Eye-tracking and the role of visual cognition in female choice

Introduction: Understanding exactly how females make mate choices, and how these map on to male fitness and quality, has important ramifications for understanding trait evolution, and for conservation in species where female choice plays a large role in male success. Leks, where many males display at once hoping to attract a mate make an ideal model because female decision-making pathways should depend only on male display or other on-lek factors, and not on extrinsic factors such as territory quality or parental care. I propose to apply eye-tracking technology to female Greater Sage-Grouse (*Centrocercus urophasianus*) to determine how they acquire information from visual displays produced by males when selecting mates. Eye movements can be used to understand cognitive processes as animals must focus on a particular subject to process the information given by it. Limitations on sensory processing determine the amount of information a female can take in about a male and thus limits what she considers when choosing a mate.[1] **I hypothesize that female choice is driven by integration of multiple signal elements.**

Aim 1: **I will track female eye movements to determine which parts of the display females consider as they focus on one element at a time before moving on to another**. Females cannot take in the whole of the display at once and should reduce their focus to only what they perceive to be the most important signal elements.

Aim 2: Once females' preferred traits are known, I will assess the differences between successful and unsuccessful males to determine if there is likely selection pressure on those traits. **Finding those differences will demonstrate that females are intaking sensory information, processing it, and using it to make decisions about mating.**

Methods: I will travel to lek sites across Montana to conduct this research. Using cameras and GPS units[2] placed on males, I will track general positions of males on the lek and estimate territory sizes for each male. I will also track mating success for each male by counting the number of matings attempted and presumably successful matings. For assessing females' preferred traits, I will use eye-tracking technology[3] to determine how females are acquiring information about important traits. Analysis of eye movements will show the specific features females target and use as criteria for mate choice. Using data from eye-tracking, I will measure the male ornaments females focused on, comparing between males with many matings, males that received some female attention but few matings, and males that did not receive any matings. I will analyze the differences between each group for each trait to assess whether the trait is under significant selection pressure driven by female choice.

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[1] Dukas R. 2002. Behavioural and ecological consequences of limited attention. Philos. Trans. R. Soc. B Biol. Sci. 357, 1539-1547.

[2] Wann, GT, Coates, PS, Prochazka, BG, Severson, JP, Monroe, AP, Aldridge, CL. Assessing lek attendance of male greater sage‐grouse using fine‐resolution GPS data: Implications for population monitoring of lek mating grouse. *Popul. Ecol*. 2019; 61: 183– 197.

[3] Yorzinski JL, Patricelli GL, Babcock JS, Pearson JM, and Platt ML. 2013. Through their eyes: selective attention in peahens during courtship. J. Exp. Biol 216:3035-3046

Intellectual Merit: Eye-tracking is currently an under-utilized[4] but insightful method in understanding visual cognition, especially in sexual selection. My research contributes to expanding use of this technology to understand how sight can affect trait evolution in an organism where visual traits are dramatic and emphasized. It provides other scientists with the understanding that these types of studies are feasible. It can be translated to see how cognition varies across the animal kingdom and increase knowledge about visual cognition's role in sexual selection. Further, my research addresses the NSF Big Idea "Understanding the Rules of Life" because the process of decision making in sexual selection and female choice is still not clearly defined. Not only will I address the intraspecific interactions between males and females in a population, but I will assess cognition on an organismal level, to figure out how females intake information and perform a highly complex behavior, choosing a mate, in response.

My experience working with autonomous recording units and GPS mapping with my undergraduate advisor and in my honors thesis has prepared me to work with various types of technology in the field. I am comfortable handling and managing equipment and data collected from the units. I am able to translate these experiences to this project to create an efficient workflow to handle mass amounts of data. I also have experience analyzing high volumes of data from audio recordings, which is easily transferable to processing video.

Broader Impacts: With my proposed research, I will create opportunities for undergraduate research and citizen science. I will have **undergraduate research assistants** help me with capture, measurements, and placement of GPS receivers. These students will gain valuable training in fieldwork techniques and experimental design, preparing them to also go on to expand scientific knowledge in ecology, animal behavior, and organismal biology. As a disabled and first generation student, I will reach out to **increase research participation for underrepresented students** alongside my plans to **expand access to research opportunities for underserved students.** I will also recruit citizens from the surrounding area to help collect data about the lek, thereby allowing more citizens to appreciate the habitat and gain an appreciation of science. Special effort will be made to extend this opportunity to **local high school students who may not otherwise have the opportunity to conduct research** with scientists. Leks are particularly charismatic and tend to engage a **wide audience of citizens** of all ages interested in birds, which gives me the opportunity to teach them about behavior and how to make scientific observations. At the same time as citizen outreach, I will also **educate the public** about the sagebrush habitat, Sage Grouse, and **emphasize the importance of conservation science** in maintaining a healthy environment. I also plan to **collaborate** with the **U.S. Fish and Wildlife Service, local conservation organizations and Native American tribes** to preserve habitat and reduce the amount of fracking in the area, leading to **improved environmental conditions, preservation of culturally important land, and more green spaces,** improving mental and physical well being for those living around sagebrush. Increased contact between the groups will also **facilitate better working relationships and improve society** for people who use these lands.

[4] Billington J, Webster RJ, Sherratt TN, Wilkie RM, and Hassall C. 2020. The (Under)Use of Eye-Tracking in Evolutionary Ecology. Trends in Ecology & Evolution. Trends Ecol. Evol.