

Developing fonts from classic and new optotypes

Desarrollo de tipografías a partir de optotipos clásicos y nuevos

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ABSTRACT:

SIGNIFICANCE: Commercial printed acuity charts offer limited adaptability for research, education, and clinical use. This study digitizes classical optotypes, extends Sloan letters, and introduces validated pediatric and reading typefaces. These free fonts enable reliable acuity measurements while offering optometrists high flexibility in test design for diverse settings.

PURPOSE: This study aimed to improve visual acuity assessment tools by introducing classic optotypes as digital fonts, expanding the Sloan letters to complete the full English alphabet and numerical digits, based on the Landolt ring concept, and creating and validating novel pediatric optotypes and a novel typeface designed to assess near vision adequacy and reading acuity.

METHODS: Classic optotypes (the tumbling E, the Landolt ring, and the Sloan letters) were converted into digital typefaces using Glyphs v3 software. LouiseOPTO-Regular typeface, which extends Sloan original optotypes to include all uppercase letters and numerals, is introduced. New paediatric optotypes, Optotipica-Kids v2022 (Kids), were designed according to the Landolt ring criteria. Additionally, a new typeface, Optotipica 5 v2022 (Optotipica), was created to measure near vision adequacy and reading acuity, with a focus on lowercase letters. Validation was conducted with 30 observers with healthy vision, adhering to ISO standards for optotype presentation and correlation/validation.

RESULTS: Validation of Kids and Optotipica against the Landolt ring showed minimal differences in legibility. Statistical analysis confirmed equivalence for the Kids optotypes ($p = 0.830$), whereas Optotipica presented a small but statistically significant difference ($p = 0.028$). This difference was deemed clinically negligible, thereby supporting the reliability of both in measuring visual and reading acuity.

CONCLUSIONS: The study introduced classic optotypes as digital fonts, extended the Sloan letters, and developed new pediatric optotypes and a comprehensive typeface for assessing visual and reading acuity. These tools, validated against the Landolt ring, provide reliable measurements and are a valuable resource for resource-limited communities by offering affordable and customizable vision assessments.

Key words:

font, typeface, optotype, visual acuity, reading acuity, reading chart

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1. Introduction

The assessment of visual acuity is a fundamental component of optometric examinations. Visual acuity charts, which employ optotypes, are essential tools for measuring the ability of the eye to perceive and recognize fine details. Optotypes are specially designed symbols or letters; among them, the Landolt ring, also known as the Landolt ring, is considered the standard optotype [1]. This ring is constructed within a $5s \times 5s$ box, with both the stroke width and the gap width measuring s . The precise and standardized nature of the Landolt ring makes it a gold standard for accurate visual assessment. Validation of optotypes used in visual acuity charts against the Landolt ring is essential to ensure their accuracy and reliability. This validation process involves rigorous testing to verify that the optotypes on the chart yield results consistent with those obtained using the Landolt ring [2].

In addition to standard visual acuity charts, reading charts are employed to assess functional vision, particularly the ability to read text at different sizes and distances. These charts use various typographies to simulate real-world reading conditions [3-5]. The choice of typography in reading charts is critical, and ideally should be validated against the Landolt ring to ensure accuracy and reliability [2,6]. This validation process guarantees that the typography used provides a consistent and standardised measure of reading and visual acuity, similar to the Landolt ring [7].

The availability of visual acuity and reading charts in multiple formats, such as printed materials or digital displays, offers flexibility for practitioners, educators, and researchers. Printed charts are traditionally preferred due to their stability and ease of use; whereas digital charts provide significant advantages, including the ability to easily adjust the size and orientation of optotypes and to create customized testing conditions [8-11].

However, it is valuable to provide optometry and vision science professionals with tools enabling the creation of visual acuity and reading charts with parameters differing from those of commercial charts. In this respect, access to classic optotypes as font files allows professionals to construct customized charts tailored to specific requirements, such as undergraduate research projects, master theses, PhD Thesis and other investigations. To the best of our knowledge, Sloan font developed by Pelli [12], available online [13], represents the first optotype designed in a font format. Later, [14, 15] developed other extensions. These



approaches allow optometrists to adjust size, spacing, contrast, colour and arrangement of optotypes to suit the needs of different patient populations, including children or individuals with low vision, for far and near distance.

