

Age-related normal limits for visual acuity and contrast sensitivity in different lighting conditions

A. Keuken^{a,b,c}, A. Subramanian^a, S. Mueller-Schotte^{b,c}, J. L. Barbur^a

Purpose Reduced (low) light levels cause significant changes in visual performance (Barbur & Stockman, 2010) which become increasingly noticeable as one ages and also in early-stage, retinal diseases (Owsley et al., 2016; Puell et al., 2012). Visual acuity measurements are common in clinical practice, however may not predict accurately visual performance in daily life. Contrast sensitivity is a better predictor of loss of spatial vision when the task involves detection of small spatial details in low contrast, but full, contrast sensitivity tests are rarely used in a clinical setting (Xiong et al., 2020). The ability to identify individuals with reduced functional vision during the early stages of disease, particularly when loss of spatial vision is more prominent in the mesopic range, may provide the opportunity to equip them with assistive or gerontechnological devices in a more timely manner. As a result, it is of interest to establish normal age-limits for monocular and binocular vision under photopic (daylight) and mesopic (low-light level) conditions so that we can reliably identify individuals with functional vision decline. **Method** Visual Acuity (VA) and Functional Contrast Sensitivity (FCS) were measured in two contrast polarities using the Acuity-Plus (AP) test (City Occupational, city-occupational.co.uk). The AP test is a single computerized test that measures VA and FCS simultaneously. The test stimulus consists of a Landolt C optotype with the gap positioned randomly in one of four quadrants. The participant has to detect and 'register' the location of the gap. Mean and $\pm 2.5\sigma$ limits were calculated within each 5-year subgroup for all participants meeting normal sight criteria. Mean values and upper and lower threshold limits for VA and FCS as a function of age were established. **Results and Discussion** Of the 382 participants, 285 passed the selection criteria for normal ageing. For each of the 16 stimulus conditions, age-related normal limits were calculated. Mean photopic VA and FCS thresholds and overall variability remain largely invariant below 50 years of age. In mesopic conditions, VA and FCS start with much larger mean values, and both thresholds and inter-subject variability increase more rapidly above 30 years. Age-limits of vision for monocular and binocular viewing under photopic and mesopic conditions were established. The results can be used to identify subjects that fall outside the normal threshold limits for VA and FCS. Additionally, they demonstrate the importance of awareness of the decline in visual performance with ageing. The decline is more pronounced in lower light levels. Therefore, daily activities involving both spatial vision and colour discrimination may be more affected by vision under low-lighting conditions, particularly in seniors. In daily life activities, binocular vision performance is of interest, and therefore, binocular summation in relation to age. Furthermore, monocular normal limits of VA and FCS are clinically useful for early detection of retinal abnormalities. Further research is needed to explore the clinical implications of these findings, particularly their role in early detection and management of retinal diseases, and their integration into routine clinical practice.

References

- Barbur, J. L., & Stockman, A. (2010). Photopic, mesopic and scotopic vision and changes in visual performance. In D. A. Dartt (Ed.), *Encyclopedia of the eye*, vol 3, (pp. 323-331). Academic Press.
- Owsley, C., Clark, M. E., Huisinigh, C. E., Curcio, C. A., & McGwin, G., Jr. (2016). Visual function in older eyes in normal macular health: Association with incident early age-related macular degeneration 3 years later. *Investigative Ophthalmology & Visual Science*, 57(4), 1782-1789. <https://doi.org/10.1167/iops.15-18962>
- Puell, M. C., Barrio, A. R., Palomo-Alvarez, C., Gómez-Sanz, F. J., Clement-Corral, A., & Pérez-Carrasco, M. J. (2012). Impaired mesopic visual acuity in eyes with early age-related macular degeneration. *Investigative Ophthalmology & Visual Science*, 53(11), 7310-7314. <https://doi.org/10.1167/iops.11-8649>
- Xiong, Y., Kwon, M., Bittner, A. K., Virgili, G., Giacomelli, G., & Legge, G. E. (2020). Relationship between acuity and contrast sensitivity: Differences due to eye disease. *Investigative Ophthalmology & Visual Science*, 61(6), 40. <https://doi.org/10.1167/iops.61.6.40>. eCollection 2020 Jun. 10.1167/iops.61.6.40

Keywords: age-related normal limits, light conditions, visual performance

Addresses: ^aApplied Vision Research Centre, The Henry Wellcome Laboratories for Vision Science, City, University of London, London, United Kingdom; ^bDepartment of Optometry, University of Applied Sciences, Utrecht, Netherlands; ^cResearch Group Technology for Healthcare Innovations, University of Applied Sciences, Utrecht, Netherlands

Email: arjan.keuken@hu.nl

ORCID iDs: A. Keuken (0000-0003-2289-4802), A. Subramanian (0000-0001-8104-5312), S. Mueller-Schotte (0000-0003-1843-1469), J. L. Barbur (0000-0002-2187-5004)