Analysis of high-order social interaction of female mice on the International Space Station

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M. Lowe[1,2], P. Solomides[2,3], E.L. Moyer[1,2], Y. Talyansky[2,4], S. Choi[2], C. Gong[2], S. Cadena[5], L. Stodieck[6], R.K. Globus[2], A.E. Ronca[2,7]

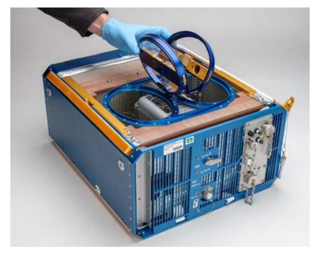
Blue Marble Space Institute of Science, Seattle, WA; Space Bioscience Division[1], NASA Ames Research Center. Moffett Field CA[2]; Space Life Sciences Training Program (SLSTP), NASA Ames Research Center[3]; San Jose State University, San Jose, CA[4]; Novartis Institutes for BioMedical Research (NIBR)[5]; BioServe Space Technologies, University of Colorado Boulder[6]; Obstetrics & Gynecology, Program in Neuroscience, Molecular Medicine & Translational Science, Wake Forest School of Medicine, Winston-Salem, NC[7]

INTRODUCTION

Social interactions are adaptive responses to environmental pressures that have evolved to facilitate the success of individual animals and their progeny. Quantifying social behavior in social animals is therefore one method of evaluating an animal's health, wellbeing and their adjustment to changes in their environment. The interaction between environment and animal can influence numerous other physiological and psychological responses that may enhance, deter or shift an animal's social paradigm. For this study, we utilized flight video from the Rodent Research Hardware and Operations Validation mission (Rodent Research-1; RR1) on the International Space Station (ISS). Female mice spent 37 days in microgravity on the ISS and video was captured during the final 33 days. In a previous analysis of individual behavior, we also reported an observed spontaneous ambulatory behavior which we termed circling or 'race tracking', and we anecdotally observed an increase in group organization around this behavior. In this analysis we further examined this behavior to determine if (1) animals joining in on this behavior were induced by other cohort members already participating in this circling behavior, (2) rates of joining varied by number already participating.

