REFRACTION: PATIENTS ARE SENSITIVE TO INCREMENTS SMALLER THAN A QUARTER DIOPTER!

Traditionally, in the ophthalmic lens industry optical corrections have been offered in increments no smaller than 0.25 D. But patients are often sensitive to smaller dioptric changes. A study carried out by Essilor International at its Singapore R&D centre with a representative sample of patients showed that 95% were sensitive to dioptric changes of under 0.25 D and that 44% could distinguish between changes of less than 0.125 D. This article presents the results of the study and demonstrates how a patient's sensitivity can influence the precision of their refraction result. It also explores the outlook offered by the new high-precision subjective-refraction techniques and the ophthalmic lenses associated with them.

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KEYWORDS
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For more than a century now, frames and contact lens prescriptions have been made out in increments of 0.25 D. This limitation exists because trial frames, manual phoropters and automated phoropters all use trial lenses in increments of 0.25 D. Furthermore, these subjective-refraction instruments allow only separate, successive actions on the sphere, cylinder and axis of the correction being sought.

Today, with the advent of phoropters that offer smooth power changes in increments of 0.01 D and 0.1 degree and allow to work with sphere, cylinder and axis at the same time, it is possible to determine a subjective refraction with greater precision and therefore get much closer to a patient's true dioptric sensitivity. Semi-automated algorithms using psychometric methods combined with vector refraction technology were developed for this, and measurements of dioptric sensitivity in patients have been carried out in studies designed to validate these new refraction techniques.[2] The following sections present the results of these measurements and discuss their implications for the future.

Measurements of dioptric sensitivity in the patients during refraction examinations

The study entailed measuring dioptric sensitivity in a representative sample of 146 patients with ametropia during subjective-refraction examinations. These were performed using Essilor Instruments' Vision-R 800 phoropter – which provides continuous power changes – and semi-automated algorithms designed to determine refraction. Their average age was 35 +/-13 (from 19 to 66), and their average ametropia was -2.55 D +/-2.00 D (from -6.25 D to +2.63 D).

Dioptric sensitivity was defined as the minimum dioptric difference to which a patient is sensitive. It is evaluated with a probability distribution curve of patient answers, using one-half of the distance separating the dioptric values corresponding to the two probability points of -50% and +50% (Figure 1). These two points represent an area of insensitivity in which the patient cannot easily choose between one option and another. The interval separating them provides a good evaluation of the dioptric sensitivity. The prescription dioptric value, corresponding to a zero probability, yields the most probable value of the dioptric threshold, which is established for each of the refraction components.

The measurements were made for the various traditional tests used during a refraction examination:

- Determining the sphere using optotypes (letters) or the duochrome test,
- Determining the cylinder power and axis (converted into a dioptric value) using the Jackson cross-cylinder method,
- Determining the binocular balance by comparing the right and left eyes with a test composed of lines of letters dissociated with polarised filters.

The results are shown in Figure 2 and represented for each refraction test by the distribution of the proportion of patients that were sensitive to values under 0.125 D, 0.25 D and 0.375 D, respectively, and also over 0.375 D. The following observations can be made:

- Dioptric sensitivity in patients varied significantly depending on the test used and the refraction component sought. The tests used can therefore greatly affect a result.
- Patient sensitivity was lowest with tests using optotypes (letters) when evaluating the sphere: only 31% had a dioptric sensitivity lower than 0.25 D. This result is particularly interesting because while optotypes are the most commonly used tests for determining sphere in most refraction examinations, they appear to be the least precise. Patient sensitivity was highest with the duochrome test: 72% of them were sensitive to dioptric changes lower than 0.125 D. The duochrome test therefore proved to be the most precise for adjusting the sphere value.
- No less than 56% of patients were sensitive to cylinder power changes of less than 0.125 D when evaluating the cylinder power. Similarly, 53% of the patients were sensitive to the dioptric effect of axis variation (i.e. the dioptric translation of cylinder axis changes) in increments of less than 0.125 D. The patients were therefore sensitive to much smaller changes in cylinder power and axis than the 0.25 D increments that are traditionally used.
- When determining the binocular balance, 42% of the patients could perceive differences of less than 0.125 D, which corresponds to the common observation of the inversion in preference of one eye over the other during the introduction of a balance power of +0.25 D in one eye. (This makes it necessary to retain the balance of the corrections giving preference to the dominant eye if it is not possible to retain the exact binocular balance.) The patients were therefore often sensitive to smaller increments of differences in correction between the right and left eyes than the 0.25 D increments generally offered.

