Reading charts in logarithmic scale: why the Jaeger test is obsolete in the present?

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Abstract

Seeing clearly from a distance close to our nose, to the end of our outstretched arms, is relevant during a large part of a human being's day. Being able to read is a frequent activity for most people. Assessing near vision is part of the daily work of an ophthalmologist. Knowing what is the maximum performance of a patient's near visual capacity allows us not only to detect ocular pathologies, but also aspects related to neurodegenerative processes. Nowadays, the correct measurement of near vision requires the use of charts developed on a logarithmic scale, which are standardized at international level. In this paper some historical aspects will be reviewed and the current characteristics of logarithmic scale reading charts will be described, with the aim of stimulating their use in the daily clinical practice, also explaining the existing differences between the use of the Jaeger test and the new Byromat reading char.
Keywords: reading charts, reading performance, Byromat chart, near visión, intermediate vision.

Introduction

Near vision has always been relevant in the different stages of a person's life.

After birth, an infant's developing vision, in conjunction with other senses, are fundamental guides to feeding[1], touching and exploring the world at their fingertips[2]. Throughout childhood, while distant vision increases, near vision allows the acquisition and perfection of psychomotor

skills[3] and the first steps to begin creative tasks, the basis for later learning to draw, write and read[4]. The eyes are a window to the brain where vision is also a constant neurosensory development pathway[5]. Near vision is necessary and indispensable throughout life, with a prominent role in the processes of neuroplasticity that even persist into old age; these constitute new areas of research due to their relevance in neurodegenerative diseases such as Alzheimer's disease[6].

Two aspects are being analyzed in the evolution of the vision: 1) the impact that the confinement that occurred during the coronavirus pandemic may have on a large part of the population in future generations; and 2) the popularization of the digital world mediated by screens, and facilitated by electronic social networks[7] beyond its obvious effect on myopia[8].

Therefore, understanding that near vision is used most of the day in different activities of most people —regardless of their age—, it is necessary to emphasize the relevance of its proper assessment in our current context. This is the aim of the present narrative review, which will also describe the limitations of the current Jaeger chart and the characteristics of logarithmic scale charts, including the Byromat chart of the Argentine Council of Ophthalmology (CAO).

The Jaeger test: historical overview

Dr. Eduard Jaeger Ritter von Jaxtthaln was born in Vienna, Austria, in 1818 and died in the same city in 1884. Although we remember him mainly for having developed the reading chart that bears his name and is still used in some parts of the world[9], he was also a pioneer in describing what diabetes produces in the back of the eye[10] and the alteration generated by glaucoma in the appearance of the optic nerve[11].

Those years were times of many revolutions in the vision sciences. A contemporary of his was Dr. Herman Snellen, who published his optotypes in 1862[12-13], but Jaeger had preceded him (1854) with the development of a test to measure vision using text. Since then, a stage of competition began between the two colleagues for two ways of measuring vision: one based on optotypes (Snellen's), proposed as more reliable and accurate, and the other based on texts (Jaeger's), proposed as more useful and user-friendly, based on the concept that in daily life people read texts.

The review performed by Martín-Moro *et al.* raises a very interesting aspect to understand the race to standardize the measurement of vision at that time[12]. Jaeger conceptualized visual acuity as a spatial frequency and introduced the possibility of summarizing the visual function to a numerical value. However, Snellen, in applying the theoretical concept of the separable minimum to reading, developed optotypes that assigned an angular value of one minute of arc to each letter detail. This design ensured that, when an individual was placed 20 feet away, each visual element had a specific angular measurement, proposing a reproducible system as Jaeger's, but which would be superior from a practical approach to visual acuity acquisition. In fact, both won the race, because thanks to their coexistence, awareness was raised of the relevance of standardizing vision measurement, where both concepts were successful and endured over time, but one of them was used to measure distance vision (Snellen), and the other to measure near vision (Jaeger).

It is clear then that Jaeger's primer was a great contribution for the time, made with the knowledge and resources available in those years, at a time when near vision was used in activities different from those of today. If we consider the limitations they had in the manufacturing tools, the limited knowledge of the physiology of vision and the technological limitations to be able methodologically to evaluate the reproducibility of the tests produced, several of the aspects that will be discussed below are explained and motivate us to support what others have previously analyzed: Jaeger's test is obsolete today[14-16]. We must understand that ophthalmology is one of the most device-dependent specialties in medicine, which has come a long way since Jaeger created his chart. Think of the growth of science and technology in the last two to three decades in association with the development of new imaging methods, new neurological insights and new therapeutics to improve and correct visual

problems, with the rise of artificial intelligence applied to this area and a wide range of options proposed by implanto-refractive surgery, from the from excimer lasers, femtosecond lasers to new designs of intraocular lenses, not to mention pharmacological advances for the control of myopia and for the treatment of presbyopia, whose worldwide innovation was and continues to be led by an Argentine development more than a decade ago[17-22].