Within this framework, the primary objective of this work is to introduce several classic optotypes implemented as custom font files developed by members of our team: the Landolt ring in eight orientations [16], the Tumbling E [20], and the classic Sloan letter set extended to include the full uppercase English alphabet and numerals. Although Balius et al. [18] previously discussed design methodologies for such typefaces, they did not address their validation. Consequently, our second goal is to validate this extended Sloan set (encompassing the full uppercase English alphabet and then ten numerical digits), developed by our team under the direction of type designer Balius [19], which differs slightly from existing versions in the literature [13, 14, 15] as described later. The third objective is to present and validate against the Landolt ring a new set of six pediatric optotypes (*Optotipica-Kids v2022*) in font format. Finally, the fourth and arguably principal aim is to introduce the new *Optotipica 5 v2022* typeface, specifically designed to assess both reading adequacy and reading acuity within a visual acuity framework, and to report its validation against the Landolt ring.

2. Methods

2.a. Converting classic optotypes into typefaces

This section outlines the conversion of classic optotypes into digital typefaces (or fonts), including those from the illiterate E test (also known as the tumbling E test) [20, 21], the Landolt ring [1], and Sloan letters [22]. All typefaces presented in this work were generated using Glyphs v3 [23], a digital font editor software for designing and exporting fonts.

Firstly, the *TumblingE Two* typeface [16], hereafter referred to as TumblingE, was created based on the original optotype derived from the Snellen E, including four orientations. These orientations can be accessed using the numerical keyboard by pressing keys 2, 4, 6, and 8.

Secondly, according to the International Standard ISO 8596:2017 [4], the Landolt ring is the only optotype that has been standardised, and is widely regarded as the gold standard for visual acuity assessment. Although the standard does not explicitly prescribe design parameters for alternative optotypes, it can be inferred that a symbol with a stroke width of s , occupying the maximum possible extension within a $5s \times 5s$ box leaving reasonable spacing, would likely elicit responses comparable to those obtained with the Landolt ring. To this end, the *Landolt Two* typeface includes the Landolt ring in the classical eight orientations [17]. Now, these orientations are accessible via keys 1, 2, 3, 4, 6, 7, 8, and 9 on the numerical keyboard.

Thirdly, in late 2023, the *LouiseOPTO-Regular* typeface [24], abbreviated as Louise, was designed based on Louise Sloan 1959 optotypes for visual acuity which originally comprised the letters C, D, H, K, N, O, R, S, V, and Z. The new Louise typeface extends this set to include the entire uppercase English alphabet and the ten numerical digits (see figure 1), adhering to design principles in line with the Landolt standard optotype. This development addressed a number of typographic inconsistencies in the original Sloan optotypes. For example, the original Sloan optotypes applied distinct curvature criteria depending on the character: O and C follow circular geometries, while D features a more squared rectilinear form. These differences informed the design of additional letters such as J, which required a broader base to fit stably within the $5s \times 5s$ box. Thus, J follows the geometry of D, whereas U mirrors the circular curvature of O. Letter A was derived from the V optotype, while E, F, I, L, and T follow the structure of the H. Diagonal letters such as M and W required careful adjustment to maintain consistent stroke thickness and typographic balance. B and P adopt the curvature logic of R, while Q is based on the O structure, incorporating a diagonal stroke inspired by X and bar alignment from H. The numerals were designed following analogous principles to ensure consistency with the Latin alphabet characters. The Sloan font by Denis Pelli, intended for non-commercial purposes and available via GitHub [13], extends the original set of uppercase letters A to Z created by Sloan. While the Louise OPTO font shares many features with the version of Pelli, it introduces significant design improvements. Notably, it refines the construction of optotypes such as G, M, and W to reduce the risk of

ink blotting, and applies distinct curvature treatments for letters like U and J to achieve a more balanced and uniform appearance.



