TALK ABSTRACTS

2023 ANIMAL BEHAVIOR CONFERENCE

Organized alphabetically by presenter last name. Presenter last names are shown in bold.

TRACING INTER-INDIVIDUAL VARIATION IN BEHAVIOR AND NEURAL GENE EXPRESSION OF AGGRESSIVE FEMALE BIRDS

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Individual differences serve as the raw material for evolutionary change; thus, studying naturally-occurring, continuous trait variation can inform our understanding of behavioral evolution. Aggressive behavior, for example, is often adaptive in the context of acquiring essential breeding resources, yet considerable among-individual behavioral differences can persist. To investigate the mechanisms underlying such behavioral variation, we studied free-living female tree swallows (*Tachycineta bicolor*), obligate secondary cavity-nesters in which higher aggression determines greater success when competing for nesting cavities. We phenotyped individuals using multiple 5-minute simulated territorial intrusions. Two to seven days after the last trial, we collected tissues from 10 stably high and 10 stably low aggression females. Using RNAseq, we explored patterns of gene activity in the hypothalamus and ventromedial telencephalon, brain regions mediating aggression. Despite a well-powered design and a breadth of behavioral variation, results showed very few differentially expressed genes between high and low aggression birds. Co-expression analyses, however, revealed more substantial differences among individuals, especially related to transcriptional networks enriched for neuronal function and metabolic processes. These findings suggest that individual differences may stem from subtle but coordinated shifts in neural gene activity. Our discussion will dive deeper into these results and highlight genes and pathways that do and do not differentiate individuals with markedly different behavior. In doing so, we shed light on gene regulatory variation that may be used during behavioral evolution in the wild.

ECOLOGY AND BEHAVIOR PREDICT AN EVOLUTIONARY TRADE-OFF BETWEEN SONG COMPLEXITY AND ELABORATE PLUMAGES IN ANTWRENS (AVES THAMNOPHILIDAE)

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The environment can impose constraints on signal transmission properties such that signals should evolve in predictable directions (Sensory Drive Hypothesis). However, behavioral and ecological factors can limit investment in more than one sensory modality leading to a trade-off in use of different signals (Transfer Hypothesis). In birds, there is mixed evidence for both sensory drive and transfer hypothesis. Few studies have tested sensory drive while also evaluating the transfer hypothesis, limiting understanding of the relative roles of these processes in signal evolution. Here, we assessed both hypotheses using acoustic and visual signals in male and female antwrens (Thamnophilidae), a species-rich group that inhabits diverse environments and exhibits behaviors, such as mixed-species flocking, that could limit investment in different signal modalities. We uncovered significant effects of habitat (sensory drive) and mixed-species flocking behavior on both sensory modalities, and we revealed evolutionary trade-offs between song and plumage complexity, consistent with the transfer hypothesis. We also showed sex- and trait-specific responses in visual signals that suggest both natural and social selection play an important role in the evolution of sexual dimorphism. Altogether, these results support the idea that environmental (sensory drive) and behavioral pressures (social selection) shape signal evolution in antwrens.

CUMULATIVE EXPERIENCE INFLUENCES CONTEST INVESTMENT IN A SOCIAL FISH

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When animals live together in long-term groups, the potential for conflict is high. Conflict is costly, so an individual's decision to engage depends on the state of its information about the costs and benefits of fighting. One such source of information could be past contest experience, resulting in winner-loser effects where winners become more likely to win, and losers to lose over time. However, repeated interactions also mean that individuals gain direct experience with conflict over time, regardless of outcome, and may learn to become better fighters. We explored how individuals integrate information and experience from previous contests to inform their future encounters in a group-living fish, *Neolamprologus pulcher*. We gave contestants single, reinforcing, and contradictory experiences and measured their behavioral and hormonal responses. We found winner-loser effects were weakened by contradictory experiences. We did not find support for the hypothesis that more fighting experience led to increased fighting investment, as consecutive losses resulted in reduced aggression. We did not find an effect of fighting treatment on androgen hormone concentrations. Interestingly, we found indications of sex differences in how perceived fighting ability changes in response to contest experience. Females and

males differed in which behaviors were influenced by past experiences, and we found a positive association between mass and androgen concentrations in males but not females. Overall, we show that repeated experiences alter an individual's propensity to invest in conflict in complex ways. Repeated interactions with winner-loser effects have been suggested to contribute to group stability; our results suggest that whether and how they do so may depend on the quality and quantity of interactions and on individual factors like sex.

EXPERIMENTAL MANIPULATIONS OF OFFSPRING FOOD AVAILABILITY SUGGEST BEGGING CONTAINS LITTLE INFORMATION IN A FROG WITH FACULTATIVE PARENTAL CARE

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Offspring solicitation signals (begging) are hypothesized to evolve to communicate information about how an offspring might benefit from parental investment. Much of what is currently known about the information content of begging signals comes from species where offspring are entirely dependent on parents for food. However, early in the evolution from non-begging to begging, the ability of offspring to self-feed may have shaped the benefits of producing begging signals. In Neotropical poison frogs, most tadpoles forage within their nurseries, but in some species, mothers provide unfertilized trophic eggs to their developing young. While egg-feeding is obligate in some lineages, in others, tadpoles both self-feed and beg for food. We tested hypotheses about what information is contained in tadpole begging in the mimic poison frog (*Ranitomeya imitator*), a species in which tadpoles can self-feed and beg for trophic eggs from parents. We reared tadpoles on three different diets shown to affect mass at metamorphosis, a common predictor of fitness in amphibians. We then assayed begging effort and intensity throughout development. Tadpoles reared on different diets did not differ in begging effort or intensity at any point during development. Our data suggests that *R. imitator* begging does not contain information about long-term differences in food intake. However, we also found that overall tadpoles did not beg often and that begging intensity decreased within a trial. Taken together, this suggests that early in the evolution of begging, offspring signals may have served simply to alert parents of their presence.