Why did Jaeger become obsolete and what are the current options?

The main reason is due to its current lack of global standardization. Whoever measures near vision using Jaeger cannot provide reproducible information because they do not have a valid scale and the test currently lacks a rigorous method of production and standardization. We cannot say that what is measured with Jaeger in one region of the world is equivalent to another. Maybe yes, maybe no. That is why the issue of unifying criteria for measuring near vision was widely discussed by the International Council of Ophthalmology (ICO) on the basis of the fundamentals set forth in an international standard (ISO 8596), defining briefly the following main following main aspects[23]:

a. By analogy with the standards for measuring visual acuity visual acuity, print sizes should progress logarithmically.
b. Calibration and standardization of optotypes and design.
c. The conditions necessary to perform the test must be specified (conditions of use), including the test distance and the minimum illumination required.
d. It is suggested that the text materials (optotypes) be continuous.
e. The typography is constituted based on the height "x" of the body of the character (considering the height of lowercase letters such as "o", "m" or "x"), which is subtended by five minutes of arc.

It is also established that this type of chart must be printed with a technique that allows obtaining a deviation of no more than 0.03 millimeters, which is relevant to ensure the legibility of the smallest text.

Of the above five items, the Jaeger chart only fulfills item "d" (which is also an optional item). The following are the main weaknesses of Jaeger:

1. Discrepancy between different Jaeger primers in terms of the print size of the optotypes of different circulating versions. Therefore, saying that a patient has "J1" as it is usually done in one place in Argentina is not necessarily equivalent to expressing the same thing when measured with another Jaeger chart. This not only happens in Argentina but is global. Jaeger is currently not reproducible.
2. In most Jaeger primers the distance of use is not stated. It is "common usage" that it is used at 30 to 40 cm at best.
3. Paragraph size does not follow a logarithmic scale.

This is mainly due to the fact that when Jaeger created his chart the smallest optotypes (equivalent to LogMAR 0.0, -0.1 and -0.2, under test conditions at 40 cm distance).

But there is another interesting aspect to highlight that has caused the loss of reproducibility of the data obtained with the Jaeger chart, and that is due to its growing popularity, many activities related to the vision sciences began to print versions without any type of control, appearing in a great variety of medical marketing material, even inadvertently leading to problems of confusion and lack of standardization in doctors who took (and continue to take) this material to measure their patients. This does not mean that they cannot use it to prescribe eyeglasses. You could also do this by giving a newspaper, a magazine or by making the patient read from a cell phone. But in none of these situations I would be able to score on a true and internationally reproducible scale the degree of a person's near visual acuity.

At the present time, the following printed reading charts are the options we recommend to replace the measurements made with the Jaeger test, as they are in accordance with the ICO recommendations: the Sloan chart, the Bailey-Lovie word chart, the MNREAD chart, the Radner chart, the Colenbrander continuous text chart,

the Smith-Kettlewell Reading test (SKread), the Oculus II Reading chart, the C-Read chart, the Arabic-BAL chart and recently the Byromat chart, from the Argentine Council of Ophthalmology.

Measuring near vision is a medical act that should not be underestimated

In the ophthalmological consultation, in a routine way and especially in people over 40 years of age, the evaluation of near vision is included. Usually, almost by tradition and custom, mainly in most of Latin America, we use the Jaeger chart. We give the chart to the patient and tell him/her to try to read the smallest part. Generally when we see that the patient begins to read the beginning of the sentence, he/she says for example the following (Spanish version of Jaeger): "Bóvedas y estos miles de columnas ..." We tell the patient that it is okay.

