





¹Department of Integrative Biology, ²Institute for Neuroscience, ³Department of Molecular Biosciences, ⁴Institute for Cellular & Molecular Biology, The University of Texas at Austin ⁵Keck Science Department, Claremont McKenna, Pitzer, & Scripps Colleges; e-mail: TSolomonLane@kecksci.claremont.edu

How individual behavior changes over time and across contexts has important consequences

• Social species across the animal kingdom live and interact in groups, which can benefit resource acquisition, finding a mate, and survival. Living in groups can also facilitate the spread of disease and lead to competition and conflict.

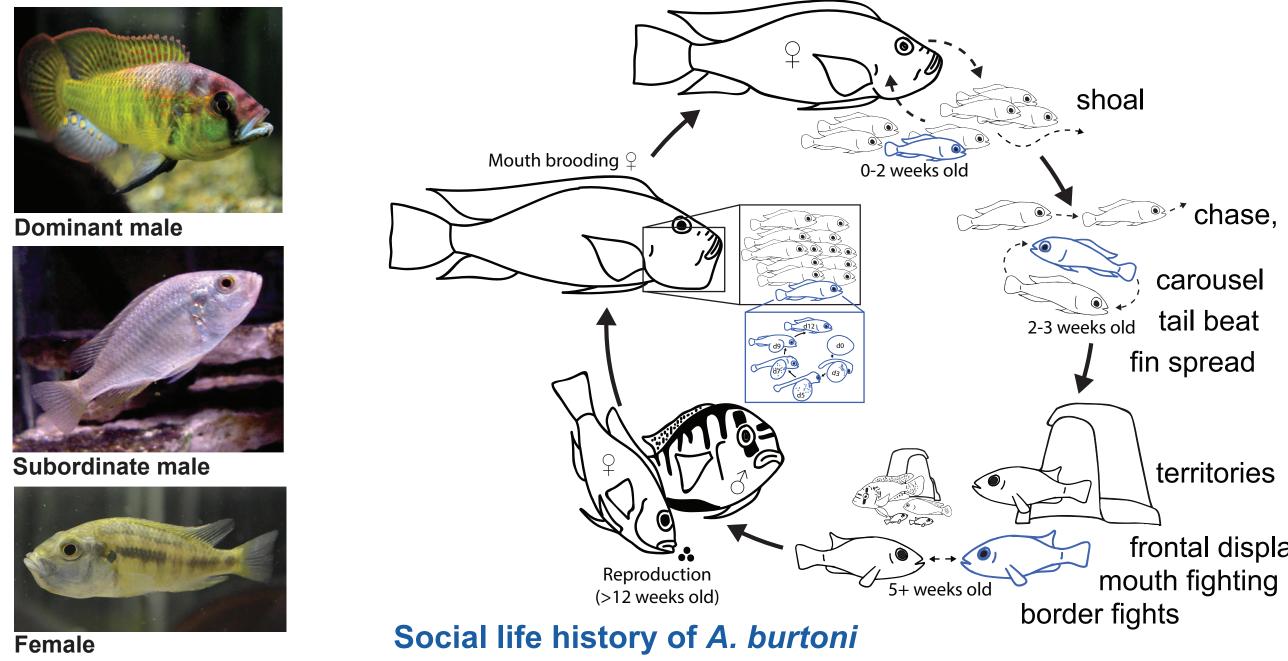


• The type and frequency of social interactions among group members is not random. Certain individuals interact preferentially, for example, while foraging, fighting, or mating. The nature of these interactions can change over short and long periods of time and across contexts, affecting individual experience and social group dynamics.