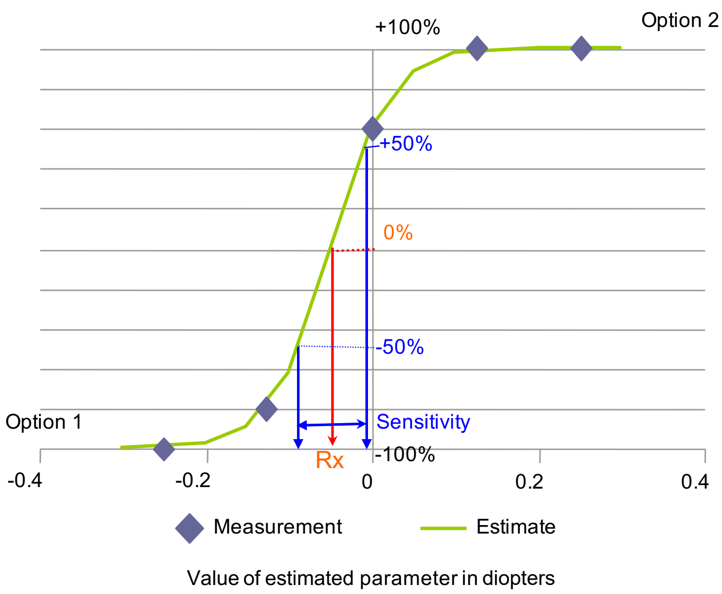

Figure 1: Measurements of dioptric sensitivity in the patients.
Each patient's sensitivity is evaluated using a distribution curve of their answers according to the dioptric level presented.
This curve represents the probability of their answer for each choice between 1 or 2.

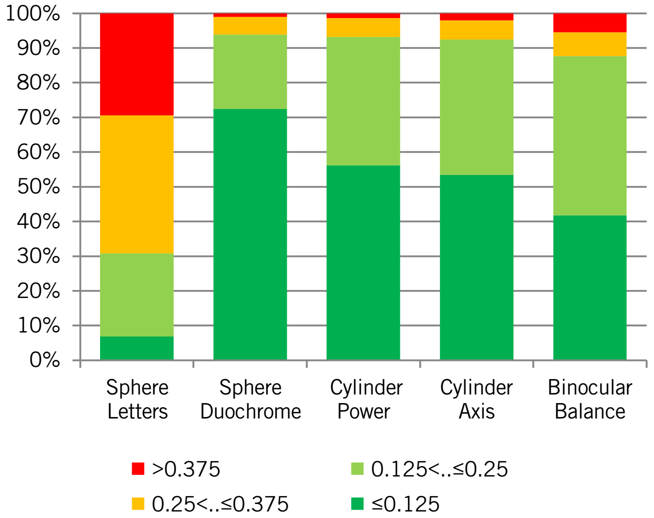

Figure 2: Distribution of patients' dioptric sensitivity for different refraction tests.

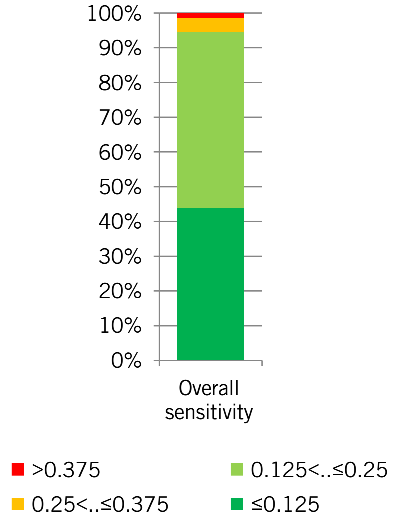

Figure 3: Average overall dioptric sensitivity in the patients

On the basis of the measurements made, it was possible to determine an overall dioptric sensitivity coefficient for each patient using an average of their sensitivities for each of the tests: sphere, cylinder, axis and binocular balance. If we combine these results, it becomes clear that **95% of the patients were sensitive to dioptric increments smaller than 0.25 D** and that **44% of them were sensitive to increments of under 0.125 D** (Figure 3).