This is the beginning of one of the smallest sentences found in the majority of Jaeger charts used in Argentina. In this case, we annotate it as J1 (although the correct notation should be V = 0.50). We are reassured that the patient can read the smallest text we are measuring with this chart, unaware that there are actually people who can see LogMAR -0.2 at 40 cm. The example described is very common and has several issues. Firstly, we are not specifying an exact distance. Remember that we are measuring near visual acuity. Therefore, the distance between the optical system (patient's eyes) and the object to be visually resolved (optotypes printed on the chart) is crucial and should be explicitly defined. Measuring vision at 32 cm is not the same as at 40 cm. Secondly, there is a crucial aspect, which is the lighting. Our optical system is designed to operate at its maximum efficiency under certain lighting conditions[24]: to evaluate near vision with logarithmic charts, it should be 80 to 100 candelas per square meter (cd/m^2)[14-16]. Additionally, it is important to consider the issue of contrast, which should be optimal[25-26].

It is important to emphasize that measuring near vision involves obtaining medical data that will be recorded for future comparisons, much like measuring macular thickness, blood glucose levels, or intraocular pressure. It should be carried out in a reproducible and standardized manner to gather accurate information.

Any medical data is relevant until proven otherwise because it might not be significant at a given moment, but it could become so over time and in the course of evolution. It is clear that accurately assessing near vision is crucial not only for prescribing glasses correctly but also because we need to precisely and reproducibly know a piece of information that represents a part of the functioning of an individual's visual system.

So, why does the Jaeger chart continue to be used in some places?

In reality, there is no scientific justification, and, in fact, we have already expressed the reasons why it should not be used. However, there is a simple, concrete, and common-sense answer based on the points mentioned below:

- **Habit**: The Jaeger chart continues to be used "out of tradition and habit", although its use is becoming distorted with each new generation of ophthalmologists. This is mainly because there are prints and reproductions of the Jaeger chart that are widely available. Some physicians mistakenly believe that by copying, pasting and printing them they possess a medical measuring device, and many others mistake it for what is essentially just promotional material. Moreover, not all doctors use the chart as Jaeger specified under the conditions existing in 1854. It is logical not to adhere to the conditions of 1854, as we are approaching the end of 2023. However, the most logical step would be to no longer use Jaeger except to highlight its place in the history of ophthalmology. There is also no "habit" of teaching new doctors this type of logarithmic scale visual acuity measurement (near or far), and that has been part of the motivation to create the Byromat reading chart of the Argentine Council of Ophthalmology, as well as to produce this review article specifically for His-

panoamerica.

• **Availability**: Until March 2023, there was no standardized logarithmic scale reading chart option developed from its origin in the Spanish language.

• **Costs**: The available options that meet the standards described by the ICO (International Council of Ophthalmology) have a current approximate global cost ranging between 150 to 170 dollars. Additionally, the existing options were originally developed in another language (English or German) and were later translated or adapted to Spanish.

In summary, using the Jaeger chart is easy and convenient, even though it is not entirely accurate, and since 1988, the reasons for its obsolescence have been specified. We can no longer ignore that using it does not align with current international standards for measuring near vision.

Concept of sentence optotype: a reading chart is not just any text

Modern reading charts that adhere to international standards contain text developed using the concept of "sentence optotypes". This concept was well explained by another Austrian physician, Dr. Wolfgang Radner, who stated that each sentence optotype constitutes a measurement tool in itself[15, 27-28]. Each sentence optotype, in turn, arises from considerations of the language of origin, taking into account factors such as word difficulty, grammatical rules, and even auditory aspects. Dr. Radner is actually leading the revaluation of this type of chart through his own development, which has been translated into multiple languages. Additionally, he is recognized for being one of those who currently emphasize the importance of considering other parameters that can be obtained through this type of tests, related to reading performance[15], as we will see later in this paper.

The creation of sentence optotypes involves various stages of development. After their design, they undergo evaluation and selection following different scientific tests. It is crucial to consider the reproducibility and reliability of each sentence optotype to ensure their equivalence, regardless of the meaning of the words. In Byromat, each sentence optotype has the following characteristics (summarized):

• Each sentence optotype is arranged in three lines.

• It always consists of an identical structure in terms of the number of syllables, words, and characters per line, including spaces.

• The developed optotypes are interchangeable measurement products, regardless of their size.

Byromat: logarithmic reading chart with sentence optotypes and letters

Currently, Byromat stands as the only test that has the capability to assess near vision using sentence optotypes that meet international standards. Additionally, it features an original development—the rounded letter optotypes. This achievement resulted from various studies, culminating in the definition and selection of 7 lowercase letters: a-e-o-u-c-n-s. These letters differ from the so-called Sloan letters, which are the 10 letters used in the ETDRS test[29-30]. Sloan letters have some that are simpler to distinguish from each other (such as k from o). If there are letters that are easier to differentiate, visual acuity may be underestimated (the patient identifies them by their differences and deduces rather than seeing them). In Byromat, 7 rounded lowercase letters were selected that proved more challenging to identify. This is crucial for achieving maximum precision when specifically measuring near visual acuity (the resolution capacity of our visual system): if the person can correctly identify them, it means they have perceived them adequately. This ensures that we measure what we truly want to measure, reducing the possibility of identifying letters based on their differences and deduction.