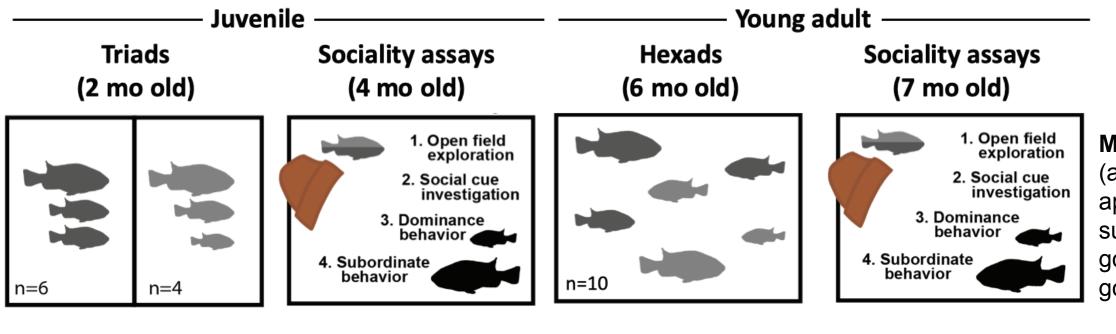
• Parasites and disease can change the behavior of an individual and affect behavioral development and life history trajectory. The social network position of infected individual(s) influences how disease spreads through the group and how a change in behavior, or death, would impact social network structure. Social behavior and social groups are nuanced and complex, and quantifying phenotypic change in a comprehensive way is important but challenging.

• Here, we focus on development as a model for understanding changes in individual behavioral phenotype over time and across contexts.

The African cichlid Astatotilapia burtoni forms highly-structured hierarchical communities of dominant males, subordinate males, and females that express behaviors common across social vertebrates, including aggression, affiliation, courtship, and cooperation.



Methods: Follow individuals (n=30) throughout development



Behavioral development and the emergence of adult phenotype in a highly social fish

Tessa K. Solomon-Lane^{1,2,5}, Kelly J. Wallace¹, Rebecca M. Butler³ & Hans A. Hofmann^{1,2,4}

