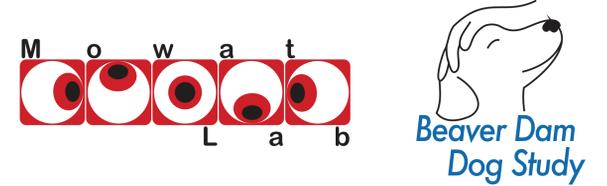


# Subjective assessment of companion dog vision shows an age-related decline: preliminary findings



Freya M. Mowat<sup>1</sup>, Leah Russell<sup>1</sup>, Ceylan Ersoz<sup>1</sup>, Michele Salzman<sup>1</sup>

University of Wisconsin-Madison, Madison, WI, USA:  
Dept. Surgical Sciences, School of Veterinary Medicine,  
Dept. Ophthalmology and Visual Sciences, School of Medicine and Public Health



mowat@wisc.edu

## Background

There are well-validated visual function questionnaires (VFQ) for humans. The National Eye Institute 25 question VFQ (NEI VFQ) score is associated with loss of visual acuity in human age-related macular degeneration (AMD;  $r = -0.5$ ).<sup>1</sup> Questions contained in a recently developed canine VFQ<sup>2</sup> are based on the NEI VFQ, and questions asked during clinical visits for visually impaired dogs by veterinary ophthalmologists. Composite score on the canine VFQ was associated with a yes/no measure of blindness in dogs.<sup>2</sup>

The human low luminance questionnaire (LLQ)<sup>3</sup> is a 32-item questionnaire with 6 subscales related to low luminance settings: driving, mobility, extreme lighting, general dim lighting, emotional distress and peripheral vision. LLQ scores are significantly associated with NEI VFQ scores and with clinical measures of visual function, particularly of the dim light rod photoreceptor pathway.<sup>3</sup> The rationale behind development of the LLQ in humans is the clinically significant decline in rod photoreceptor-mediated vision with aging and in prevalent age-related retinal disorders such as age-related macular degeneration (AMD). Human LLQ score correlates with measures of low luminance vision, particularly subcategories for driving and extreme lighting and provide a non-clinical method to assess relevant retinal pathways in AMD patients.<sup>4</sup>

The purpose of our study was to examine the association between companion dog age and subjective assessment of visual function using the validated canine VFQ, and a novel canine LLQ that specifically enquired about dog visually mediated behavior in different lighting conditions. Our **hypothesis** is that similar to humans, **scores from the canine VFQ and LLQ will be associated with age, and canine LLQ scores will be associated with objective measures of rod-mediated vision in dogs.** Dogs are an important companion species that share many environmental and lifestyle risk factors for age-related diseases with their human owners. These outcome measures once validated would provide a straightforward method to assess canine vision in the epidemiological study of aging and environmental exposures.

## Methods

- Canine LLQ questions designed based on:

1. Human LLQ: response options and questions applicable to companion dog behavior.
2. Discussion with dog owners + veterinarians about common dog behaviors/activities in different lighting conditions.

- Content validation: group of evaluators (10 dog owners and 10 veterinarians) - only favorable questions used in final questionnaire

- Questionnaire dissemination by mail or digital means to previous participants in a human longitudinal study of aging.

- 899 responses to-date:

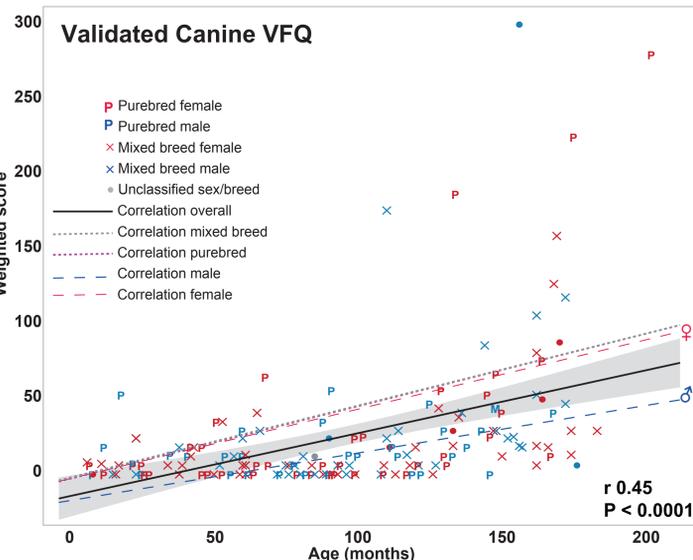
- 53% ( $n = 487$ ) disclosed they did not currently cohabit with a dog
- 24% ( $n = 212$ ) consented to participate

- Statistics: multivariate analysis (JMP 15.0) comparing age with visual function questionnaire scores. interaction between age, sex and breed (purebred or mixed breed) assessed by least square means student's t-test (continuous variables) or effect likelihood ratio (ordinal variables).

