)</td>
<td>$G(r) = 1 - r/k$</td>
</tr>
<tr>
<td>Simple Gaussian</td>
<td>$G(r) = \exp(-r^2/k^2)$</td>
</tr>
<tr>
<td>Cauchy</td>
<td>$G(r) = 1/(1 + r^2/k^2)$</td>
</tr>
<tr>
<td>Eye light spread*</td>
<td>$G(r) = 0.933*\exp(-2.59*</td>
</tr>
</tbody>
</table>

Table 1. Spread functions, expressed in terms of radial distance $r$, each with a single parameter $k$, to be convolved with target light array to generate blurred displays. Blur increases with increasing $k$.  

Figure 4. Spatial-frequency pass band of a typical normal eye (Artal, 1990) and of three spread distributions, a Gaussian with $k = 4$, Cauchy with $k = 2.5$, and the image in an eye with 3 mm pupil and 1 diopter defocus.
tumbling Es or Landolt Cs, usually presented in only four orientations, with guessing allowed for. Perceptual factors, in particular attention, prior familiarity, and learning, are an inescapable component of these test, in which the observer uses clues to correct identification in blurred configurations and will need consideration in further developments of the method.

As a beginning, blur thresholds were determined for distinguishing between elements within each of four pattern families: overall shape, edge contours, letter-like configuration, and a simple geometrical pattern. In each case the ensemble size was small, two, three, or four, and known to the observer, yet not having been trained on (Figure 5). Within the ensembles, members differed only in shape and only in minor ways, if at all, in size, contrast, luminance, and contour length.

The targets had been prepared as 40 × 40 pixel maps. Laptop LCD screen displays under control of computer programs written in the Java language were achronemic and viewed at a distance at which a pixel subtended 1 arcmin at the observer’s eye. Maximum luminance was in the range of 100–300 cd/m². Each trial, with unlimited exposure duration, featured a member of the ensemble chosen at random, convolved with the particular spread function (see below). The pattern was presented centered on a full-brightness, sharp-edged, 40-arcmin circular background superimposed on the black screen.

**Image spread and contrast**

A Gaussian spread function $G(r) = 1 - \exp(-(r/k)^2)$ characterized by the parameter $k$ was employed. In each trial, the member of the target ensemble was convolved with the particular parameter value of the spread function mandated for this presentation at that stage of the psychophysical procedure. Both target and spread were dark against a bright background; the target only full black and white, the spread graded from black in the center to white. To obviate contrast variations among presentations, a further computational step was introduced which fixed the overall Michelson contrast $(I_{\text{max}} - I_{\text{min}})/(I_{\text{max}} + I_{\text{min}})$ to 0.33 in all situations, that is, the darkest point in the light distribution always had 50% of the luminance of the background. Although fortunately the essentials of the display were all at the high end of the brightness pixel range where luminance advances linearly, a generic gamma correction algorithm was included in the translation of the brightness pixel map arrived by these computational steps.

In a separate experiment, the intent was to obtain parallel results in which target recognition was impaired not by blur but by contrast reduction. Targets remained sharp throughout and the experimental parameter was contrast. These results were expressed in terms of the Michelson contrast for threshold shape discrimination.

**Procedure**

A staircase method was used to identify the blur threshold. For each presentation (trial) the observer was required to judge which ensemble member appeared represented and to respond by activating the corresponding keyboard key. The display remained visible until the observer responded; there were no error signals. In sequential trials, blur was decreased (constant of the Gaussian spread function reduced) until $n$ responses in a row were correct; $n$ depended on the number of alternatives and was three, four, and five for the cases of four, three, and two alternatives, respectively (4:1, 3:1, and 2:1 chance, respectively, of this not being the result of guessing). This was followed by a blur increase until there were two incorrect responses in a row, and the cycle repeated for a total of 15 reversals, of which only the last 12 were used to compute the average. Thus the threshold value on which the data converge is the mean of six consecutive spread parameters at which the observer loses discrimination with increasing spread and six reductions in spread at which discrimination is reliably recovered. A run usually numbered 100–150 trials and data from two runs, on different days, were averaged. The error bars show the 95% confidence limit of the average of all the last 12 “up” and “down” reversal points. In the Michelson contrast experiments, otherwise similar, the change from trial to trial was reduction of contrast to make the task more difficult or increase in contrast to make it easier.

In preliminary experiments, the psychophysical procedure of constant stimuli was used. Instead of being adaptive in that the spread parameter in any trial is predicated on previous responses, each trial featured at random one of a set of seven preselected spreads and the threshold identified by probit analysis of the psychometric function. This method gave basically identical results, but its implementation required more extensive prior surveying of the likely parameter range.

**Observers**

The experiments followed a protocol approved by the Institutional Review Board and in accord with the Helsinki Declaration. Participants, whose vision was normal for the purposes of such observation, had experience in this kind of visual data acquisition but, apart from one or two practice runs, no training in this task. Observation was foveal and binocular with refractive correction, if one was needed. The findings are typical for the particular targets and spread functions, but the effect of the many perceptual factors
that influence results remains to be studied. Full data in two observers for all conditions and both the blur and contrast reduction regimes are given below. Three more observers gave concordant results in subsets of these conditions.