LET'S GET PHYSICAL: PHYSICAL ENRICHMENT ALTERS MALE MOUSE RESPONSE TO COURTSHIP REJECTION VOCALIZATIONS

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Environmental enrichment (EE) is used in laboratories to improve animal welfare by promoting naturalistically complex environments. However, few studies have explored

the effects of EE on communication and courtship behavior. Here, we evaluate the effects of both social and physical EE on the perception of negatively valenced vocal signals in male house mice. During courtship interactions, female mice produce broadband vocalizations (BBVs), commonly associated with courtship rejection. Male mice produce prosocial ultrasonic vocalizations (USVs) which are hypothesized to promote mating. During interactions, males decrease their USV output in response to BBVs. In this study, mice were either in social (S+) or isolated housing (S-) and either physically enriched (P+) or physically deprived housing (P-) for a month, creating four distinct groups with varying levels of social and physical EE: S+P+, S+P-, S-P+, and S-P-. Mice then underwent a split cage assay in which limited contact with a female mouse was allowed through a barrier for 15 minutes during which they were exposed to 5 minutes of silence (baseline), 5 minutes of BBV playback, and 5 more minutes of silence (recovery). USV production was measured to gauge perception of the BBVs. There was a significant effect of both social and physical EE on USV production, with P+ increasing and S+ decreasing baseline USV production. Mice exposed to physical EE, regardless of their social EE level, also produced significantly longer USVs than physically deprived mice. Physical EE also altered mouse perception of courtship rejection signals and the trajectory of vocal behavior during and after BBV playback, with P+ causing a decreased response to playback and decreased recovery after playback. Surprisingly, social treatment did not significantly affect these measurements, suggesting that physical enrichment powerfully alters mouse perception and vocal production in a social interaction, while social enrichment alone does not.

WOLF SPIDER DECISION-MAKING BASED ON DISTANCE FROM A FOOD SOURCE

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Research has shown that jumping spiders, which primarily utilize visual cues to hunt, are capable of decision-making processes that allow them to choose prey that is closer to them. Such research is lacking in wandering spiders, which utilize both visual and vibratory cues to hunt. We studied this process in *Schizocosa*, a genus of wolf spider, by presenting them with both visual (video) and vibratory signals of prey. The spiders were placed in a Y-maze and allowed to choose between a short (10cm) and long (20cm) path to the simulated prey. Sixty-two trials were run with adult spiders of both sexes; half were starved, and the other half were well-fed. We hypothesized that the spiders would choose the shortest path. Further, we predicted that if spiders were motivated (starved), then they would be more likely to choose the shorter path to prey. While most of the spiders made no decision, of those that did make a decision, they usually chose the shorter path, but motivated spiders were not found to be more likely to do so. Overall, this research suggests that wolf spiders have the capacity to choose the shorter path to a prey item without experiencing the environment prior.

DIFFERENCES AMONG FEMALE AND MALE *PHRYNUS MARGINEMACULATUS* (ARACHNIDA: AMBLYPYGI) IN THE USE OF SELF-DERIVED CHEMICAL CUES FOR SHELTER RECOGNITION

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Previous research has shown that whip spiders (*Phrynus marginemaculatus*) can recognize a shelter based on self-derived chemical cues. Field studies in related species (*Phrynus pseudoparvulus*) have also revealed sex differences in refuge fidelity. This study tested for sex differences in the use of self-derived chemical cues for shelter recognition by *P. marginemaculatus*. Eight females and eight males were placed individually in a 1.8 m circular arena containing a shelter at the center. Subjects underwent four test nights, with the shelter removed from the arena, alternated by familiarization nights where the shelter was present. For half of the subjects of each sex, the arena floor was cleaned every night (control), while for the other subjects, the arena was cleaned only during the day after each shelter-removed test night (treatment). An overhead camera tracked the movement of subjects throughout the night, and the proportion of time spent in the center of the arena on shelter-removed nights was used as a metric for shelter recognition. Treatment females spent significantly more time in the center of the arena than treatment males and male and female controls. These results suggest that, in the absence of a shelter, females, but not males, use self-derived chemical cues to recognize the spatial location of a previously occupied shelter.

