Name of the project: GAZELAB

Description: Study of measurement's accuracy for GazeLab® device in 22 healthy patients

Table of contents

1. Presentation GazeLab® strabometer

BcnInnova has developed and patented a new system for the measurement of strabismus. Based on artificial vision technology and a laser projection system integral with the patient's head, it has achieved objective measurements with an accuracy far superior to traditional approaches.

The true value of this technological advance is the possibility to create a map of ocular motility that allows the study of each eye's muscle function separately. As a consequence, detail information, actually unknown, can be obtained and this will significantly improve surgical efficiency ratio.

GazeLab ®is the only device in the market that projects and films a pattern and the eyes reaction from a helmet. This greatly facilitates the exploration and opens the possibility of exploring children (who in any way would hold a disciplined exploration on a chin-support device).

2. Precision and accuracy concepts

The following explains the concepts of precision and accuracy of scientific measurement.

Precision

A *physical magnitude* is an attribute of a body, a phenomenon or a substance, which can be determined quantitatively, that is, an attribute that could be measured. Example of *magnitudes* are length, mass, power, speed, etc..

The magnitude of a specific *object,* that is being measured, is called *measurand*. For example, if we are interested in measuring the length of a bar, that specific length will be the *measurand*.

To set the value of a *measurand*, *measuring instruments* and a *measuring method* must be used. It is also necessary to define *measurement units*. For example, if we are going to measure the length of a table, the *measuring instrument* could be a ruler.

If the International System of Units (SI) is chosen, the measurement unit will be *meter* and the ruler to be used should be calibrated in that unit (or sub-multiples). The measurement method is determined by how often the ruler and fractions of it enters in the length measured.

In science and engineering, the term *error* has a different meaning from its regular use. Colloquially, it is usual to use the term error as similar or equivalent to mistake. In science and engineering, an *error* is rather associated with the concept of *uncertainty* in determining the outcome of a measurement.

More precisely, what is sought in any measurement is to know the dimensions (or probabilistic limits) of these uncertainties.

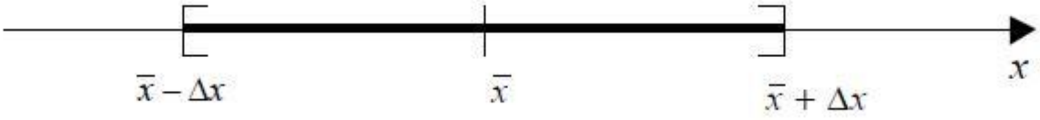


Figure 1.1. Interval associated with the result of a measurement. It can be observed that, instead of giving a single number, an interval of values is defined. (*x*) is the representative value of the center of the interval, and (Δx) is the way the *uncertainty* or the *absolute error* of measurement is named.

Graphically, we are trying to set an interval $x - \Delta x \leq x \leq x + \Delta x$ as in Figure 1.1 where, with certain probability, we can say that the *best value* of the magnitude *x* lays within it. This best value *x* is the most representative of our measurement and the half-width Δx is called the uncertainty or absolute error of the measurement.

In any process of measurement there are limitations given by the instruments used, the method of measurement, the observer (or observers) that performs the measurement. Also, the measurement process itself introduces errors and uncertainties. For example, when using a thermometer to measure temperature, some of the heat of the object flows to the thermometer (or vice versa), so that the result of measurement is a variation from the original value due to the inevitable interaction during the process. This interaction may or may not be significant: when measuring the temperature of one cubic meter of water, the amount of heat transferred to the thermometer may not be significant, but it will be if the volume involved in the process is a small fraction of milliliter.

Both, the instruments we use to measure and the magnitudes themselves, are a source of uncertainties when measuring. The instruments have a finite precision, so that for a given instrument, there is always a minimum variation of the magnitude that can be detected.

This minimum amount is called the *nominal appreciation* of the instrument. For example, with a ruler graduated in millimeters, we cannot detect variations smaller than a fraction of a millimeter.