**Results**

Shape recognition threshold for a particular target ensemble constitutes a measure of how distinguishable its members are in the face of image degradation and contrast reduction.

Data were obtained for the four different internally coherent ensembles representing a variety of shape categories each designed so that its members were broadly equivalent to one another, shown in Figure 5. Allowance for guessing was appropriate for the size of the ensemble. Two kinds of form discrimination thresholds for these ensembles were determined. One, Table 2A and Figure 6, top, was in terms of the parameter of the Gaussian spread, in arcmins, the other, Table 2B and Figure 6 (bottom), of the Michelson contrast. Because values in the two measures move in the opposite directions, the reciprocal of the Michelson contrast was plotted in Figure 6B to permit better comparison. Both can be seen as indicators of
the target groups’ relative discriminability, but because they tap into the visual system at different levels, there are differences. In both, performance in the triads is best and the distinction between a square and an octagon is possible under a much higher handicap. However, the relative order of difficulty among all the four pattern styles is not the same in the two regimes.

In the experiments, on each trial the observer had to decide, if necessary by guessing, which one of the two, three, or four members of the particular ensemble to which the run was dedicated the shown configuration seems to resemble most. Correct responses and errors across all targets were utilized in the single staircase progression by which the threshold value of the parameter for that run was arrived at, a procedure necessarily lumping all targets in the ensemble together. This ambiguity was removed in one instance by generating individual staircase sequences separately for each ensemble member and randomly intertwining them in single runs. Here also the observer’s task on each trial was to decide between degraded representations of ensemble members, but the up or down shift in the parameter was governed by errors for each of the particular members separately and not the aggregate. When this procedure was implemented, intertwined staircases for the square and octagon yielded almost identical threshold values for discriminability.

Table 2A. Parameter, together with the 95% confidence interval, in arcmins of Gaussian spread function at form discrimination threshold with Michelson contrast fixed at 0.33.

<table>
<thead>
<tr>
<th>Observer</th>
<th>Triad Edge contour Letters Square/octagon</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.27 ± 0.27 2.83 ± 0.20 3.34 ± 0.19 5.76 ± 0.16</td>
</tr>
<tr>
<td>B</td>
<td>8.71 ± 0.32 4.35 ± 0.41 5.13 ± 0.31 5.80 ± 0.28</td>
</tr>
</tbody>
</table>

Table 2B. Michelson contrast \((I_{\text{max}} - I_{\text{min}})/(I_{\text{max}} + I_{\text{min}})\) (in bold, their reciprocals), together with the 95% confidence interval, for form discrimination thresholds of sharply delineated targets.

<table>
<thead>
<tr>
<th>Observer</th>
<th>Triad Edge contour Letters Square/octagon</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.039 ± 0.005 0.066 ± 0.008 0.122 ± 0.016 0.041 ± 0.006</td>
</tr>
<tr>
<td>B</td>
<td>0.024 ± 0.006 0.041 ± 0.008 0.097 ± 0.01 0.047 ± 0.006</td>
</tr>
</tbody>
</table>

Discussion

Form recognition depends on the delivery to the sensorium of signals that are, in the first instance, funneled through the eye’s optics and the light-transducing and neural transcription apparatus of the retina. If a beginning study might start with the time-honored probing by means of perturbation, much as psychophysical detection and increment thresholds are used in the light and color sense, then form analysis ought to proceed in terms appropriate to itself and not be caught up by limitations of the input stages. The ubiquitous, clinically invaluable visual acuity test does not serve well here, because it pushes form recognition to its limits by reducing pattern size, which soon brings optical and receptor mosaic obstacles, irrelevant to the perceptual aspects of shape, into play.

In the search for other stimulus attributes that allow perturbation probing of form yet leave feature size alone, contrast comes to mind. Minimum contrast for detection and just-discriminable contrast difference thresholds both have found a place in studies of spatial vision. Processing of low-contrast signals has, however, a prominent retinal component that may again obstruct the exploration of purely perceptual imperatives in form recognition.

In the effort to overcome these constraints, the present study examines the form sense by determining how robust is the discrimination of differences in full-size and high-contrast targets to blur by image degradation. Numerical threshold values, in terms of the parameter of an imposed Gaussian spread, allow comparison between and within shape classes. The procedure permits evaluation of the contrast distributions needed to distinguish form in spatially restricted regions that are nevertheless unaffected by the limitations of the eye’s optics and receptor mosaic or of local retinal processing circuitry.

Because there is good overlap as regards target size and shape and research methodology, findings on the
minimum blur and the minimum contrast for shape discrimination can be compared directly.