RESOURCE SCARCITY ALTERS ADDICTION-RELATED BEHAVIORS AND THE BASOLATERAL AMYGDALA TRANSCRIPTOME IN SEX-SPECIFIC WAYS

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Early life adversity (ELA) is a well-known risk factor for the development of psychiatric disorders including substance use disorder (SUD). However, stress that is not overwhelming may have an inoculating effect by promoting resilience later in life. Therefore, ELA has the potential to produce behavioral and neurological changes that may be adaptive. In our laboratory, we use the limited bedding and nesting (LBN) paradigm in rats to model mild ELA. We previously found LBN reduces morphine self-administration in adult male, but not female rats. We are now extending this to work to determine whether changes in reinforcing efficacy for morphine also apply to cocaine. Our behavioral analysis demonstrates that rats exposed to LBN do not self-administer doses of cocaine different from controls. However, we do find differences in incubation of craving, a model of craving and relapse; LBN animals lever press for cocaine at a higher rate than control animals. The basolateral amygdala (BLA) is a

region critical for behavioral responses to stress and is a key regulator of reward circuitry; we are beginning to investigate the molecular correlates induced by LBN within this region. RNA sequencing was conducted to delineate the effect LBN had on the transcriptional profile of the BLA in adult rats. We used rank-rank hypergeometric overlap analysis to compare overall gene expression pattern in males and females induced by LBN. We found that LBN induces sex-specific changes in transcription. Specifically, we see significant distinction between genes upregulated in males and downregulated in females due to LBN. We narrowed our analysis to genes showing a significant difference between control and LBN and found 209 differentially expressed genes (DEGs) in females and 149 DEGs in males. Changes in gene expression were predominantly sex specific as only 11 genes overlap. These findings further our understanding of the effects of ELA on addiction-like traits and the BLA transcriptome.

DEPLETION OF GLUCOCORTICOID RECEPTORS IN PREFRONTAL CORTEX PYRAMIDAL NEURONS MITIGATES STRESS-INDUCED SYNAPTIC AND BEHAVIORAL DEFICITS

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Neuroendocrine responses to chronic stress can promote physiological and behavioral adaptations through glucocorticoid receptor (GR) signaling. Specifically, GR signaling has been implicated in stress-induced structural remodeling on pyramidal neurons in the prefrontal cortex (PFC). Significantly, stress-induced synaptic loss in the PFC underlies behavioral deficits and working memory impairments. Our recent studies indicate that GR signaling engages neuron-microglia interactions and this contributes to synapse loss on neurons in the PFC. Despite this work, the cell type-specific role of GR signaling in stress has not been studied. Thus, we aimed to determine how GR depletion in PFC pyramidal neurons influenced neurobiological and behavioral responses to chronic unpredictable stress (CUS). Transgenic mice targeting the Nr3c1 gene (GR-flox) or wild-type conspecifics received bilateral viral infusion in the medial PFC to selectively deplete GR in pyramidal neurons. Immunofluorescence showed that GR-flox mice had a significant reduction in GR levels in mCherry+ neurons compared to wild-type mice. Additionally, all mice had elevated plasma corticosterone levels and reduced weight gain after exposure to CUS, suggesting that GR depletion did not influence stress responses. We found that wild-type mice exposed to CUS had impaired discrimination in temporal object recognition and that this deficit was mitigated in GR-flox mice. No significant results were found in other behavioral analyses such as nest building and sucrose consumption. Further studies will use gene expression analyses to compare transcriptional changes mediated by GR depletion in neuronal and non-neuronal samples. In addition, immunohistology is being performed to quantify dendritic spine density in the PFC following CUS. Altogether, our results provide strong evidence that GR depletion specifically in PFC pyramidal neurons attenuates neurobiological and behavioral consequences of CUS.

WITH FRIENDS LIKE THESE: A GLOBAL SYNTHESIS OF DISTURBANCE-BASED FORAGING ASSOCIATIONS OF BIRDS

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Species interactions link animal behavior to community structure and macroecological patterns of biodiversity. One common type of trophic species interaction is disturbance foraging -- the act of obtaining food at a disturbance created by another organism. Disturbance foraging is widespread across the animal kingdom, yet previous research has been largely anecdotal and we currently lack a synthetic understanding of how the behavior varies geographically, phylogenetically, or ecologically. To address these questions, we conducted a comprehensive literature review of disturbance foraging behavior in birds. We found that avian disturbance foraging was geographically widespread, occurring in both aquatic and terrestrial habitats across six continents and four oceans. The majority of terrestrial disturbances occurred in forest habitats and at tropical latitudes, while aquatic disturbance foraging occurred most frequently in temperate waters. Disturbance foraging was widespread yet highly conserved (Pagel's $\lambda = 0.7$) across the avian phylogeny, with 7.5% (822/10,906) of all bird species from 47% (117/249) of families and 68% (28/41) of orders recorded engaging in the behavior. Suboscine landbirds of the families Thamnophilidae (52/237 species, 22%), Furnariidae (43/307 species, 14%) and Tyrannidae (40/441 species, 9.1%) were the most common terrestrial responders, while seabirds of the families Laridae (39/99 species, 39%) and Procellariidae (36/97 species, 39%) were the most common aquatic responders. Swarm-raiding ants were the primary terrestrial disturbers and cetaceans were the primary aquatic disturbers. We anticipate that our comprehensive assessment of disturbance foraging will serve to generate additional hypotheses and spark future research and management considerations about this fascinating but poorly studied suite of behavioral interactions.