Each letter "counts" as 0.02 LogMAR, so similar to the ETDRS test, an exact score of vision (in this case, near vision) can be obtained. This allows the use of the rounded letter optotype section as a reliable and reproducible measuring instrument in research, including clinical studies on

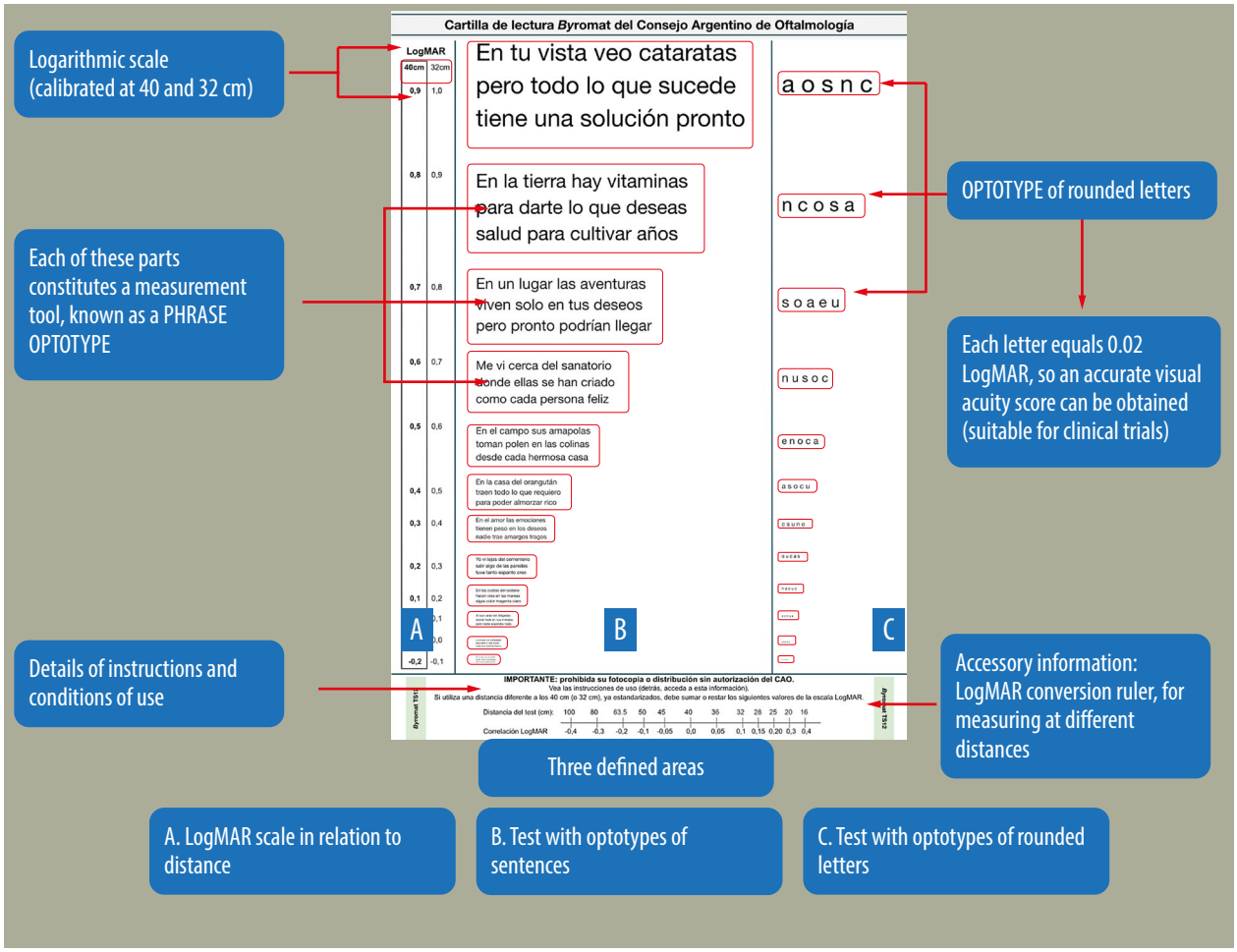

Figure 1. A CAO Byromat chart is shown in the center and its most relevant elements are detailed and described on the sides.

outcomes in implant-refractive surgery or assessing the progress and response to treatments (such as diabetic retinopathy or age-related macular degeneration). Figure 1 describes the main elements present in the Byromat chart, TS12 model, of the Argentine Council of Ophthalmology (CAO).