At the same time, the measured magnitudes are not defined with infinite precision. Suppose we want to measure the length of a table. It is possible that when using increasingly accurate instruments we will start to notice the typical irregularities of cutting edges or, going even further, eventually detect atomic or molecular nature of the material that constitutes it. It is clear that at this point the length is no longer well defined. In practice, it is possible that, long before getting to these "extreme cases", the lack of parallelism at the edges of the table makes the concept of "length of the table" starts to become less and less defined. This intrinsic limitation is called *intrinsic uncertainty* or *lack of definition* of the magnitude.

Another example is set when counting the number of alpha particles emitted by a radioactive source in 5 seconds. Successive measurements will yield different results (similar, but in general different). In this case, again, we face a manifestation of an *intrinsic uncertainty* associated with this magnitude "number of particles emitted within 5 sec.", rather than an error of the instruments or the observer.

Accuracy

Another source of error that originates in the instruments, in addition to precision, is the accuracy. As we already defined in the previous lines, the precision of an instrument or a measurement method is associated with lower sensitivity or variation of the magnitude that can be detected with the instrument or method. Thereby, a micrometer screw (with a nominal appreciation of 10 μm) is more precise than a ruler in millimeters, or that a timer is more precise than a common clock, etc.

The accuracy of an instrument or measuring method is associated with the quality of the calibration of it. Let's say that the timer we are using is capable of determining the hundredth of a second, but goes ahead two minutes per hour, while a common wristwatch does not. In this case we say that the timer is still more precise than the wristwatch, but less accurate. Accuracy is a measure of the quality of the calibration of our instrument for internationally accepted standards of measurement. In general, the instruments are calibrated within certain limits. It is desirable that the calibration of an instrument is as good as the appreciation of it. Figure 1.2 shows both concepts in a schematic way.