COMMUNICATIVE ANTECEDENTS TO HELPING BEHAVIOR IN RATS

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Empathy involves the sharing of affective states and often includes discerning the cause of the resulting emotion. To better understand the evolution of this capacity and proximate mechanisms supporting its expression, experiments have steered toward investigating the empathetic abilities of smaller brained mammals. Rats are affected by the emotions of conspecifics, display consolation behavior, and have repeatably

demonstrated a capacity for targeted helping that is flexibly dispensed based on a variety of factors, thus making them an ideal candidate to explore unanswered questions surrounding empathy. While the neural correlates of empathetically motivated behaviors have recently received necessary attention, the communication surrounding such behaviors have remained scarcely explored. Rats utilize a variety of ultrasonic calls to communicate information and these calls can be used to indicate the affective state of the source. 22 kHz calls are emitted in response to distress and are indicative of a negative emotional state, while 50kHz calls are emitted in anticipation of and during engagement with a rewarding stimulus and are thus indicative of a positive affective state. Examining the communicative antecedents to helping behavior can shed light on the motivations underlying prosocial behavior and necessary precursors to facilitate its performance.

IN SICKNESS AND IN HEALTH: COMPLEX EFFECTS OF SOCIAL BEHAVIOR ON INFECTIOUS DISEASE

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Social behavior is intricately linked to animal health and fitness. When animals form groups they often benefit from better access to resources, but they also incur important costs. One of these costs is an increase in the transmission of pathogens. Interestingly, although elevated infection risk is considered a near universal cost of group living, the social interaction that occurs in groups may simultaneously provide benefits that mitigate the negative impacts of infection. These complex effects of social behavior on pathogen exposure, on one hand, and pathogen defense on the other, complicate our understanding of how social behavior shapes infectious disease outcomes. In this talk, I describe ongoing work in my lab that is using experimental and longitudinal studies of wild mammals to shed light on the links between social behavior, infection, and pathogen defense.

INDIVIDUAL CONDITION AND STEROID LEVELS COVARY WITH SOCIALITY AND CONTEXT IN ELECTRIC KNIFEFISHES

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A species' social structure can influence the regulation and responsiveness of steroid hormones during social interaction. Steroid hormone levels can also vary by individual condition, experience, and type of social interaction. How sociality and the more immediate social context interact to influence circulating steroid levels is less well understood. Weakly electric knifefishes exhibit extensive variation in steroid-dependent social communication and social behavior across species. Here, we test how

steroid hormone levels respond to isolation, same-sex pairing, and opposite-sex pairing in three species of apteronotid knifefishes that vary in sociality: territorial *Apteronotus albifrons*, semi-social *Apteronotus leptorhynchus*, and social *Adontosternarchus balaenops*. Blood samples were collected before and after social housing to quantify hormone levels using enzyme-linked immunoassays in four steroids: 11-ketotestosterone (fish androgen), testosterone, estradiol, and cortisol. Steroid levels were not consistently responsive to social context itself across species. Individual relationships between size and reproductive condition, however, were highly sensitive to both species' sociality and social context. In both territorial and social species, gonadal steroid levels largely mapped onto reproductive condition. In the semi-social species that forms clear dominance hierarchies, *A. leptorhynchus*, androgen levels were better explained by size than by reproductive condition. In territorial species only, bigger fish and males in better reproductive condition also had lower cortisol levels in response to social pairing. Together, these results suggest that integrating comparisons across species and social context can unmask relationships between hormones and individual condition that are not evident in isolation.

STRESS RESPONSIVE GROOMING IN F344 RATS

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Obsessive Compulsive Disorder (OCD) is commonly characterized by the presence of thoughts (obsessions) that trigger the execution of repetitive behaviors (compulsions). Rodent models of OCD typically examine highly stereotyped behaviors such as grooming. Self-grooming increases in the presence of stress in numerous rodent models. Mechanisms underlying this process remain to be delineated. We propose that a stressor triggers activation of BLA, synapses in the NAc, which in turn drives a striatonigral pathway known to induce grooming. We used tracing approaches in Fischer 344 rats to characterize this pathway. Rats received a unilateral PHA-L (anterograde tracer) iontophoretic injection in the BLA along with ipsilateral red Retrobead (retrograde tracer) injection in the SNr. PHA-L labeled terminals were observed in both the NAc and in ventromedial SNr, indicating the existence of BLA projections. Subsequent experiments used behavioral tests to characterize stress-induced grooming. Fischer 344 rats (a high grooming strain) were exposed to two versions of elevated plus maze (EPM) testing (traditional vs. closed arm removal) paired with restraint stress. F344 rats exhibiting low baseline grooming significantly increased grooming behavior in the traditional EPM test following restraint exposure, consistent with stress enhancement of behavior. Removal of the EPM close arm enclosure in EPM-trained markedly increased grooming behavior in all rats, consistent with selection of an alternative coping strategy in the absence of the darkened recess. These data identify behavioral strategies to 1) explore individual differences in stress-induced grooming and 2) test the ability to increase grooming behavior by removal of

environmental safety signals. Future studies will examine whether the BLA-NAc-SNr pathway mediates stress-potentiated grooming in these behavioral models.