## Results

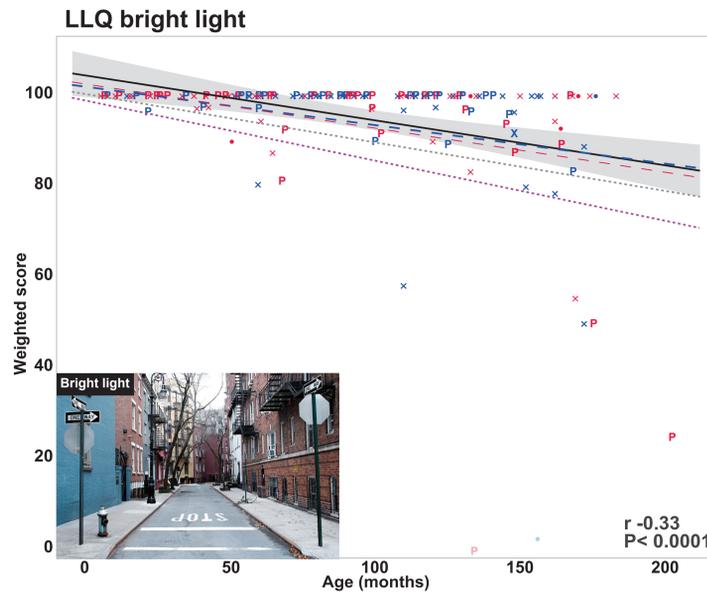
| Age, mo (mean $\pm$ SD) | Sex, N (%) |            | Neutering status, N (%) |           | Purebred, N (%) | Mixed breed, N (%) |
|-------------------------|------------|------------|-------------------------|-----------|-----------------|--------------------|
|                         | Female     | Male       | Neutered/spayed         | Intact    |                 |                    |
| 93.7 $\pm$ 49.2         | 94 (54.3%) | 79 (45.7%) | 158 (90.8%)             | 15 (8.6%) | 78 (45.1%)      | 87 (50.3%)         |

**Table 1. Study sample.** There was an equal balance between male/female and purebred/mixed breed between the groups. Mean age was 7.8 years (range 0.5-16.8 years).



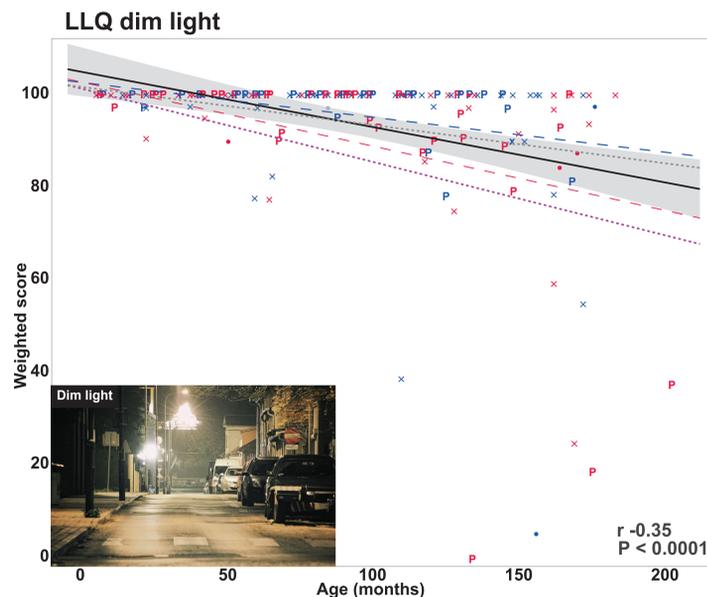
**Figure 1. Established canine VFQ.**

Using the previously validated canine VFQ, there was a significant positive correlation with age in dogs indicating worse vision with increasing age. The correlation in males ( $r = 0.36$ ) and females ( $r = 0.5$ ) was not significantly different ( $P = 0.53$ ). The correlation in purebred ( $r = 0.48$ ) and mixed breed ( $r = 0.46$ ) dogs was also not significantly different ( $P = 0.37$ ).