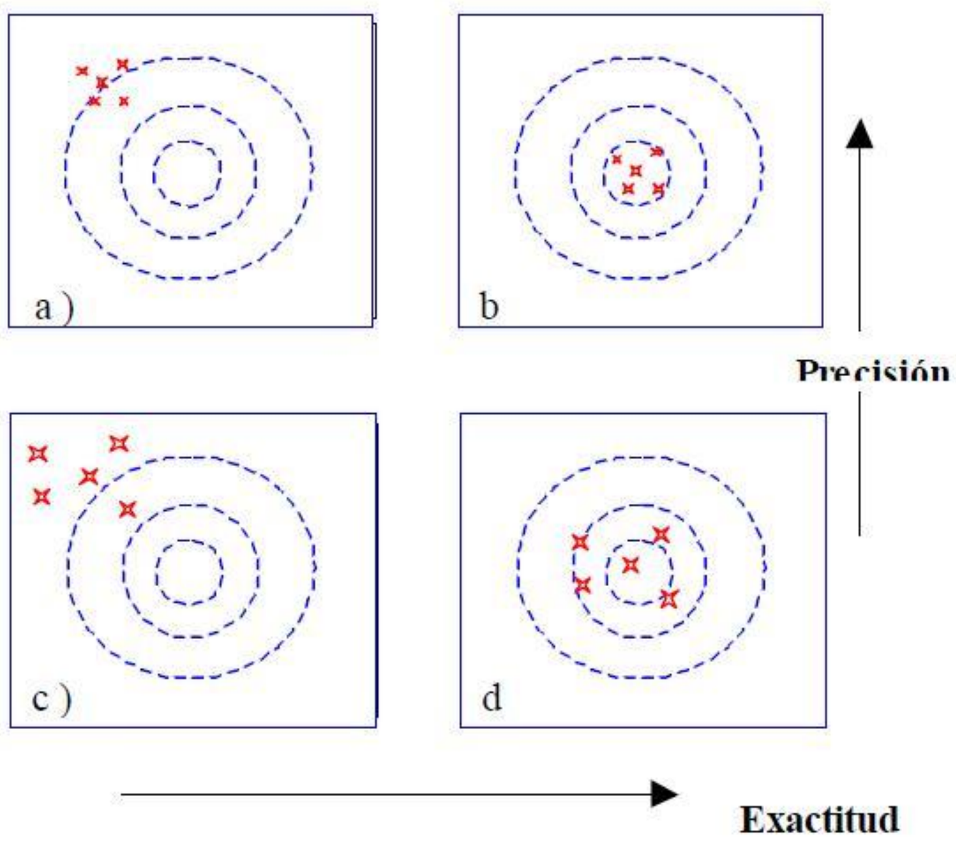


Figure 1.2. This figure schematically illustrates the concepts of precision and accuracy. The centers of the circles indicate the position of the "true value" of the *measurand* and the crosses the values of several determinations of the center. The dispersion of the points gives an idea of precision, while its effective center (*centroid*) is associated with accuracy. **a)** is a precise but inaccurate determination, while **d)** is more accurate but imprecise; **b)** is a more accurate and more precise, **c)** is less precise than **a)**.

We say we know the value of a given magnitude, as far as we know their errors. In science, it is believed that the measurement of a magnitude with a certain error does not mean that a *mistake* or a *bad measurement* has been made. With the indication of measurement error it is expressed, quantitatively and as precisely as possible, the limitations that the measurement process introduces in the determination of the measured magnitude.

3. Binocular deviation statistics in a sample of healthy persons (accuracy and precision measurement in different individuals)

Tests definition

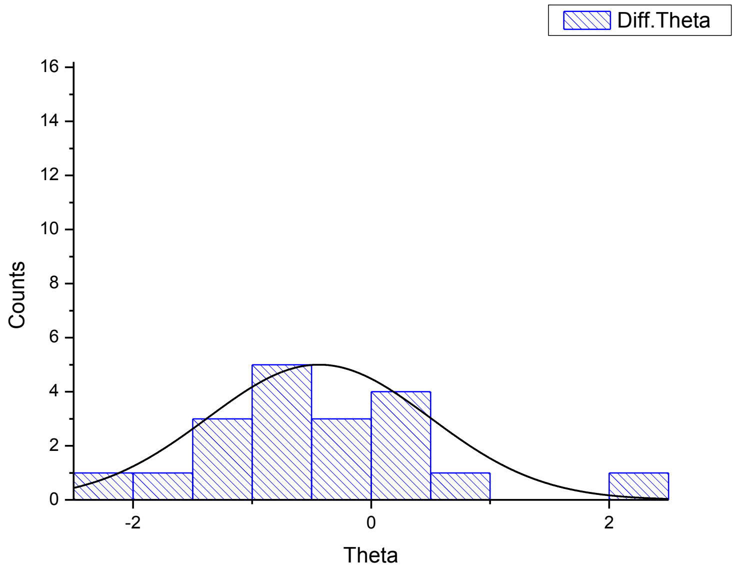
We have conducted 38 tests on 22 healthy people using the strabometer **GazeLab**®. The tests consisted of binoculars scans following 2 patterns, one upper and one lower. These scans allow us to determine the average binocular deviation on a healthy person.

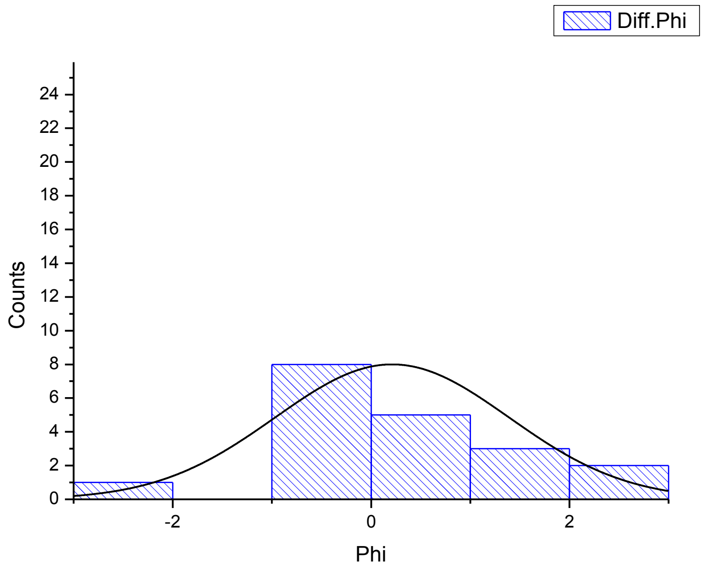
Sample definition

Sample of 22 healthy persons, 38 tests conducted following the upper and lower patterns.