HOUSE SPARROW (*PASSER DOMESTICUS*) AND HOUSE FINCH (*HAEMORHOUS MEXICANUS*) SIGNAL TRANSMISSION VARIES ACROSS AN URBANIZATION GRADIENT

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Urban expansion has increased pollution, which includes both the physical (e.g., exhaust) and sensory (e.g., anthropogenic noise) components. Research shows that birds increase the frequency and amplitude of their song in urban areas to reduce masking by low frequency noise pollution. However, bird song (i.e., a signal) is also affected by the environment and accompanying ambient noise. This study investigates how anthropogenic disturbances alter the ability of birds to communicate. Specifically, this study examined differences in active space, or the maximum distance a receiver can detect a signal, across an urbanization gradient. This study utilized the house sparrow (*Passer domesticus*) and the house finch (*Haemorhous mexicanus*), as both species can inhabit urban areas and rely on vocal cues from conspecifics. Recorded songs were played back with a speaker at urban, rural, and suburban locations in Holland, MI, and recorded at distances up to 100 meters. This set-up mimicked bird communication, with the speaker acting as the sender, the song as the signal, and the recorder as the receiver. We expected songs in rural areas to have a larger active space compared to urban environments due to lower noise pollution. Results suggest a significant two-way interaction in which active space differed depending on urbanization and species. In rural and suburban areas, house finches had a larger active space than house sparrows. However, this trend did not exist in rural areas, where house sparrows and house finches had similar active spaces. Furthermore, we also found a significant main effect in which active space differed depending on song exemplar. These results suggest that urban environments constrain the propagation of vocal signals. This has implications in which urban environments may inhibit the ability of birds to communicate to potential mates or kin.

PERINATAL OPIOID EXPOSURE LEADS TO DECREASED SOCIAL PLAY IN ADOLESCENT MALE AND FEMALE RATS

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Juvenile play is a necessary part of rodent social development and is impacted by acute opioid exposure during adolescence. However, the effects of opioid exposure during critical early developmental stages on play and sociability is unknown. Using a novel paradigm of gestational morphine exposure to model the clinical features of infants born with an opioid use disorder (OUD), we tested the hypothesis that chronic opioid

exposure during perinatal development would alter juvenile social play. Our results show that adolescent male and female rats perinatally exposed to morphine displayed decreased social play behavior (including time spent playing and pinning/nape attacks), with a more robust reduction observed in females. Oxytocin receptor binding was reduced in the nucleus accumbens in morphine-exposed females, suggesting that the observed decrease in play behavior was due to a reduction in social reward valence. As children exposed to opioids *in-utero* have increased risk of developing attention-deficit hyperactivity disorder (ADHD) and autism spectrum disorders (ASD), often associated with problems in sociability and play, these results propose a theoretical model of decreased sociability after early developmental opioid exposure, and indicate the oxytocin system as a potential therapeutic target.

NEST ARCHITECTURE INFLUENCES HOST USE BY AVIAN BROOD PARASITES AND IS SHAPED BY COEVOLUTIONARY DYNAMICS

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Brood (social) parasites and their hosts exhibit a wide range of adaptations and counter-adaptations as part of their ongoing coevolutionary arms races. Obligate avian brood parasites are expected to use potential host species with more easily accessible nests, whilst potential hosts are expected to evade parasitism by building more concealed nests that are also difficult for parasites to enter and lay eggs in. We used phylogenetically-informed comparative analyses, a global database of the world's brood parasites, their host species, and the design of avian host and non-host nests (~6200 species) to examine first, whether parasites preferentially target host species that build open nests and, second, whether host species targeted by specialist parasites are more likely to build enclosed nests. As predicted, the nests of host species are more accessible to brood parasites than are the nests of non-host species, and host species with domed nests tend to be targeted by more specialist brood parasites. Furthermore, evolutionary-transition analyses demonstrate that host species building enclosed nests frequently evolve to become non-hosts. We conclude that nest architecture and the accessibility of nests for parasitism represent a critical and previously under-appreciated stage of the ongoing coevolutionary arms race between avian brood parasites and their hosts.

IT'S ALL GREEK TO ME: CULTURALLY DIVERGENT SONGS AS A MECHANISM FOR POPULATION DIVERGENCE IN NUTTALL'S WHITE-CROWNED SPARROWS (*ZONOTRICHIA LEUCOPHRYS NUTTALLI)*

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Animal culture evolves alongside genomes, and the two modes of inheritance—culture and genes—interact in myriad ways. For example, stable geographic variation in culture can act as reproductive barriers, thereby producing genetic divergence between "cultural populations." White-crowned sparrows (*Zonotrichia leucophrys*) are a well-established model species for bird song learning and cultural evolution, as they have distinct, geographically discrete, and culturally transmitted song types (i.e., song dialects). In this study, we tested the hypothesis that divergence between culturally transmitted songs drive genetic divergence within Nuttall's white-crowned sparrows (*Z. l. nuttalli*). We characterized the population structure and song variation in the subspecies and found a genetic boundary coinciding with a major song boundary at Monterey Bay. We then conducted a song playback experiment that demonstrated that males discriminate between songs based on their degree of divergence from their local dialect. These results support the idea that discrimination against non-local songs may have produced genetic divergence between the northern and southern populations. Altogether, this study provides evidence that culturally transmitted bird songs can act as the foundation for speciation by sexual selection.

ADOLESCENT AND ADULT RATS DIFFER IN EXPRESSION OF ACUTE EARLY LIFE STRESS-ENHANCED FEAR LEARNING

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Posttraumatic stress disorder (PTSD) affects nearly 8 million people in the United States, making it one of the most common psychiatric illness diagnoses. Individuals diagnosed with PTSD are more likely to have experienced trauma during childhood, suggesting that early adversity is an important vulnerability factor in subsequent development of PTSD. It is important to develop animal models of psychiatric dysfunction to determine evident vulnerability considerations, potential biomarkers, and novel treatment avenues to improve the human condition. The present experiment addressed whether rats exposed to acute early life stress (aELS) differ in the acquisition and/or expression of fear during adolescence or adulthood. Rats received 0 or 15 footshocks on postnatal day (PND) 17. Rats were fear conditioned in a novel context on PND 41 or PND 91 using a single, mild footshock. Adult, but not adolescent, rats demonstrated stress-enhanced fear learning. When rats that were fear conditioned in adolescence were retested in adulthood, rats that received aELS demonstrated stress-enhanced fear learning comparable to rats that were fear conditioned and tested in adulthood. Taken together, these data demonstrate persistent effects of aELS and age on fear learning and show that while adolescent animals are impacted by aELS, they are unable to demonstrate enhanced freezing until

adulthood. Future investigation into these mechanisms is warranted to better understand key differences that emerge during adulthood.