chase, nip



Tag fish to keep track of individuals

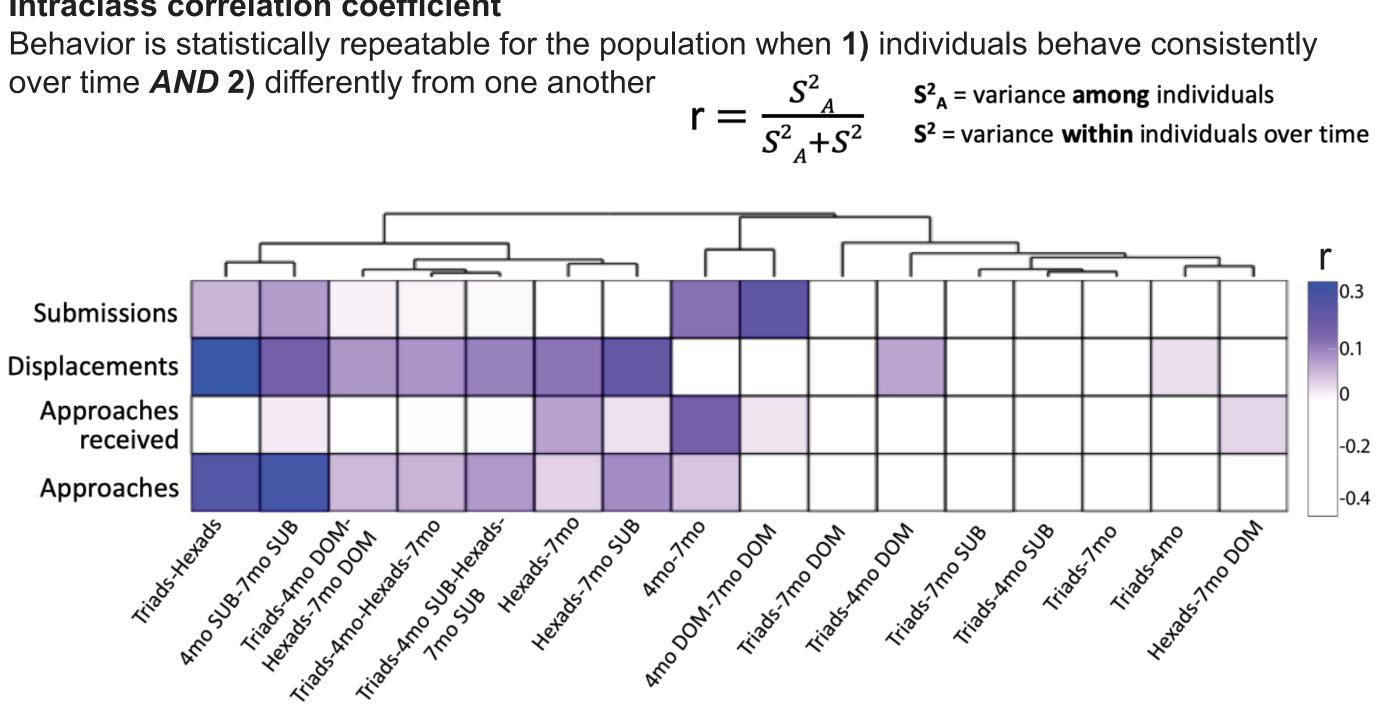


Measure: behavior (approaches, displacements, approached by others, submissions), size, sex, gonad size, and gonadosomatic index (GSI)

1. Is social behavior repeatable over time and across contexts?

Hypothesis: Rates of specific behaviors are plastic (and inconsistent) over time and across contexts.

Intraclass correlation coefficient over time AND 2) differently from one another



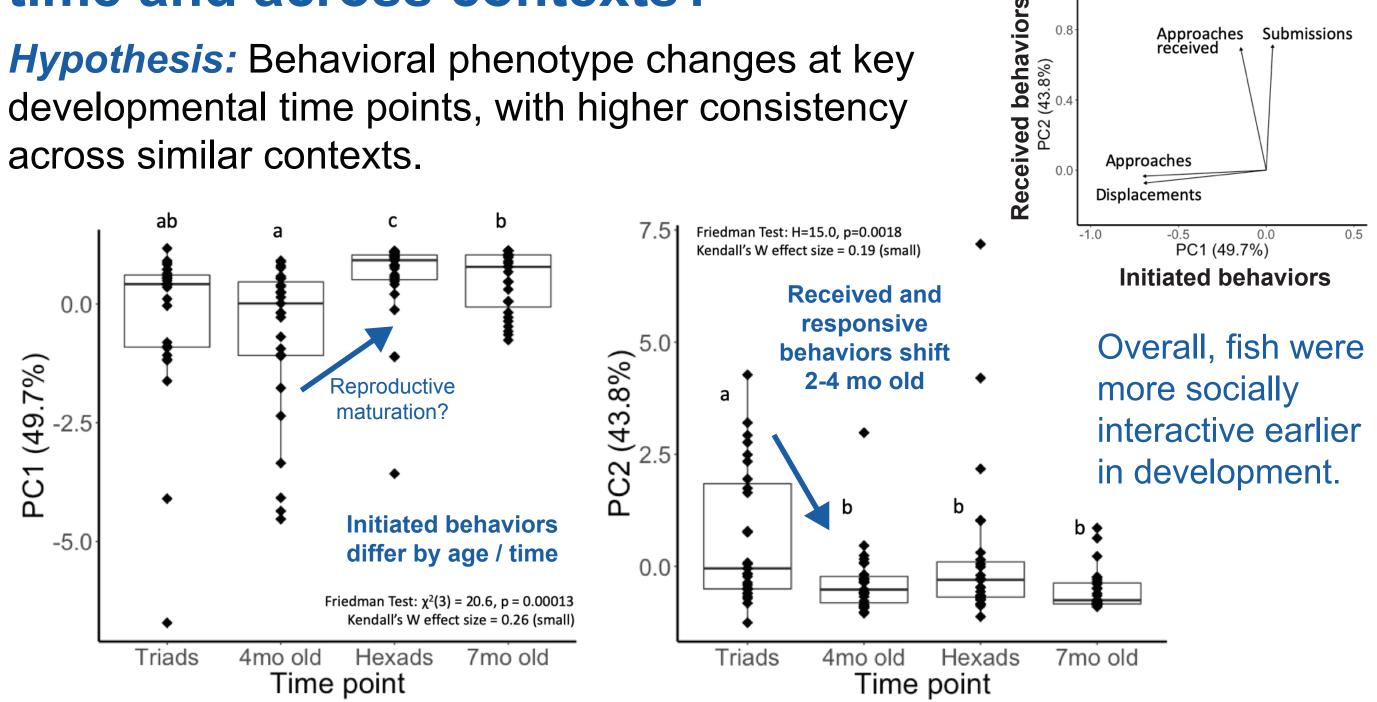
Comparisons across time points / contexts