Discussion and outlook

The results of these measurements suggest the following:

Traditional refraction instruments limit precision in subjective refraction

Given that they use lenses that vary by increments of 0.25 D, the traditional instruments used in subjective refraction are by nature insufficiently accurate in comparison with patient's true dioptric sensitivity.

Today, new and more precise optical technologies combined with semi-automated refraction algorithms make it possible to improve precision when determining subjective refraction. This means a patient's sensitivity and not the instruments used for measurement can be the main limiting factor in refraction precision.

The refraction tests used influence the result

The measurements performed showed that the patient sensitivity varied from one optometric test to another. The precision with which the refraction components are evaluated can thus vary significantly as well. However, each practitioner performs refraction examinations with their own method and different approaches to refraction are possible. Depending on the practitioner, refraction results can vary by as much as +/-0.50 according to estimates given in a number of studies.[3]

Semi-automated refraction algorithms monitored by practitioners offer the possibility of standardising refraction methods and improving the reproducibility of results from one practitioner to another.

Dioptric sensitivity in patients: a new parameter to consider

We frequently observe that some patients are much more sensitive to power changes than others. Measuring dioptric sensitivity in patients is thus a useful complementary approach when determining refraction.

A parameter for quantifying a patient's dioptric sensitivity can, for example, be used for the following:

- Adjusting the phoropter's power change increments during the refraction process itself, using smaller increments if the patient is sensitive to them and larger ones if not,
- Choosing the type of corrective lenses to offer the patient, either in 0.25 D or 0.01 D increments, depending on the patient's sensitivity,
- Integrating into the lens design a new customised parameter associated with the patient's dioptric sensitivity.

Measuring dioptric sensitivity in patients clearly opens up a new field of investigation.

Increments of 0.01 D are necessary to most accurately capture patient sensitivity

If we are to get as close as possible to the real dioptric sensitivity in a patient, we must be able to precisely control the optical powers presented to them.

Even though patients are obviously not sensitive to power changes of 0.01 D, being able to change the powers by a value of 0.01 D during a refraction examination remains useful in determining a patient's real sensitivity, which is often close to 0.10 D or even less.

Digital surfacing makes it possible to manufacture lenses in increments of 0.01 D

Developed more than 10 years ago, digital surfacing can be used to manufacture ophthalmic lenses with high-precision corrections. Previously, since refraction could be determined only in 0.25 D increments, this technology could not be used to make lenses in smaller increments.

But today, with the advent of subjective phoropters that can determine a patient's exact refraction through continuous power changes, it is possible to develop a new category of lenses calculated on the basis of refraction determined in increments of 0.01 D. The superior performance of the lens design and calculation systems can thus now be fully leveraged to target the prescription's exact power. Lenses of this type, which can offer patients a correction closer to their exact ametropia, are now (becoming) available.

Conclusion

Although the 0.25 D increment has long been considered the smallest possible precision for both correction and optical instruments, measurements have shown that most people are sensitive to smaller variations. Improvements in subjective refraction techniques on the one hand and lens design and manufacturing expertise on the other now allow us to achieve greater precision in optical correction. This can be integrated in 0.01 D increments into lens calculation and manufacturing to more accurately reflect patient sensitivity. Advances in technology thus enable us to improve precision throughout the entire optical correction chain and offer patients optical corrections that are more accurate than ever before.

KEY TAKEAWAYS

- Refraction has traditionally been performed using subjective phoropters equipped with lenses that vary by increments of 0.25 D. However, patients are very often sensitive to smaller dioptric changes.

- Measurements of dioptric sensitivity in a sample of patients showed that 95% were sensitive to dioptric changes under 0.25 D and that 44% could distinguish between changes of less than 0.125 D.

- A new generation of phoropters offering continuous power changes allows the practitioner to change powers in increments of 0.01 D. Refraction algorithms associated with them make it possible to get much closer to a patient's real dioptric sensitivity.

- Refraction can now be determined in increments of 0.01 D, and lenses can be manufactured using digital surfacing technology to offer a highly accurate optical correction.

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