Fig. 1. LouiseOPTO-Regular.

In contrast to the approaches described above, this level of stylistic and structural coherence, such as the fixation of the letters and numbers within the 5s×5s box, is notably absent in other existing designs developed concurrently with the present work, such as Optician Sans [14] or PseudoSloan 2022 [15].

2.b. New pediatric optotype: Optotipica-Kids v2022

The most widely used pediatric drawing optotypes (figure 1 in Iwata) [25] do not conform to the ISO standard for optotype design [1]. In this context, only the Kolt-test by Lithander (figure 2 in Lithander) [26] and Patti Pics by Colenbrander meet the criteria to be considered true optotype drawings [27]. To develop pediatric optotypes presented as typeface, A. Balias, F. Salvadó and M. Tàpias created a set of original figures grounded in the design principles of the Landolt ring, which have been implemented in the font file named *Optotipica-Kids v2022*, from now on Kids. This set, illustrated in figure 2, comprises six optotypes: arrow, umbrella or mushroom, circle or wheel, bridge or door, square, and house. These figures can be confused in pairs (arrow-umbrella, circle-bridge, square-house) or in triads (e.g., arrow-umbrella-house, umbrella-circle-bridge), depending on the observer. To aid optotype recognition, children are provided with matching cards that allow them to select the correct optotype from a predefined set. The use of all or a subset of the optotypes is left to the discretion of practitioners, educators, and researchers. The Kids typeface is freely available for download and may be used exclusively for research and educational purposes under a Creative Commons licence [28].



Fig. 2. Optotipica-Kids v2022.

2.c. New typeface for both reading acuity and near vision adequacy: Optotipica 5 v2022

In the initial development of the typeface Optotipica 5 v2022 (hereafter referred to as Optotipica), A. Balias, F. Salvadó, and M. Tàpias were faced with the decision of which components of the type design would be regarded as optotypes. As reading texts and charts predominantly feature conventional text composed largely of lowercase letters, evidence suggests that x-height, the vertical distance from the baseline to the top of the lowercase 'x', is a key determinant of legibility [29, 30]. Taking this into account, the authors opted

to design a square x-box with a stroke width set to one-fifth of the x-height, in accordance with ISO 7921:20247 [6]. This core structure was considered the primary optotype,[1] despite the presence of ascenders and descenders. To complement the lowercase set, an uppercase alphabet was also designed. However, the uppercase characters do not share the proportions or stroke thickness of their lowercase counterparts and are not intended for use in reading acuity assessments. Validation efforts therefore focused solely on the lowercase letters, whose stroke width serves as the reference unit for calculating test parameters. This design approach aligns with the principles used for visual optotypes and supports a clear analogy between visual acuity and reading acuity. Furthermore, a previous work concludes that the Optotipica lowercase design yielded the highest legibility scores among the fonts tested (Roboto, Helvetica and Georgia) [31]. The typeface is presented in figure 3 and is freely available for educational and research use under a Creative Commons licence [32]. Optotipica is distributed as a TrueType font, fully compatible with any software that supports OpenType fonts. It includes the Latin Basic character set with lining figures and includes all diacritics used in Western European languages. This encompasses both uppercase and lowercase letters, as well as numerals, enabling the creation of various near vision reading charts and the composition of any document.



Fig. 3. Optotipica 5 v2022.

2.d. Correlation of Optotipica-Kids v2022 and Optotipica 5 v2022 against the Landolt ring

This subsection develops the procedure detailed by ISO/T 19498:2015 for establishing the correlation of optotypes, as applied to the Kids and Optotipica typefaces [2].

Observers

Thirty observers (17 women and 13 men) took part in this study. All were recruited from the Terrassa School of Optics and Optometry. The mean age was 20 years ($SD = 1.9$). All observers met the inclusion criteria, which required healthy monocular and binocular vision and a minimum decimal visual acuity of 1.0 with the best eye at distance, as measured with the Landolt ring. This threshold permitted one or no errors in identifying the eight possible orientations of the ring. Optotype and letter identification tasks were conducted monocularly using the participant's best eye.

