The Mars Letter Contrast Sensitivity Test

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The **Mars Letter Contrast Sensitivity Test** is a simple portable set of contrast-calibrated letter charts for testing contrast sensitivity that has recently become available exclusively through **Mars Perceptrix**. Its design is similar to, but improves upon that of the well-known Pelli-Robson chart. Since the Pelli-Robson chart has been available for some 18 years and is widely known, we first describe the Pelli-Robson chart, and then detail the improvements that the **MARS test** has.

The Pelli-Robson (**P-R**) Contrast Sensitivity Chart, originally described by Pelli et al. (1988), is a large wall-mounted chart, 59 cm wide and 84 cm high, that consists of 16 triplets of letters each subtending 2.8 deg at the intended 1 m test distance, arranged in 8 rows of two triplets each. The three letters *within* each triplet have constant contrast, whereas the contrast *across* triplets, reading from left to right, and continuing on successive lines, decreases by a constant factor ($1/\sqrt{2}$). The patient reads the letters across and down the chart, as in standard letter acuity measurement. Instead of the letters decreasing in size, however, they decrease in contrast. The final triplet at which the patient read 2 of 3 letters correctly, then, determines the log contrast sensitivity, which can be read off a score sheet that relates each triplet to a log contrast sensitivity value.

The P-R chart comes in two forms each of which is printed on a large sheet of resin-coated paper, and mounted on cardboard. To use both forms requires almost 1 m^2 of wall space, and a means of illuminating this area evenly, which is very difficult to accomplish in the typical examination room.

The Pelli-Robson chart has been widely used by researchers (but generally not clinicians), for many years now. There are several reasons for this:

- Prior to the appearance of the **MARS test,** it has been the only letter contrast sensitivity chart available. Letter contrast sensitivity testing is in principle fast to administer, accurate, and easy for patient populations to understand, due to its familiar similarity to letter acuity testing.
- Relative to CRT-based grating methods, a chart is much simpler to calibrate: generally the clinician or technician needs only set proper viewing distance and insure adequate illumination.
- Contrast sensitivity has traditionally been measured more completely with gratings, in which sensitivity is measured to a sample of spatial frequencies spanning the visible range. The **P-R** chart yields a measure that can be easily related to the peak of the contrast sensitivity function (normally at 0.5—3 cycles/degree). Pelli and Robson (1991) have forcefully argued that peak contrast sensitivity and ordinary visual acuity are alone sufficient to determine the full form of the contrast sensitivity function in all but a small number of controversial cases. Given this, a full contrast sensitivity curve contains much redundant information and thus collecting it wastes precious clinical time.
- It has been shown to have good test-retest reliability and repeatability (Elliott, Sanderson, & Conkey, 1990; Reeves, Wood, & Hill, 1993; Rubin, 1988; Simpson & Regan, 1995). It has been used in large population studies such as the Salisbury Eye study (Rubin et al., 1997), as well as many other smaller clinical studies (e.g. Bose, Piltz, & Breton, 1995; Butuner, Elliott, Gimbel, & Slimmon, 1994; Gardiner, Armstrong, Dunne, & Murray, 2002; Hawkins, Szlyk, Ardickas, Alexander, & Wilensky, 2003; Maaranen & Mantyjarvi, 1999; Quaranta, Mauget-Faysse, & Coscas, 2002; Roesen, Scheider, Kiraly, Gofferje, & Feldmann, 1998; Rubin & Bressler, 2002). The United States National Research Council of the National Academy of

Sciences recently published a report that recommended adding letter contrast sensitivity as a basis for disability determination for the U.S. Social Security program (Lennie & Hemel, 2002).

Why hasn't the P-R chart become a standard for use in the offices of clinicians?