Figure 7 (top) illustrates, somewhat schematically, the threshold stimulus light distributions in otherwise identical situations when shape discrimination is made against the handicap of (upper line) contrast minimization of a sharply delineated target and (lower line) edge degradation of a high-contrast target. An illustration of the resulting appearance of a letter is given in Figure 7 (bottom). The task is obviously different, stressing low-signal retinal light difference circuitry in one instance and spatially more distributed mechanisms in the other. The similarities and differences in the results, Figure 6 and Table 2, suggest that the two approaches are by no means equivalent and the range of their practical utilization, which should include
diagnostic analysis of patients with dysfunction of spatial vision, different.

Having a numerical handle should also prove useful in the effort, ongoing since it was explicitly articulated over 100 years ago, of categorizing and finding rules for sorting configurations, Gestalten. In his seminal paper, Wertheimer (1923) talked about these rules in only the most general terms and subsequent progress has been slow. As such rules are being formulated, empirical techniques are needed for their examination. To utilize rigorous psychophysical methods, in the way described by Brindley as class A (Brindley, 1960), the subjects’ decisions need to be pared down, ideally to only a yes/no response whether two stimuli are identical or whether a particular presentation contains a specific component feature. One such probe for Gestalt quality is how well a configuration can act as a separate entity by ungrouping itself from a neighboring spatial task (Sayim, Westheimer, & Herzog, 2010). Relative robustness to blur could serve well as a measuring index for assessing Gestalt rules.

Alphanumeric characters, signs, and symbols are known to differ in legibility. Ranking them according to how well they survive size reduction uses criteria of optical resolution, which may not match their perceptual conspicuity when they are seen in standard size conditions. Robustness to diminished contrast is unquestionably of consequence in some visual situations. But, to cite a specific example, distinguishability of road sign shape is likely to be best assessed by their relative blur thresholds. And with the ability to implement this on computer displays with, for example, Gaussian spread functions, the uncertainties and ambiguity of dioptric blur can be circumvented.

A particularly relevant application of the method here described is in numerical evaluation of the improvements that result from perceptual learning, where the right quantification of the observer’s performance is not always attained (Polat et al., 2012). The case is made here for contour gradients rather than target size as the means of measuring changes in an observer’s form discrimination ability.

Use of the word “measuring” in the forgoing implies that the attempt is to assign a numerical predicate to forms or at least to their differences. And insofar as a single parameter of a Gaussian spread is being quoted as characterizing the degree of difficulty of distinguishing elements of a small ensemble from each other, this is true. Comparing values across ensembles is also a valid use of the data.

Numerical order is, however, an elusive concept. Suppose a blur value for reliable recognition of an octagon had been secured, as in the experiment included in the results in Table 2. Now the next experiment is performed, identical in all respects except that the second target in the run is not a square but a circular disk, of the same area, width, and almost the same total contour length. The Gaussian parameter for discrimination of the octagon under blur would be less, i.e., the task harder, and this would be the case for both the lumped ensemble single staircase and for the two randomly intertwined double staircase procedures, i.e., whether the up or down blur sequence was common to both targets in the run or separate for each.

Obviously the same task, finding the blur for threshold discrimination of the given octagon, yields different answers and not because of the methodology or differences in the neural signal arriving in the primary visual cortex. (Although the possibility of top-down influences cannot be eliminated, it is reasonable to assume that the signal emerging from “early vision,” i.e., the processes centered on the eye’s optics, retinal circuitry, and the operations of the primary visual cortex, are the same for any given blurred octagonal configuration in a trial, whatever the other member of the ensemble in the run.) The differences are rather in the decision criteria on which the responses are based. The change undergone by different patterns when convolved with a given Gaussian spread is not singular, even when the patterns share most of the visual
attributes of brightness, contrast, color, size, contour length, symmetry, and so on. As the procedures described here are utilized to assess relative conspicuity within shape categories, they will also, it is hoped, help outline the relative distance separating individual patterns in multidimensional perceptual spaces and in this way contribute to the quest of charting them.

Conclusions

Testing form discrimination by size reduction in the manner of traditional visual acuity is associated with optical and receptor-lattice limitations of an eye and thus may introduce factors that may have little to do with the perceptual imperatives of form discrimination. These concerns are minimized when form discrimination thresholds are determined in terms of the parameter of convolved spread for targets whose size and contrast remain unchanged in the course of measurement. Results are similar but not identical with those obtained with contrast reduction that involve a prominent retinal component. Initial validation of the technique suggests that it might find application in clinical situations of spatial visual dysfunction, in evaluating progress in the learning of shape discrimination, and in studies of form perception.

Keywords: visual acuity, contrast detection, resolution, shape perception, eye’s optical spread function, dioptric defocus

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Footnote

1 A conceptual divide, also in semantics, between the realms of physical stimuli and of percepts has been found helpful in other areas of visual science (luminance/brightness, disparity/depth). For this reason here it is advocated that the word “blur” be reserved for an observer’s percept of fuzziness and the change in physical light distribution that causes it be referred to as image degradation or spread or sharpness reduction. No terminological confusion arises for phrases such as “blur test” or “blur threshold,” which contain a component of observers’ participation.

References