Informed written consent was obtained from all observers, and the study was conducted in accordance with the principles of the Declaration of Helsinki [33]. The research protocol was reviewed and approved by the Faculty Ethics Review Board.

Experimental setting

The experimental setup conformed to ISO/T 19498:2015 [2]. This standard specifies the criteria for the presentation of optotypes and letters during validation procedures. Observations were conducted at a distance of 5 m, with heads of observers stabilised using both chin and forehead rests. The test area was circular, with a diameter of $4^\circ \pm 1^\circ$, and was surrounded by a visual field measuring $15^\circ \pm 1.5^\circ$. In line with current practices in reading assessment, optotypes were displayed on a computer screen. A white circular mask, adhering to the specified dimensions, was positioned in front of the monitor to ensure compliance with size requirements. The luminance of the central field was maintained at 190 cd/m^2 , which falls within the required range of $200 \pm 50 \text{ cd/m}^2$. The luminance of the surrounding field did not exceed that of the test area, measuring 18 cd/m^2 in this setup. Optotypes were presented on a 28-inch monitor with a resolution of 3840×2160 pixels and an aspect ratio of 16:9. This configuration results in a pixel size of 0.158 mm, corresponding to an angular subtense of 0.110 arcmin. The experimental arrangement is illustrated in figure 4.

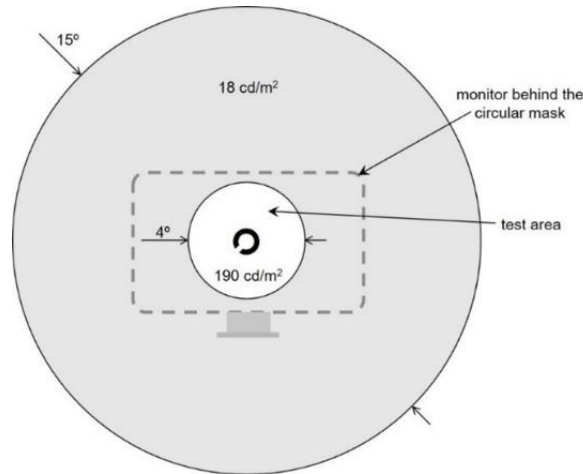


Fig. 4. Experimental setup.

It is important to emphasise that this study investigates the recognition of isolated letters (legibility) under controlled conditions, rather than assessing the typeface's performance in continuous reading tasks (readability).

Optotype and letter presentation

In accordance with ISO/T 19498:2015 [2], each optotype or letter was presented for 3 seconds, followed by a 4-second interval prior to the appearance of the subsequent character. It is important to note, for Optotipica, that only lowercase letters were included in the analysis.

ISO/T 19498:2015 stipulates a minimum of 120 randomized presentations for each set of optotypes or letters (Landolt ring, Kids, and Optotipica) [2], thereby ensuring that all elements are represented the same number of times. Table 1 presents the total number of presentations per observer for each set of optotypes or letters assessed.

TABLE 1. Presentations for each set of optotypes/letters.

Set of optotypes/letters	Number of optotypes/letters	Number of optotype repetitions per acuity grade	Number of acuity grades	Total number of presentations per observer
Landolt ring	8	2	10	160
Kids	6	2	10	120
Optotipica	26	1	10	260

The comparison was started with a size of the Landolt ring optotypes sufficiently large to ensure a 100% recognition rate. The other considered sets of optotypes (Kids and Optotipica) were displayed at this size. Once these measurements were completed, the procedure was repeated using progressively smaller optotype sizes until the failure rate corresponds to the level of guessing (the reciprocal of the number of different optotypes in the set), that is, 1/8 for the Landolt ring, 1/6 for Kids, and 1/26 for Optotipica. In total, ten different optotype sizes (acuity grades) were shown to each observer, covering the full range of responses between 0 and 1. According to ISO/TR 19498:2015 [2], which states that "each optotype must be represented the same number of times in 120 presentations", the number of repetitions per acuity grade must be 2 for both the Landolt ring and Kids, whilst Optotipica was presented once per acuity grade. In accordance with the standard, which requires a minimum of 10 observers, the full experimental protocol was carried out with all 30 observers.