One reason is that contrast sensitivity testing is relatively new to clinicians. Early proponents of such testing justified its value based on a complicated systems theoretical model of the visual system that failed to relate contrast sensitivity to functional activities of everyday life. It is only in recent years that clinicians have become aware that visual acuity is not as good a predictor of performance in some important activities of daily living such as mobility (Kuyk & Elliott, 1999; Marron & Bailey, 1982) and driving (Owsley, Stalvey, Wells, Sloane, & McGwin, 2001; Wood, 2002); and that contrast sensitivity may be a sensitive indicator of disease and disease progression (Alexander, Derlacki, & Fishman, 1995; Bose et al., 1995; Elliott & Hurst, 1990; Essock, Fechtner, Zimmerman, Krebs, & Nussdorf, 1996; Ghaith, Daniel, Stulting, Thompson, & Lynn, 1998; Hawkins et al., 2003; Maaranen & Mantyjarvi, 1999; Quaranta et al., 2002; Roesen et al., 1998; Rubin, Adamsons, & Stark, 1993; Stewart, Fielder, Stephens, & Moseley, 2002; Tan, Spalton, & Arden, 1999; Trobe, Beck, Moke, & Cleary, 1996; Wood & Lovie-Kitchin, 1992).

A host of other reasons, mostly stemming from the chart's large size, are probably even more compelling reasons why the test has not become more popular. First, it is inconvenient for testing in small clinical spaces, as it requires a large amount of wall space must be devoted to it. Second, it is difficult to arrange lighting that will illuminate such a large area uniformly. Third, a wall-mounted chart is difficult to keep clean, and free of defects.

It is also worth noting that the actual Pelli-Robson chart that is currently available from Clement Clarke departs somewhat from the one described in (Pelli et al., 1988) and from the one originally available in the early 1990s (there was a period of several years during which the chart was not available at all). Here are the main differences:

- Test distance specified in (Pelli et al., 1988) was 3 meters, with the letters subtending 0.5 deg, whereas in the currently available chart, test distance is 1 meter, with 2.8 deg letters.
- Log contrast sensitivity values for the chart specified in (Pelli et al., 1988) ranged from 0.05 to 2.30, whereas in the currently available chart they range from 0.00 to 2.25.
- Because the contrast values may change over time due to exposure to light, the currently available chart is now sold with an expiration date beyond which the chart's accuracy is uncertain.
- The original chart was printed on durable plastic; the currently available chart is made of cardboard.

Advantages of The Mars Contrast Sensitivity Test

The **MARS test** follows many of the same design principles as those described in (Pelli et al., 1988); it uses the identical Sloan letter forms used in that test, and presents these letters declining in contrast from across and down the chart. However, the Mars test uses much smaller contrast decrements (0.04 log unit) than the **P-R**, which uses 0.15 log unit decrement between triplets of letters. It yields results that are entirely comparable to those of the P-R; in fact, using both analytic and Monte Carlo simulations and a model of visual performance identical to that used in the design of the Pelli-Robson (Pelli et al., 1988), the test yields virtually identical scores to the **P-R**, yet has 28% better accuracy (Arditi, 2004) (i.e. 28% smaller score standard deviations). The only substantial difference between the proximal stimuli of the two tests are the particular sequence of Sloan letters

chosen, and the finer gradations of contrast. Because of the high degree of similarity between the stimuli of the **MARS test** with those of the P-R chart and the equivalence of its scores, **all of the normative data that applies to the P-R chart can be applied to the MARS test**.

The **MARS test** is portable: it measures only 22.8 cm x 35.6 cm. It is intended for testing at 0.5 meters, at which distance each letter subtends 2 deg. It can be handheld (by the patient). Alternatively, it can be placed on a stand on a table, or slid into a light box (however, this should be done only as a means of supporting the chart---it should not be retro-illuminated). In any case, it does not require any significant space in the office.

Because of its small size, it is much easier to illuminate the chart uniformly, typically with the instrument stand lamp angled at 45 deg. The recommended illumination is 85 cd/m^2, the same as the P-R, and that recommended by the Committee on Vision of the U.S. National Academy of Science's National Research Council (Committee on Vision, 1980). In fact, in conjunction with portable lighting, the test can (and has been) used in studies of vision function that have been conducted in subjects' homes.

When the charts are not used on a daily basis, they can be stored in a small portfolio case, protecting them from light, and helping to extend their useful life.

Three forms of the chart are supplied, each mounted on its own durable sheet of plastic, making it easy to test each eye independently, and even binocularly, without being concerned about possible learning effects.

The set of three charts, user manual and protective portfolio case is being offered at an introductory price of U.S. $350.00, exclusively through

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