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LETTER TO THE EDITOR

ARE LETTERS BETTER THAN GRATINGS?

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Contrast sensitivity testing to detect disease has been of great interest to both psychophysicists and clinicians for some time (e.g. Bodis-Wollner, 1980). In his article in this issue Leguire (1991) raises the intriguing subtopic of relating the results of different contrast sensitivity tests to each other. In particular, Leguire describes several characteristics of letter charts that worry him. Many of his comments are as applicable to traditional acuity tests as to the new letter-based low-contrast acuity and contrast sensitivity tests. We shall specifically address several of his points before making some general remarks.

CHART CONSTRUCTION

Leguire points out that letters, unlike gratings, have a mean luminance that depends (slightly) on their contrast, and suggests that the "change in mean luminance (from top to bottom of the chart) may cause increased variability in measurement". However, since the change is systematic and identical in all charts, it doesn't contribute any variability. Furthermore, in the Pelli–Robson chart the change is a trivial 13%, from 74 cd/m^2 in the top line to 85 cd/m^2 in the bottom line, and similar statements apply to most eye charts. Since it is practically impossible to control the mean luminance of any clinical instrument with an accuracy as good as $\pm 13\%$, it is important that Zhang *et al.* (1989) showed that the contrast sensitivity for large letters changes very little (± 0.1 log unit) over the much larger range of 7–514 cd/m^2.

Leguire notes that letter charts use many different letters, and is concerned that differences among the letters might increase the variability of the test. Like Snellen (1862) and Donders (1864), we consider the use of multiple symbols to be a distinct advantage of letter charts, because having multiple symbols essentially eliminates a correct response being made by guessing, making the threshold measurement faster and more accurate. Pelli *et al.* (1988) analyzed the issue quantitatively, showing that it is highly advantageous to have at least 3 different symbols. Nevertheless, sharing Leguire's concern, Robson *et al.* (1990) recently did an analysis of the sources of variance in the measured scores on the Pelli–Robson chart, and found that a theoretical model of the observer based solely on the measured steepness of the observers' psychometric functions, relating the probability of correct identification to letter contrast, fully accounted for the measured variance in test scores. A more elaborate model, incorporating the measured (small) variations in sensitivity among letters predicted essentially the same variance, indicating that the variation in sensitivity among letters is too small to matter.

Leguire notes that some diseases might affect contrast sensitivity for letters and sinusoidal gratings differently. This is quite correct. However, he fails to note that the same is true of contrast sensitivity measured using grating tests of different extents, durations, and spatial and temporal envelopes. We believe that the difference between letters and gratings is probably less important than variations in extent and duration of a grating (Graham *et al.*, 1978; Watson, 1979). A true sine wave would go on forever, so grating tests restrict their extent and duration by a spatiotemporal envelope; top hats (abrupt edges and sudden onset) and Gaussians (soft edges and gradual onset) are both popular envelopes, yet give very different results (Campbell and Robson, 1968; Campbell *et al.*

1969; Robson, 1966; Tolhurst, 1975a,b). Ultimately all anyone can do is to show that a particular test is useful in detecting or diagnosing a disease. Attempting to functionally subdivide contrast sensitivity tests seems counter productive at this early juncture.

Leguire states that Regan's low-contrast test (Regan, 1988; Regan and Neima, 1983) has too few contrasts. We disagree. As a practical matter we believe that it is unreasonable to expect clinics to routinely make more than one vision measurement to supplement the ordinary high-contrast letter acuity, at least until a clinical trial demonstrates the efficacy of more measurements in early detection of disease. As evidence of this fact, we note that most studies using Regan's charts have followed Regan and Neima's (1983) suggestion, and use just the 100% (i.e. traditional) and 10% charts, which is quite sensible in our view.

LETTER IDENTIFICATION

Leguire explains the differences between detection, discrimination, and identification tasks. However, it is all irrelevant. Leguire forgets to mention that most *clinical* grating tests, like letter tests, use an identification task. For example the Vistech chart uses gratings of 3 orientations and a blank (Ginsburg, 1984). The observer must *identify* which is present. Clinical tests use identification tasks in order to have more than two response alternatives for each test patch. Multiple response alternatives are important in reducing the guessing rate, as Snellen (1862) and Donders (1864) pointed out so long ago. Leguire suggests that some diseases affect identification more than detection, but that would seem to be a reason to *prefer* identification. Again, particular diseases may affect contrast sensitivities differently for different targets and tasks, there are many independent dimensions to this space, and the difference between gratings and letters does not seem particularly important compared to differences in extent, duration, envelope and task.

SENSITIVITY AND SPECIFICITY

Having argued that letter charts are *more* sensitive to disease, Leguire then argues that they might be *less* sensitive. Unquestionably, different diseases may affect different tests differently. Whether they do or not is an empirical matter. Researchers will want to have many tests available, choosing whichever they think would be most effective in revealing the disease. Letter charts will always have the advantage of offering a familiar and objective test procedure.

Zhang *et al.* (1989) reported that contrast sensitivity for letters is insensitive to large changes in luminance, viewing distance and defocus. This suggests to Leguire that the test will be insensitive to pathology, although Zhang *et al.* were able to use the test to demonstrate the known but small effect of age. More importantly, because these physical variables are not tightly controlled in the clinic, any test that is sensitive to them (e.g. acuity) will produce test scores reflecting these variables and thereby conceal any subtle effects of disease. Acuity is acutely sensitive to refractive error, so there is little point in making a second measurement, such as high-spatial-frequency contrast sensitivity, that measures the same thing. Sensitivity is useless without specificity.

As Leguire notes, in the presence of unknown disease there is no way to relate contrast sensitivities on different tests, but this is as true for comparisons among different gratings tests as for comparisons between gratings and letters.

Leguire may be unduly worried about the difficulty of relating results of different contrast sensitivity tests. Pelli *et al.* (1986) found that the widely differing contrast sensitivity functions of 30 low vision and 20 normal observers, plotted as log contrast sensitivity vs log spatial frequency were all well fit (RMS error ± 0.2 log unit) by the same parabolic curve, shifted horizontally and vertically. Furthermore they found that two measurements, acuity and Pelli–Robson contrast sensitivity, predicted the entire contrast sensitivity function, with an RMS error of only ± 0.3 log units.

CONCLUSIONS

We agree with Leguire that more clinical studies are needed to establish the efficacy of all contrast sensitivity (and low-contrast acuity) tests. And it is indeed essential that all studies carefully specify how contrast sensitivity was measured, including extent, duration, spatiotemporal envelope, task and test patterns.

In clinical research that can devote hours to testing each patient there may be some questions that are best addressed by carefully measuring contrast sensitivity for gratings at many spatial frequencies. However, in routine clinical practice, with only a few minutes to

screen each patient, letters make it possible to measure acuity and contrast sensitivity quickly and accurately. Compromises offering multiple unreliable measurements are pointless.

We prefer letters for clinical vision testing simply because letters (unlike gratings) provide the basis for a quick reliable test applicable to a patient who has just walked in off the street, as Snellen proved so long ago. Even so, only empirical study will discover which tests are actually the most effective as screening tests for eye disease.

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