Overall, repeatability is relatively low. Repeatability is higher across similar contexts (rather than time points), and behaviors initiated by the focal fish have higher repeatability than behaviors directed towards the focal fish by others in the social group.

Relevance & future directions: Comparing repeatability across condititions, such as infected vs. non-infected populations, or across life history stages (e.g., pre- and postpuberty), can reveal subtle but consequential differences in behavioral patterns. Juvenile A. burtoni vary dramatically in developmental trajectory (e.g., the timing of maturation), and the direct roles of parasite/disease state, or indirect roles via effects on behavior, social status, or social network structure, have not yet been tested.

2a. How does behavioral phenotype change over time and across contexts?

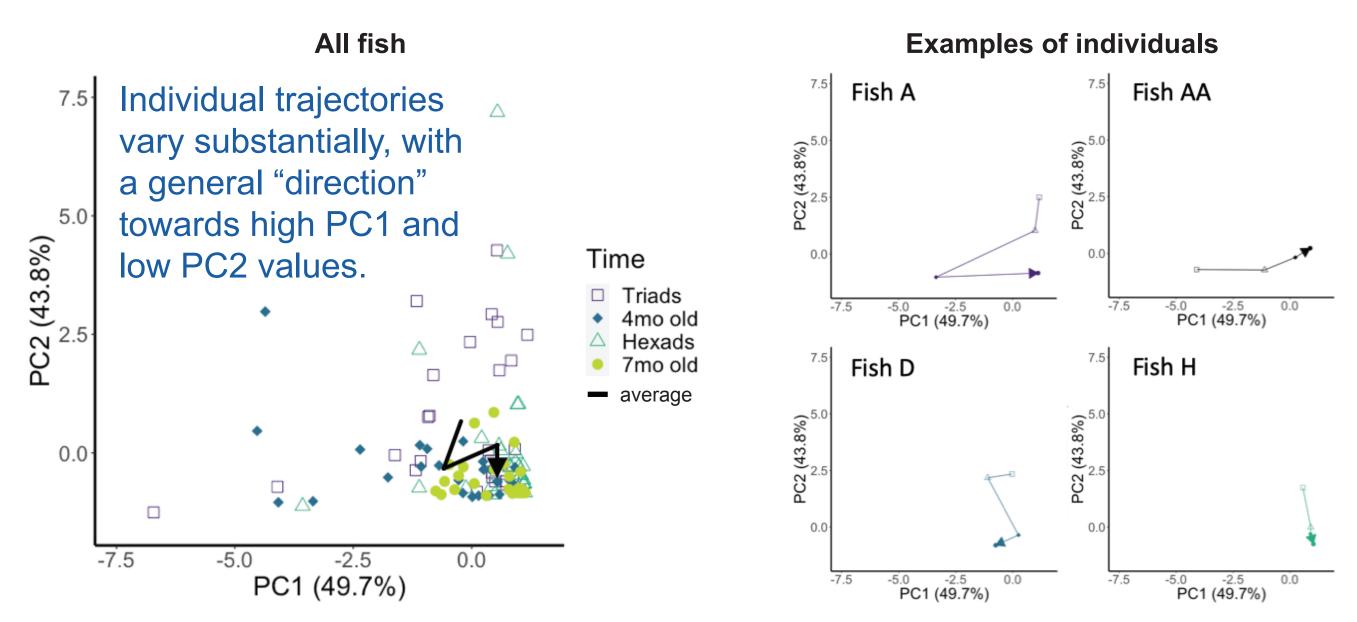
across similar contexts.