Assignment of an acuity score

Initially, the number of correct responses (R) was recorded for each participant across different sets of optotypes and acuity grades or size levels. To account for the potential influence of random guessing, the values were corrected (f_c) using the following formula:

$$f_c = \frac{E}{N} = \frac{R - N \cdot p}{N \cdot (1 - p)} \quad (1)$$

where E represents the number of correct answers adjusted for guessing, N is the number of presentations, R is the number of correct answers, and p is the reciprocal of the number of optotypes or letters in the set [2].

For each observer and size level, the corrected recognition frequency was plotted against the logarithm of the critical detail size of the Landolt ring ($\log s$), which served as the reference standard. In accordance with ISO/TR 19498:2015 [2], the psychometric function was fitted using standard methods for cumulative frequency curves. In this case, a logistic function was applied:

$$f_c = \frac{e^{a+b \cdot \log(s)}}{1 + e^{a+b \cdot \log(s)}} \quad (2)$$

The parameters were estimated using the Generalised Reduced Gradient (GRG) non-linear optimisation method implemented in Microsoft Excel. This method ensures that negative f_c values do not affect the fitting of the function within the range [0,1]. From these fitted curves, the logarithm of the critical detail sizes corresponding to a corrected recognition frequency 0.5 were identified ($\log L_t$ for Landolt, $\log K_t$ for Kids, and $\log O_t$ for Optotipica). These values represent the thresholds for each observer and optotype set.

For each set of optotypes, the mean of the thresholds of the observers was calculated, $\overline{\log L_t}$ for the Landolt ring, $\overline{\log K_t}$ for Kids, and $\overline{\log O_t}$ for Optotipica. In accordance with ISO/T 19498:2015 [2], the difference between the mean of the thresholds of the observers for the two sets of optotypes being correlated (Kids and Optotipica) was defined as $\Delta_K = \overline{\log K_t} - \overline{\log L_t}$ for Kids, and $\Delta_O = \overline{\log O_t} - \overline{\log L_t}$ for Optotipica. A positive value indicates that the optotype is more difficult to recognise than the Landolt ring, whereas a negative value implies greater recognisability. As stated in the standard, [2] if the absolute value of either Δ_K or Δ_O is less than 0.05 log units, then the two sets (the optotype and the Landolt ring) are equivalent.

A paired T-test was conducted to assess the statistical significance of the differences in legibility between each of the optotype sets and the Landolt ring. If a statistically significant difference is detected, adjustments in the size of the optotypes or in the observation distance may be necessary to establish precise equivalence with the Landolt ring.

3. Results

The experimental results concerning the correlation of Kids and Optotipica with the Landolt ring are collected in table 2.

TABLE 2. Correlation of Kids and Optotipica typeface against the Landolt ring.

Set of optotypes/ letters	Difference of the means (Δ_K and Δ_O) and 95% Confidence interval (log units)	p -value	Size correction factor (10^A)	Observation distance correction factor (10^{-A})
Kids	-0.0006 ± 0.0056	0.830	0.999 (≈ 1)	1.001 (≈ 1)
Optotipica	-0.0086 ± 0.0077	0.028	0.980	1.020

The second column presents, in logarithmic units, the differences in the means of the threshold values corresponding to a corrected recognition frequency of 0.5, along with the 95% confidence intervals. These values are $\Delta_K = -0.0006$ for Kids, and $\Delta_O = -0.0086$ for Optotipica. The p-value from the paired T-test comparing Kids and Landolt (0.830) is well above 0.05, indicating statistical equivalence with the Landolt ring. Furthermore, the Δ_K value is two orders of magnitude smaller than the threshold defined by the standard (0.05 log units) [2].