Based on the aforementioned points, the Byromat test can be used for both daily clinical activities, prescribing glasses for near vision, and for rigorous research studies. Below are questions and answers regarding general and practical aspects to consider in logarithmic scale charts.

What is LogMAR?

It is a scale that, in turn, involves a notation system. Its name comes from an acronym meaning the logarithm of the minimum angle of resolution. In near vision, there is not truly an equivalent between the LogMAR scale and what can be measured with Jaeger.

Is it good to have 0.0 vision in LogMAR?

Yes, and it's necessary to change our way of reasoning when assigning scores since in this notation format, zero is good, and if the result is negative, it's even better (indicating higher visual resolution capacity). Perhaps that's why the LogMAR scale initially causes confusion because the value of 0.0 in LogMAR would potentially be equivalent to 1.0 in decimal notation (10/10) or 20/20 in distant vision. Saying that zero is a good result can be culturally challenging to understand (generally, getting a 10 is considered good, and 0 is bad).

How far is it considered normal for my patient to see on this type of chart?

We are accustomed to wanting the patient to read the smallest letter, and typically with Jaeger, we provide the chart to the patient and ask them to read down to the smallest letter. We aim for them to always reach the smallest letter on the Jaeger chart. Moreover, the patient themselves will consistently attempt to read the smallest text, and if they can't, they become concerned or frustrated. This is something that needs to change. In any standardized international logarithmic scale reading chart (whether it be Byromat, Radner, MNREAD, etc.), at a distance of 40 cm, few people will be able to read LogMAR 0.0, and very few will achieve LogMAR -0.1 or -0.2. The majority of healthy individuals can read between LogMAR 0.1 and 0.2. This concept is relevant because Jaeger 1 can correlate very inaccurately, as previously mentioned, between LogMAR 0.1 and 0.3 (there is considerable discrepancy among Jaeger charts) if both tests are conducted at a 40 cm distance.

To explain to our patients the approximate sizes of texts in daily activities, we can use the following practical references measured at 40 cm on the LogMAR scale:

- Text on digital newspapers: 0.5 LogMAR
- Text in printed newspapers, books, or magazines: between 0.3 and 0.5 LogMAR
- Text on digital phone or tablet screens: between 0.2 and 0.3 LogMAR
- Text on medical leaflets, food products, cosmetics, or similar items: can range from -0.2 LogMAR (those seen by very few people) to 0.1 LogMAR.

Why measure something so small that not everyone can see?

It's a reasonable question when we're used to measuring with Jaeger. However, physiologically or after refractive surgical procedures, there are individuals who can even see up to LogMAR -0.2 up close at 40 cm. If we don't evaluate a person with a logarithmic scale test, we will never know their maximum visual potential at a given moment, and therefore, we won't know if they are losing vision over time, whether due to normal wear and tear or some pathology.

The measurement of near vision is a medical act in which we must assess the maximum capacity, record the data, and track its evolution over time. Currently, when we use the Jaeger scale, we can never measure beyond LogMAR 0.1 up close (at 40 cm). As Jaeger doesn't measure beyond that, a change detected in Jaeger could potentially have been detected much earlier. This is clinically relevant, and taking near vision with a Jaeger test undermines this. Using a logarithmic scale reading chart is, in fact, an early detection method for many eye diseases, such as age-related macular degeneration[31-32].

How to transition from Jaeger to logarithmic scale reading charts?

We need to change how we ask the patient to read the chart. It's crucial to explain that they should read as far as they can, but not worry about seeing the smallest text. This is because most healthy, normal, well-prescribed, and/or well-operated individuals fall within the range of 0.1 to 0.2 LogMAR at 40 cm. Additionally, a person reading LogMAR 0.3 or 0.4 at 40 cm may still have visual capability suitable for most daily activities, except for reading a medical leaflet or information about food composition presented on packaging, which is typically in sizes equivalent to LogMAR ranging from -0.2 to 0.1.

The reality is that information on food labels can sometimes be indecipherable due to defects in printing on packaging, curved surfaces, poor contrasts, and wear and tear inherent in each product's handling from production, distribution, and storage in a supermarket. It is crucial for the physician to understand all of the above so that the patient can grasp it later on.