DISENTANGLING DECISION RULES UNDERLYING FLEXIBLE SEX-REVERSAL OF PARENTAL CARE IN A POISON FROG

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Flexible parental care strategies are widespread in nature, and factor particularly prominently into conflict between the sexes and the realization of sex roles. While one sex is typically the primary caregiver, the other sex may retain caregiving capabilities but limit their involvement to a compensatory capacity. While adaptive explanations abound, the mechanisms that underlie flexible 'sex-reversal' of care are not always clear. Here, I enlist a biparental frog (*Ranitomeya imitator*) with flexible sex-reversal of tadpole transport to investigate how multiple sources of environmental information are integrated to inform takeover decisions. Using standard mate removal experiments in the laboratory, I show that members of the flexible sex (females) express greater individual variation in transport behavior than members of the primary transporting sex (males). To differentiate whether successful females are responding to cues of an absent partner or of offspring need, I next manipulate acoustic and visual stimuli of mates following their removal. Preliminary data suggest that a female's perception of her social environment can affect her involvement in care, potentially overriding signals of offspring need. Acoustic cues (playback of partner calls) appear to have stronger effects on female behavior in this species than visual cues (frog dummy). These behavioral data lay the groundwork for future investigations into the neurogenomic mechanisms of sex-reversed care.

MORPHOLOGICAL CHANGES PERSIST FOLLOWING MTBI-INDUCED EPISODIC MEMORY IMPAIRMENT IN RATS

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Mild traumatic brain injury (mTBI) is the most common type of traumatic brain injury. It leads to temporary memory impairment and an excitotoxic response in the brain, particularly in the hippocampus. In an earlier study, we used the item-in-context task (Panoz-Brown et al., *Current Biology*, 2016) to assess episodic memory function in Sprague-Dawley rats who sustained an mTBI using the Wayne State University weight drop model (a model of mTBI that recapitulates key elements of a sport-related injury). We observed a selective decline in episodic memory performance during the first four days post-injury. In this study, we analyzed the expression of astrocytes and microglia at various time points following mTBI. Using several measurements to quantify

morphological changes, we documented a delayed onset of substantial changes to the morphology of astrocytes and microglia. On most measures for astrocytes, we detected changes at eight days; one change was detected at four days. Microglia showed substantial differences in one parameter at four days. We conclude that morphological changes persist after the peak episodic memory deficit.

ARE YOU LISTENING? URBAN LIVING IMPACTS AUDITORY PROCESSING IN A CITY-DWELLING SONGBIRD

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Animal communication involves a sender producing a signal (e.g., a vocalization) that travels through the environment before being detected by a receiver. Increased urbanization can complicate receiver sensory processing as anthropogenic activities (e.g., noise pollution) affect the way birds communicate. This study examined the influence of urbanization on the auditory processing system of house sparrows (*Passer domesticus*), known for inhabiting urban areas and relying on vocal cues from conspecifics. Birds (N = 48) were collected across an urbanization gradient in Holland, Michigan, and performed an auditory brainstem response (ABR) test. ABRs are generated from the auditory brainstem at the onset of a sound stimulus. We presented birds with 6 different frequencies (0.5, 1, 2, 3, 4, 6 kHz) at 9 intensity levels (from 8 dB to 72 dB in 8 dB intervals). The amplitude, latency, and threshold (the lowest intensity level at which there is still an ABR) of each waveform was analyzed. We predicted decreased auditory sensitivity in urban birds because they are exposed to consistent anthropogenic noise. In Holland, urban areas are roughly 10 dB louder than rural areas, which has the potential to cause hearing damage. Moving from rural to urban, we expected decreases in amplitude and increases in threshold. Our results showed two significant three-way interactions between season, sex, and urbanization level on threshold and between season, intensity, and urbanization level on ABR amplitude. Although males showed no significant difference, females presented differences in threshold based on season and urbanization level. It has been suggested that females tend to have greater frequency selectivity during breeding months in order to select mates. Thus, our results corroborate previous work and provide insight to understanding the impacts on bird communication.

EARLY POSTNATAL HEAT AND THE POTENTIAL FOR CARRYOVER EFFECTS IN GENE EXPRESSION IN TREE SWALLOW NESTLINGS *TACHYCINETA BICOLOR*

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High temperatures are the new norm as heat waves increase in number, intensity, and duration. Experimental approaches demonstrate that acute heat engages behavioral and physiological thermoregulatory mechanisms in songbirds. What is not known is the extent to which these heat events have carryover effects. Here, using free-living songbird nestlings (tree swallows, *Tachycineta bicolor*), we tested the extent to which a prior acute heat challenge had a lasting effect on gene expression of heat shock proteins (HSP). We also evaluated whether there are key developmental windows for any carry-over effects. We focus on two key time points in the nestling period, including postnatal day 6, when chicks are at their peak of growth, and day 12, when chicks reach their asymptotic mass. Further, we quantified behavioral thermoregulatory responses at the individual-level, and we explored how these behavioral mechanisms interacted with any HSP responses. Understanding the temporal scope and internal mechanisms by which birds respond to heat challenges will generate important insights into how populations may respond to our warming world.