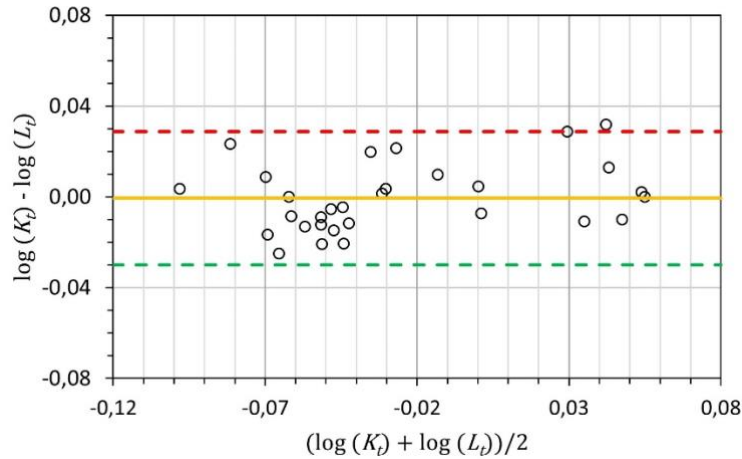


Fig. 5. Bland-Altman analysis for the Kids ($\log(K_t)$) versus the Landolt ring ($\log(L_t)$).

Furthermore, the Bland–Altman analysis between the Kids ($\log(K_t)$) and Landolt ring ($\log(L_t)$) typefaces yields similar conclusions (see figure 5). Specifically, we obtain a correlation value of -0.0006 (represented by the orange line in figure 5) and a standard deviation of 0.0150. Consequently, the values lie predominantly within the $-0.0006 \pm (1.96 \times 0.0150)$ range (indicated by the red and green lines in figure 5, respectively), which corresponds to the interval $[-0.0300, 0.0288]$. This result further demonstrates a strong correlation between both typefaces.

In contrast, the paired T-test comparing Optotipica and Landolt reveals a statistically significant difference between the two mean values ($\Delta_O = -0.0086$ and p-value = 0.028). Nevertheless, since this difference remains below the 0.05 log unit criterion set by the standard [2], Optotipica is still considered equivalent to the Landolt ring. Although the p-value suggests statistical non-equivalence, the observed difference (Δ_O) is clinically negligible, being an order of magnitude smaller than the standard limit of 0.05 log units [2].

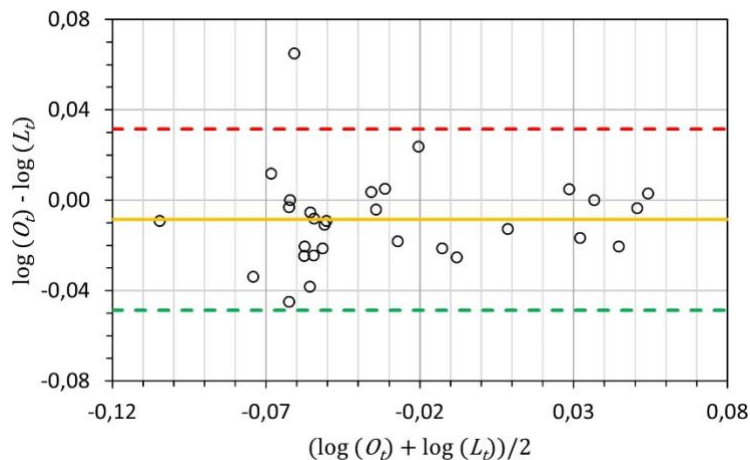


Fig. 6. Bland-Altman analysis for the Optotipica ($\log(O_t)$) and the Landolt ring ($\log(L_t)$).

As with the previous case, we present the Bland–Altman analysis between the Optotipica ($\log(O_i)$) and Landolt ring ($\log(K_i)$) typefaces (figure 6). In this analysis, the bias value is again very small at -0.0086 (represented by the orange line), with a standard deviation of 0.0205 . The values fall predominantly within the $-0.0086 \pm (1.96 \times 0.0205)$ range (indicated by the red and green lines, respectively), which corresponds to the interval $[-0.0488, 0.0316]$. This result reinforces the strong agreement between both typefaces.