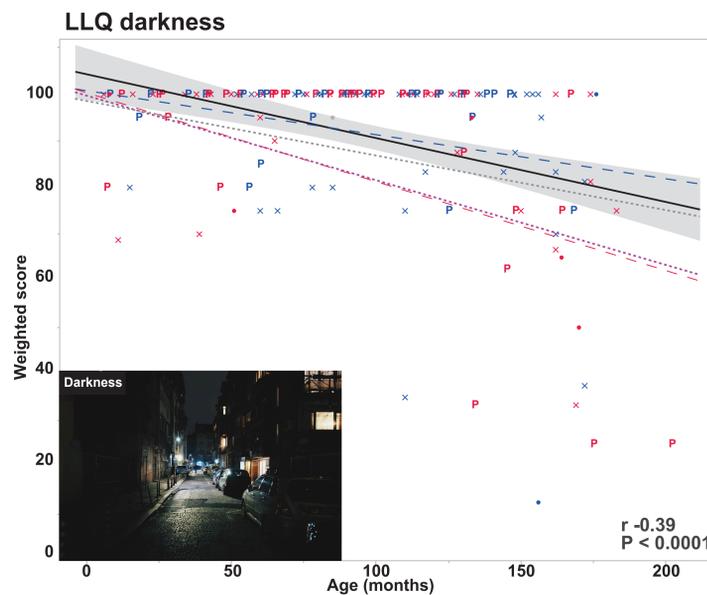
**Figure 2. Bright light vision.**

For visually-mediated behavior in bright light, there was a significant negative correlation with age in dogs indicating worse vision with increasing age. The correlation in males ( $r = -0.33$ ) and females ( $r = -0.33$ ), was not significantly different ( $P = 0.32$ ). The correlation in purebred ( $r = -0.41$ ) and mixed breed ( $r = -0.30$ ) was also not significantly different ( $P = 0.22$ ). The VFQ and bright light LLQ scores were significantly correlated ( $r = -0.84$ ,  $P < 0.0001$ ).



**Figure 3. Dim light vision.**

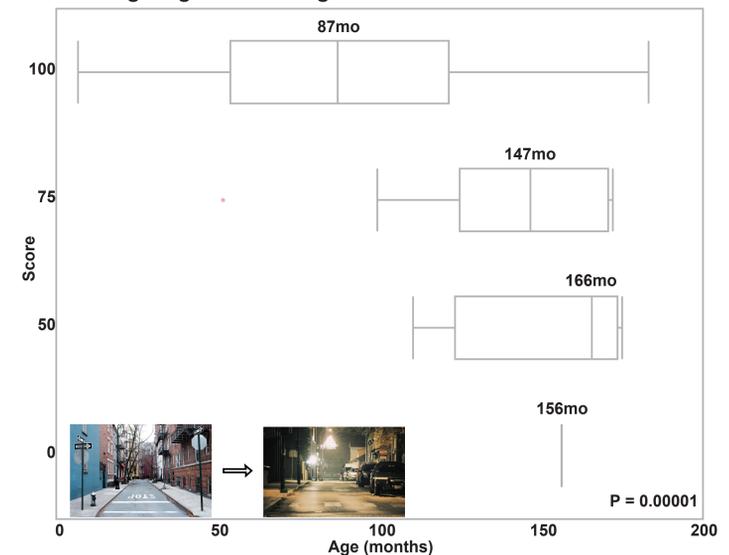
For visually mediated behavior in dim light, there was a significant negative correlation with age in dogs indicating worse vision with increasing age. The correlation in males ( $r = -0.27$ ) and females ( $r = -0.41$ ) was not significantly different ( $P = 0.11$ ). The correlation in purebred ( $r = -0.45$ ) and mixed breed ( $r = -0.26$ ) was also not significantly different ( $P = 0.39$ ). The VFQ and dim light LLQ scores were significantly correlated ( $r = -0.87$ ,  $P = 0.0001$ ).