Analysis of results in coordinate (0,0) (Histogram)

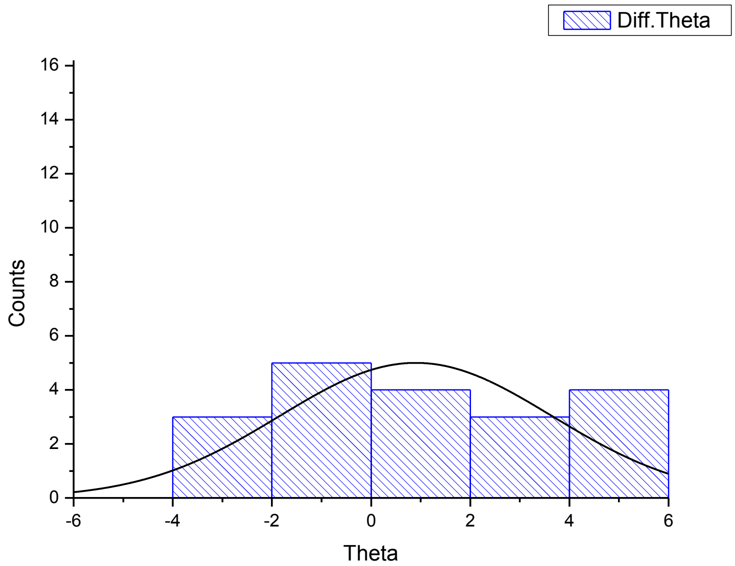
2 Histograms of the binocular differences between the left and the right eye in coordinate (0,0).

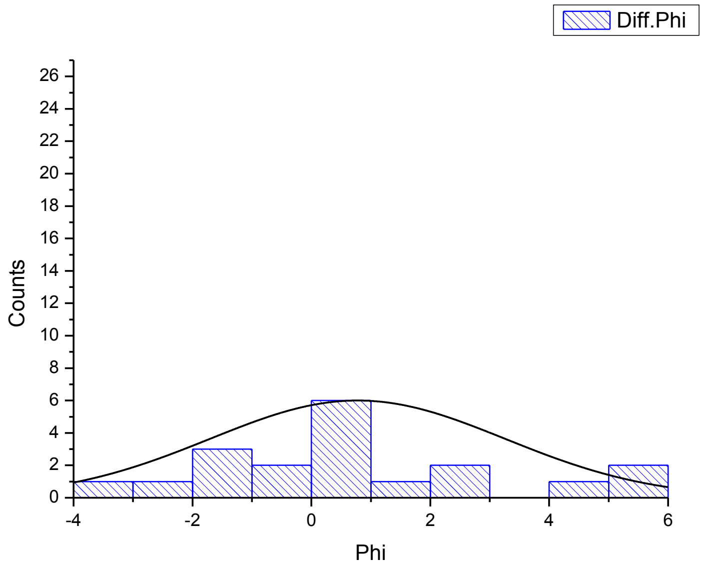




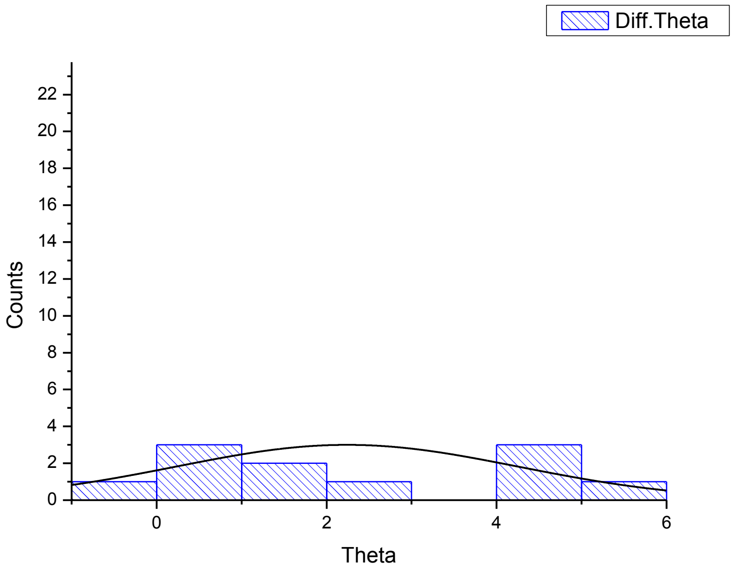
Analysis of results in coordinates (40,20) and (40,-20) (histogram)