THE EFFECTS OF PUBERTAL ONSET ON BEHAVIORS MEDIATED BY THE DOPAMINE SYSTEM IN LONG EVANS RATS

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Adolescence is associated with increases in cognitive function, social and emotional skills, and increases in sensation-seeking and risk-taking behavior. These behaviors are mediated by the dopamine-producing cells of the ventral tegmental area (VTA). Within the broad period of adolescence, pubertal onset specifically has been associated with rapid changes in the brain and behavior, but the effects of puberty on development of the VTA and VTA-mediated behaviors have received little attention. This region is highly sensitive to steroid hormones like estrogen and testosterone that surge at puberty. In the present study, we assessed risk-taking across adolescence from postnatal day (P)30 (prepubertal), recently pubertal, and P60 (post-pubertal) in male and female rat subjects. To measure risk-taking and motivation for reward, we used a predator-odor risk-taking task. We hypothesize that pubertal onset will be associated with changes in the motivation to take a risk for a reward. Additionally, we tested another set of male and female rats in young adulthood and compared their scores on elevated plus maze, open field, and novel object recognition tests to the age at which they reached pubertal onset. Interestingly, we found that for male subjects, there was a positive correlation between age of pubertal onset and time spent in the open arms of the elevated plus maze. These experiments aim to add to our knowledge of the effects of pubertal hormones on behavior.

MICE EXHIBIT SIMILAR BEHAVIOR ORGANIZATION ACROSS DIFFERENT SCALES OF MOVEMENT

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Researchers have long set out to characterize motor primitives, or building blocks, to better understand the spatiotemporal representation of movement. However, it is unknown if these motor primitives are sequentially organized and conserved across different scales (ambulatory and manipulatory). Although there appear to be distinctions between tasks using different scales of movement, the kinematic organization of these behaviors has yet to be directly compared. Therefore, the current study assessed five adult female mice in one ambulatory (open-field) and two manipulatory (string-pulling/rung-walking) behavioral tasks. Open-field data was processed through motion tracking software and segmented by speed into stops and progressions. For the string-pulling and rung-walking data, forelimbs were tracked using separate machine learning networks. The tracked limbs were segmented into reach/withdrawals (string-pulling) or swing/stances (rung-walking) to derive several measures. Results indicate that similar organizational patterns are conserved across different scales of movement. Specifically, during progressions, swings, and reaches mice scale their movement speed to distance traveled; however, withdrawal kinematics are not scaled. These results suggest that although spontaneous behaviors are represented in different neural systems, they share some similar organizational characteristics. Future work should consider specific kinematic organization of ambulatory and manipulatory behavior in rodent models to detect subtle changes in the brain as this can inform the development of early detection, prevention, and treatment of a range of neurological disorders.

REPLAY OF INCIDENTALLY ENCODED EPISODIC MEMORIES IN THE RAT

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Although events are not always known to be important when they occur, people can remember details about such incidentally encoded information using episodic memory. Importantly, when information is explicitly encoded for use in an expected test of retention (as in most assessments in animals), it is possible that it is used to generate a planned action; thus, the remembered action can occur without remembering the earlier episode. By contrast, when information is encoded incidentally, it is impossible to transform information into an action plan because the importance of the information and the nature of the test are not yet known. Thus, accurate performance in an unexpected test after incidental encoding documents episodic memory. Here, we show that rats replay episodic memories of incidentally encoded information in an unexpected assessment of memory. In one task, rats reported the third last item in an explicitly encoded list of trial-unique odors. In a second task, rats foraged in a radial

maze in the absence of odors. On a critical test, rats foraged in the radial maze, but scented lids covered the food. Next, memory of the third last odor was assessed. All participating rats correctly answered the unexpected question. These results suggest that rats encode multiple pieces of putatively unimportant information, and later they replayed a stream of episodic memories when that information was needed to solve an unexpected problem. Evidence that rats replay episodic memories of incidentally encoded information documents a critical aspect of human episodic memory in a nonhuman animal.

INTERINDIVIDUAL VARIATION IN ADOLESCENT FEMALE-INFANT INTERACTIONS: PRELIMINARY DATA FROM THE AMBOSELI BABOONS

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Adolescent female primates demonstrate a striking degree of interest in other females' infants, pursuing social interactions and physical contact with them. Many hypotheses have been proposed to explain this interest, including the ideas that females are gaining mothering skills, engaging in reproductive competition, or that this interest is a byproduct of selection on female parental care. However, testing these hypotheses has been hampered by a lack of data on the fitness consequences of adolescent female behavior. We will test these hypotheses using fine-grained focal animal sampling of adolescent female baboons *(Papio cynocephalus)* and data on individual fitness proxies collected by the Amboseli Baboon Research Project. The Amboseli baboons are an ideal study system as this population is monitored on a near-daily basis providing long-term data on social interactions and female reproductive success. From August to December 2022, we collected 317 focal samples on 20 adolescent females, for a total of 149.18 hours of observation. Here, we present preliminary results from this pilot dataset investigating drivers of interindividual variation in infant interaction rates. These results will form the groundwork for future research disentangling hypotheses about adolescent female interactions with infants and what the consequences of these interactions may be for the adolescent females.