Can anything other more than near visual acuity be measured with this type of chart?

Yes, when we use reading charts with sentence optotypes, we can measure the time it takes to read. For this, we ask the patient to start reading aloud, and we time how many seconds it takes until they can no longer read a complete sentence-level optotype. We record the visual acuity in LogMAR of the optotype they managed to read and note the time. With these visual acuity

and time data, we can determine the number of words per minute and obtain much more information related to reading performance. This, in turn, can be associated with characterizing both ophthalmological and neurological/cognitive conditions[33-36].

Are there limitations for these tests such as age, literacy level, and/or low vision?

This type of test evaluates reading, and from this, near visual acuity and other data are determined, which are transformed into indices that mark the performance of the visual system and, in turn, neurosensory cognitive aspects. However, there are logarithmic scale near vision tests designed for illiterate individuals and children who cannot read but can identify figures and symbols. There are also tests specifically designed for people with low vision. The CAO is in the final stages of validating tests tailored to this segment of the population.

Does it make sense to measure near vision in people without presbyopia?

Yes, and it is a practice that is currently underutilized. As we have expressed earlier, with this type of test, we can assess a person's maximum visual capacity at close distances. Measuring near vision in a young person allows us to have not only the data on near visual acuity but also aspects related to visual performance. This information can be compared over time and will help us detect not only potential ophthalmological alterations but also issues that may affect the cognitive system. It becomes an additional data point in the evaluation of neurodegenerative diseases.

Is it correct not to use this type of tests on patients who have undergone refractive and/or cataract surgery due to fear that they won't see the smallest text?

It is a conceptual error not to measure results accurately, and we have already explained why using Jaeger is not valid today. You should not be afraid that your patient cannot see LogMAR -0.2 at 40 cm. To prevent both you and your patient from feeling frustrated, you should learn to assess vision by explaining that most people cannot see the smallest text. However, you may very well encounter patients who have undergone surgery with new corneal ablation systems or implantable optical devices that can see up close better than you. You must measure and record the maximum potential for near vision to accurately track your patient's progress over time. Moreover, consider it contradictory —and even scientifically unfair— to perform treatments with techniques and materials from 2023 and measure their results using a test from 1854.

If you invest a lot of financial resources in acquiring new and expensive measurement equipment to be more surgically precise, if you also undergo training to learn how to use this technology and pay for maintenance services, surely you can acquire and use a modern logarithmic scale chart considering all the previously explained reasons.

However, none of this limits us from recognizing that the most important verdict is ultimately expressed by the patient when subjectively telling us if they are satisfied or not, something for which we still don't have such an exact measurement tool, let alone a way to make accurate predictions. This is one of the reasons why empathy should be practiced, and preoperative expectations should be managed with postoperative facts and evidence.

In this review, we have explored the topic of printed charts, but what about digital visual tests?

This is a growing trend, but it still faces limitations in terms of widespread use, as technology, while highly beneficial, still has challenges to overcome in unifying conditions[37-39]. However, the potential is significant, and it is likely that in the short term, an international consensus may be reached to standardize the features that digital vision tests should have. What is clear at the time of writing this study is that great caution should be exercised when using visual tests on screens, especially those from applications installed on smartphones and/or tablets. It is important to inquire about the developer, carefully read the terms of use, limitations, and instructions for proper use. Nevertheless, the suggestion is to compare this information with what is currently

considered the gold standard: printed logarithmic scale reading charts.

Conclusions

The Jaeger test, developed in 1854, allowed for the measurement of near vision, but it is no longer valid today due to its general lack of standardization and non-compliance with the international consensus established in 1988. During this consensus, standards and features of current reading charts were determined, emphasizing the need for logarithmic scale representation. Although its use is common in many parts of the world, there are still regions, particularly in certain countries in Hispanoamerica, that have not adopted these standards. This discrepancy needs to be resolved promptly to share accurate and reproducible information in a globalized world, which is increasingly relying on trustworthy data for artificial intelligence systems. For this reason, the CAO, with the development of the Byromat chart, has aimed to provide an accessible tool for all Spanish-speaking colleagues. This chart is the only one developed entirely in Spanish from the outset, without translation or adaptation. We understand that transitioning away from Jaeger will be a slow process, but it is necessary. Modern medicine is based on evidence, and the data on near vision is crucial, as is its accurate acquisition.

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