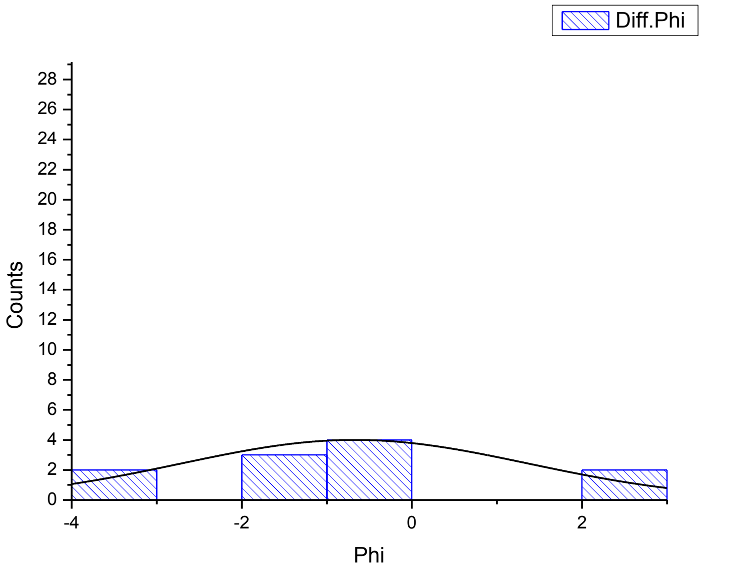
2 Histograms of the binocular differences between the left and the right eye in coordinate (40,20).





2 Histograms of the binocular differences between the left and the right eye in coordinate (40,-20).





Analysis of results in the whole visual field (data tables)

Analysis of results in the whole visual field, for 38 tests conducted, are expose in the following tables (measurements and standard deviation).

Upper pattern:

		BINOCULAR			
Patro X	Patro Y	AVERAGE(X)	DEVEST(X)	AVERAGE(Y)	DEVEST(Y)
0,00	0,00	-0,44	0,94	0,21	1,18
20,00	0,00	-0,11	1,23	0,15	1,24
20,00	20,00	0,45	1,78	0,37	1,55
20,00	35,00	1,04	2,57	0,67	2,73
40,00	0,00	0,82	1,94	-0,17	1,63
40,00	20,00	0,90	2,75	0,78	2,48
-20,00	0,00	-0,30	1,38	0,00	1,01
-20,00	20,00	-0,02	1,50	-0,65	1,77
-20,00	35,00	0,41	2,65	-0,55	2,79
-40,00	0,00	0,84	1,95	0,04	1,17
-40,00	20,00	0,80	2,58	-0,63	2,51
0,00	0,00	-0,79	1,08	0,16	1,14

Lower pattern:

		BINOCULAR			
Patro X	Patro Y	AVERAGE(X)	DEVEST(X)	AVERAGE(Y)	DEVEST(Y)
0,00	0,00	-0,38	0,53	0,25	1,22
20,00	0,00	0,23	0,68	0,10	1,49
20,00	-20,00	-0,59	1,33	-0,49	1,62
20,00	-30,00	-0,16	1,74	-0,29	1,66
40,00	0,00	2,76	2,36	1,31	2,79
40,00	-20,00	2,24	2,01	-0,67	2,04
-20,00	0,00	-0,22	0,74	0,30	1,11
-20,00	-20,00	-1,14	1,50	0,39	1,17
-20,00	-30,00	-0,12	2,34	0,05	1,37
-40,00	0,00	0,71	1,50	0,15	1,51
-40,00	-20,00	1,04	2,22	0,12	1,93
0,00	0,00	-0,18	0,57	0,49	1,23