Both Bland–Altman plots (figures 5 and 6) show a highly uniform distribution of the data points around the mean difference, with no apparent systematic trend or proportional bias. Furthermore, the spread of the differences remains approximately constant across the entire measurement range, indicating consistent agreement between the two methods.

4. Conclusions

Based on the results, and within a 95% confidence level, the legibility of the Kids and Optotipica optotype sets is either indistinguishable or only marginally different from that of the Landolt ring. Both sets yield marginally superior visual acuity scores compared to the Landolt ring of identical dimensions. Full equivalence between a given optotype set and the Landolt ring can be established via two alternative methods. First, by adjusting the optotype size according to the correction factors (10^A) shown in table 2 (column 4). Second, by modifying the observation distance according to the reciprocal correction factor (10^{-A}). Since both optotype sets were more legible than the Landolt ring, the appropriate adjustment would be to reduce the letter size (table 2, column 4) or to increase the testing distance (table 2, column 5).

The findings confirm that Kids is functionally equivalent to the Landolt ring, $\Delta_K = -0.0006$ (see table 2). As for Optotipica, even though its lowercase ascenders and descenders were not considered in the definition of optotype, the thresholds obtained at a corrected recognition frequency of 0.5 revealed minimal differences when compared to the Landolt ring, $\Delta_O = -0.0086$ (table 2). These results support the assertion made earlier in the section “Converting classical optotypes into typefaces”, that optotypes designed in accordance with Landolt ring construction principles can yield comparable visual acuity measurements.

This work introduces classic optotypes as fonts and extends the Sloan letter set to encompass the full Latin alphabet and numerical digits. Additionally, new pediatric optotypes were developed. Moreover, a versatile typeface suitable for both visual acuity and reading assessments was developed, allowing for use in continuous text. Validation against the Landolt ring confirmed the reliability of these new optotypes in measuring visual and reading acuity. Free and open access to these tools is available under the Creative Commons licence, for tall educators, researchers, and professionals interested in utilising them for their non-commercial scientific tasks and projects. These advancements provide practitioners with greater flexibility because they will be able to create customized visual and reading acuity tests. For instance, L. Clavé L, A. Torrents A and M.S. Millán [34] made all their Landolt ring charts using the Landolt Two font [20].

The development and adoption of digital optotypes and typefaces offer substantial advantages for underserved communities and low-resource countries, primarily by enhancing accessibility through seamless internet distribution, thereby eliminating the need for expensive printed materials or specialized equipment. These innovations are economically efficient, reducing expenditures associated with traditional eye charts, as well as minimising production, shipping, and maintenance costs. Furthermore, digital optotypes enhance standardisation, enabling consistent and reliable assessment of visual and reading acuity across diverse clinical settings and geographic regions. This consistency supports more accurate diagnosis and underpins robust, data-driven public health strategies.

The scalability of digital optotypes makes them particularly well suited to addressing the needs of large populations, especially in regions with high demand for visual care services. Additionally, the ability to customize colour and contrast in digital typefaces increases the versatility and effectiveness of vision assessments, accommodating a wide range of visual needs. By enabling precise and reliable assessments of visual and reading acuity, these digital tools improve vision care, contribute to research, enhance educational outcomes, and ultimately elevate the overall quality of life.

Finally, several lines for future research are outlined. First, to rank the relative difficulty of recognising each of the 26 letters, as well as the numbers, of LouiseOPTO typeface using known and new measures [31]. Second, it is interesting to examine the risk that certain combinations of LouiseOPTO letters may be

significantly easier or more difficult to recognise compared to established standards for visual acuity using game theory [31]. Third, the alphanumeric characters within the LouiseOPTO typeface should be validated against the Landolt ring. Fourth, the performance of reading charts constructed using the Optotipica font should be measured against other established reading charts in both clinical and research settings.^{4,6} Fifth, to compare Optotipica-Kids v2022 with other pediatric charts in children.

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