STARTLE RESPONSE AND CORTICOSTERONE IN NEOTROPICAL TADPOLES

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An essential challenge for all organisms is to detect and respond to environmental dangers, both behaviorally and physiologically. One type of defensive reflex is a startle response: a fast activation of head and body muscles in response to threatening stimuli. Tadpoles often defend against predation and competition via startle response.

We are interested in how this behavior evolved and persists and if it is mediated in part by corticosterone, a hormone often correlated with stress. We analyzed inter- and intraspecific variation in corticosterone levels and startle responses of three species of tadpole: the dyeing poison frog (*Dendrobates tinctorius*), the mimic poison frog (*Ranitomeya imitator*), and Fleischmann's glass frog (*Hyalinobatrachium fleischmanni),* and if corticosterone can predict startle response. We found that species differ in startle response, open field behaviors, and baseline corticosterone levels. We predict that corticosterone levels will be positively correlated with startle response. Our preliminary results indicate that these tadpoles have differing sensitivities to a ventral startle stimulus. By elucidating the patterns and mechanisms of these behaviors we may better predict how they have evolved and persist in differing habitat types.

INVESTIGATING PHYSIOLOGICAL COSTS OF RESISTANCE TO MALARIA PARASITES IN BREEDING CONDITION MALE SONGBIRDS

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Parasitism is ubiquitous among animals, yet the factors driving heterogeneity in host functional responses to parasitism remain understudied. Our earlier work showed that male songbirds (*Junco hyemalis*) with long-term (i.e., 'chronic') infections with *Plasmodium*, the causative agent of avian malaria, tend to be heavier, have higher hematocrit, and have larger cloacal protuberances (i.e., sperm storage capacity) than males without chronic infections. This pattern persisted following experimental inoculation with *Plasmodium*, but we did not observe an effect of chronic infection on GnRH-induced testosterone levels, sperm count, or proportion of non-deformed sperm. In this presentation we will discuss whether the effect of experimental *Plasmodium* inoculation varied between males with and without chronic infections in relation peak parasite load. Parasite load reflects the interaction between the host's immune response and the parasite's ability to reproduce. Low peak loads could indicate a strong host immune response, which is predicted to be energetically costly to the host (i.e., resistance). Conversely, high loads might reflect a reduced host immune response, presumably to prioritize allocating energy to self-maintenance and/or breeding (i.e., tolerance). We also discuss whether host resistance explains variation in functional responses (mass, hematocrit, cloacal protuberance volume, testosterone, etc.) to experimental *Plasmodium* inoculation.

USING VIDEO GAMES TO REVERSE ENGINEER ANIMAL INTELLIGENCE

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What algorithms power animal intelligence? How can we reproduce these algorithms in machines? To address these questions, I propose an interdisciplinary approach at

the intersection of animal behavior, artificial intelligence, and video games. The approach involves raising newborn animals and 'newborn' artificial agents in the same virtual worlds, then testing their behavior with the same tasks. Since the animals and agents are tested in parallel experiments, we can directly compare the learning abilities of animals and machines. I will describe how my lab is using this approach to reverse engineer object perception and collective behavior. By modeling animals as task-performing artificial agents raised in realistic virtual environments, we can discover and formalize the neural algorithms found in nature. These biologically-inspired algorithms are an untapped goldmine for next-generation artificial intelligence systems and can serve as rigorous computational models for the study of animal intelligence and behavior.

CRITICAL FACTORS INFLUENCING BOBCAT RECOVERY IN EAST-CENTRAL OHIO

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A significant global challenge is the ongoing decline of biodiversity, especially loss of apex predators. Understanding ecological factors influencing apex predator success is key to predicting outcomes of population recovery in areas where they have been extirpated. Previous work shows that ecological factors like landscape, prey availability, and interspecific competition influence success of apex predator (e.g., wolves) recovery. Unfortunately, few studies address smaller predators, often mesocarnivores that assume an apex role where large predators are absent, even though these smaller predators are informative for predicting outcomes of apex predator recovery. Ongoing recovery of bobcats (*Lynx rufus*) in Ohio offers an opportunity to study non-traditional apex predator recovery. Using occupancy modeling, I hypothesize that access to suitable habitats, including proportion of forest within territories, relative prey abundance (e.g. rabbit abundance), and relative abundance of non-native coyote competitors, will impact bobcat recovery. I further predict that forest proportion and relative rabbit abundance will positively impact bobcat occupancy, while relative coyote abundance will have a negative impact. Using 26 field sites in east-central Ohio for camera traps, I recorded the presence/absence of bobcats and calculated a relative abundance index (number of independent photo captures/100 trap nights) for rabbits and coyotes in each site. I used ArcGIS Pro to calculate forest proportion around my field sites within a buffer zone set to the mean territory size of male bobcats in Ohio. Results indicate that forest proportion has a positive impact on bobcat occupancy ($P=0.0467$), while relative abundance of rabbit and coyote has little impact. Since important prey are uniformly distributed in my study area, prey availability and interspecific competition may not be intense, leaving proportion of forest cover as the factor influencing bobcat occupancy and recovery.