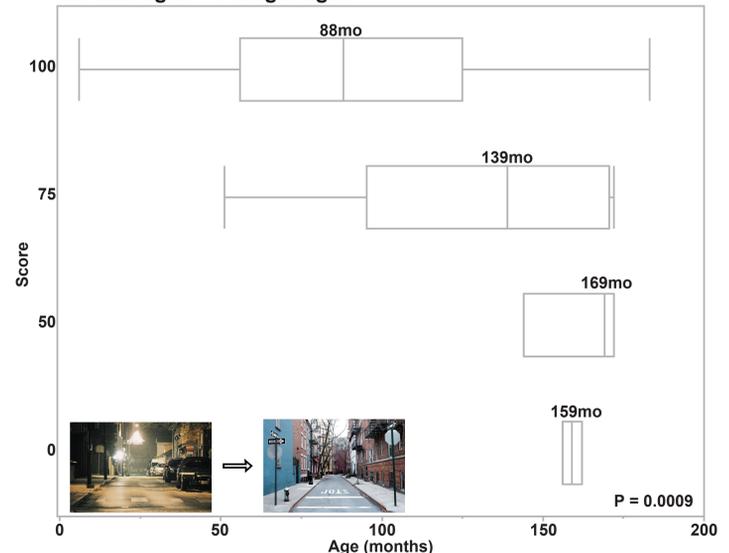
**Figure 4. Vision in darkness.**

For visually mediated behavior in very dim light or darkness, there was a significant negative correlation with age in dogs indicating worse vision with increasing age. The correlation in males ( $r = -0.29$ ) and females ( $r = -0.46$ ) was not significantly different ( $P = 0.49$ ). The correlation in purebred ( $r = -0.44$ ) and mixed breed ( $r = -0.29$ ) was also not significantly different ( $P = 0.97$ ). The VFQ and darkness LLQ scores were significantly correlated ( $r = -0.85$ ,  $P < 0.0001$ ).

**A: Bright light  $\rightarrow$  Dim light**



**B: Dim light  $\rightarrow$  Bright light**



**Figure 5. Transitions between bright and dim illumination.**

We asked dog owners about how well their dog navigated transitions from either bright light to dim light (BL  $\rightarrow$  DL; A) or dim light to bright light (DL  $\rightarrow$  BL; B). The effect likelihood ratio for age vs. BL  $\rightarrow$  DL transition ordinal score for difficulty (lower score = more difficulty) was significant ( $P = 0.00001$ ), there was no significant effect of sex ( $P = 0.32$ ) or breed ( $P = 0.58$ ). For the DL  $\rightarrow$  BL transition, the effect of age was significant ( $P = 0.0009$ ), there was no significant effect of sex ( $P = 0.55$ ) and breed ( $P = 0.29$ ).

## Conclusions

In this preliminary analysis, subjective (human-owner) assessment of canine visual function declines in association with dog age. Similar to aging humans, dim light vision in dogs subjectively declines with age and aging dogs have difficulty transitioning between different lighting environments. These results can inform dog owners to help them mitigate the effects of visual decline in their pets, for example by providing a safe, well-lit outdoor environment for evening or night time exercise.

Future directions include validation of the canine LLQ in relation to clinically measurable parameters of canine visual ability such as electroretinogram amplitudes and peak times. In addition, we would like to develop a straightforward, reproducible and sensitive behavioral method of testing vision in dogs (similar to Snellen acuity charts and/or Pelli-Robson contrast sensitivity charts). This type of test would be applicable both for researchers and for veterinary clinicians.

Ultimately, we plan to define the relationship between dog and human aging using these dogs that are cohabitants with the well characterized cohort of human participants in the Beaver Dam Offspring Study (BOSS).<sup>5</sup> We predict that the rate of neurologic decline will be similar in dogs and humans that share the same environment.

*the authors have no conflicts to disclose*

## Acknowledgements

Supported by NIH K08EY028628 (FM), UW-Madison Department of Ophthalmology donor funds, a Clinical and Translational Science Award (CTSA) program through the NIH National Center for Advancing Translational Sciences (NCATS), grant UL1TR002373 and an Unrestricted Grant from Research to Prevent Blindness, Inc. to the UW-Madison Department of Ophthalmology and Visual Sciences. We acknowledge the BOSS investigators (Karen Cruickshanks, Natascha Merten and Adam Paulsen) for collaboration, the ophthalmology faculty at UW-Madison for helpful discussions and Aaron Kopydowski for questionnaire dissemination and data input.

## References

1. Orr, P., et al. (2011). "Validation of the National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25) in age-related macular degeneration." *Invest Ophthalmol Vis Sci* 52(6): 3354-3359.
2. Graham, K. L., et al. (2019). "Development of a vision impairment score for the assessment of functional vision in dogs: Initial evidence of validity, reliability, and responsiveness." *Vet Ophthalmol* 22(6): 807-818.
3. Owsley, C., et al. (2006). "Development of a questionnaire to assess vision problems under low luminance in age-related maculopathy." *Invest Ophthalmol Vis Sci* 47(2): 528-535.
4. Thompson, A. C., et al. (2018). "Association of Low Luminance Questionnaire With Objective Functional Measures in Early and Intermediate Age-Related Macular Degeneration." *Invest Ophthalmol Vis Sci* 59(1): 289-297.
5. Schubert, C. R., et al. (2019). "Brain Aging in Midlife: The Beaver Dam Offspring Study." *J Am Geriatr Soc* 67(8): 1610-1616.