Relevance & future directions: Patterns of social behavior change over time, and risk of disease / parasite transmission may be higher at times of more frequenty interaction (early in development). Furthermore, infection at key developmental time points may have a disproportionately large future impact (e.g., on behavior, reproductive maturation). Developmental variation in disease / parasite risk or rates, or variation in immune system function, has yet to be tested in *A. burtoni*.

2b. How does individual behavior develop over time and across contexts?

Hypothesis: Individual behavior changes over time. Similar individuals (by sex, size, disease/parasite state, or other trait) have similar trajectories.

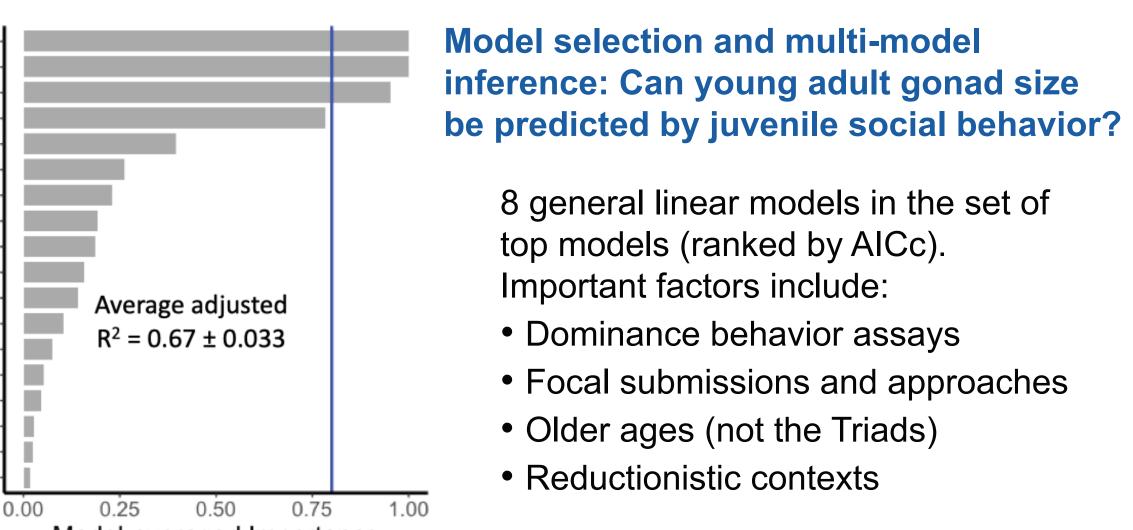


Relevance & future directions: The key factors determining the direction and magnitude of developmental changes in behavioral phenotype have yet to be identified, including a role for disease/parasite state. Certain trajectories may be associated with more (or less) influential positions within the social network.

3. Can young adult phenotype be predicted?

Hypothesis: Juvenile behavior can predict young adult phenotype.

Submissions (7mo DOM) Submissions (4mo DOM) Approaches (7mo DOM) pproaches (Hexads) ubmissions (4mo SL Displacements (4mo DOM) Approaches (4mo DOM) Displacements (7mo SUI



Model-averaged Importance

Relevance & future directions: Juvenile behavior, in part, predicts young adult phenotype of direct relevance to adult social status, behavior, and reproductive success. These models can be used to test the consequences of early-life conditions, such as disease / parasite state, resource availability, social /environmental conditions, and more.

Conclusions: A. burtoni social behavior is remarkably rich, starting from a very early age! Systematically studying individuals over time and across contexts provides important insights, including for early-life effects, reproductive maturation, and mechanisms underlying behavior. The experimental and analytical approaches in disease ecology and parisitology are highly valuable to this work, and directly relevant to questions of development in social species.

Acknowledgments: We thank Lisa Paggeot for fish maintenance and care and members of the Hofmann Lab for discussion and feedback. This work was supported by NSF grant IOS-1354942 to HAH and the BEACON Center for the Study of Evolution in Action to HAH and TKSL.