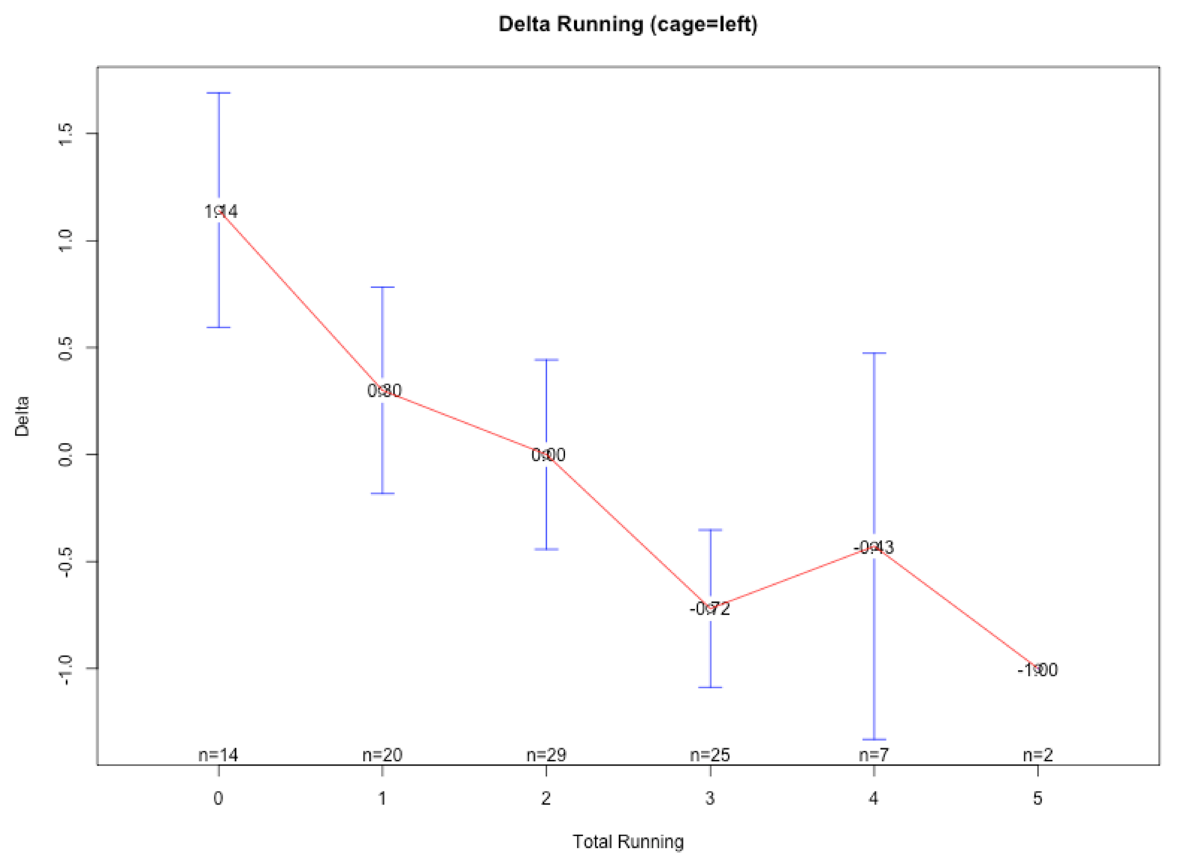
METHODS

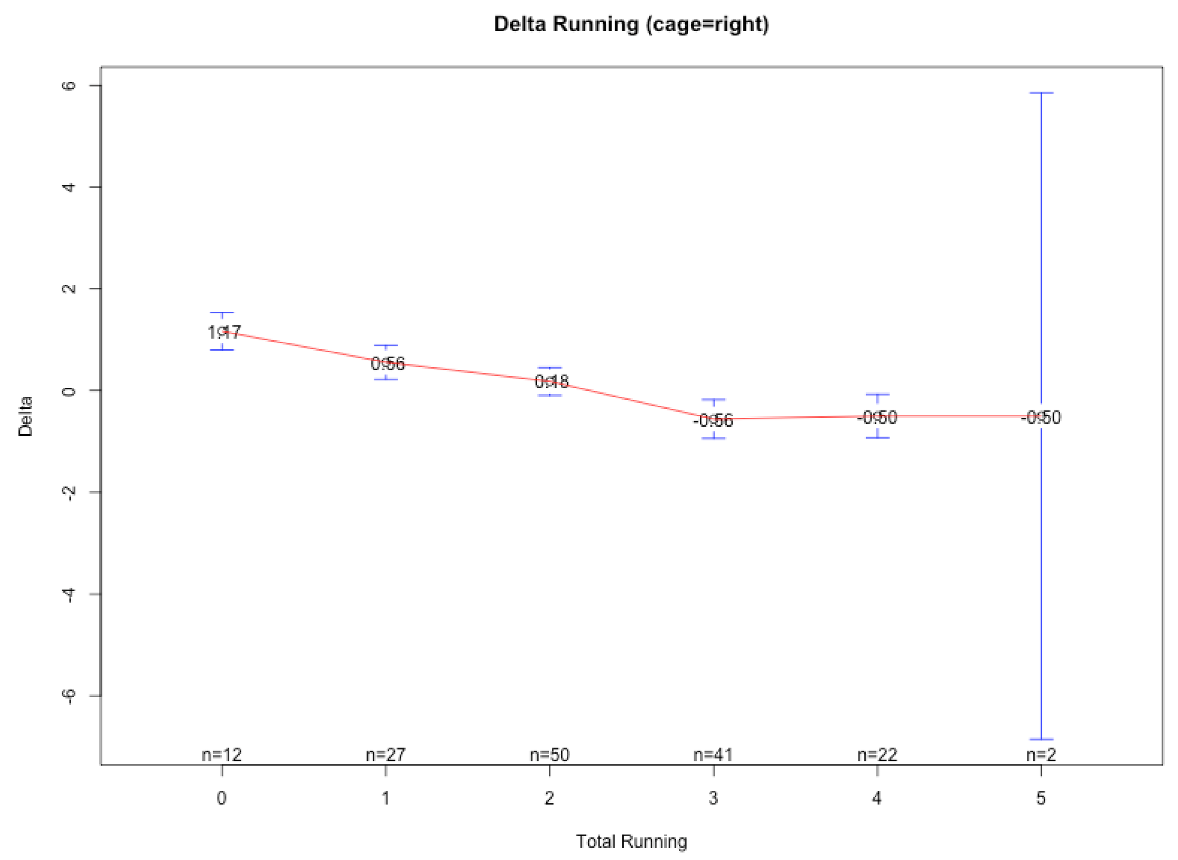
- The RR1 was a 37 day mission, video was recorded for 33 days of mice on the ISS, permitting daily assessments of overall health and well-being . The days were organized into quarters. Two days from the last three quarters were sampled and analyzed. All samples were taken from the dark cycle.
- NASA ISS Mice: Ten adult (16-week-old) female C57BL/6
- The Rodent Habitat consisted of one container divide into two distinct habitats termed "left filter" and "right filter" based on camera view. There were five mice per habitat and there was no physical way for animals of a habitat to interact with animals of another habitat.

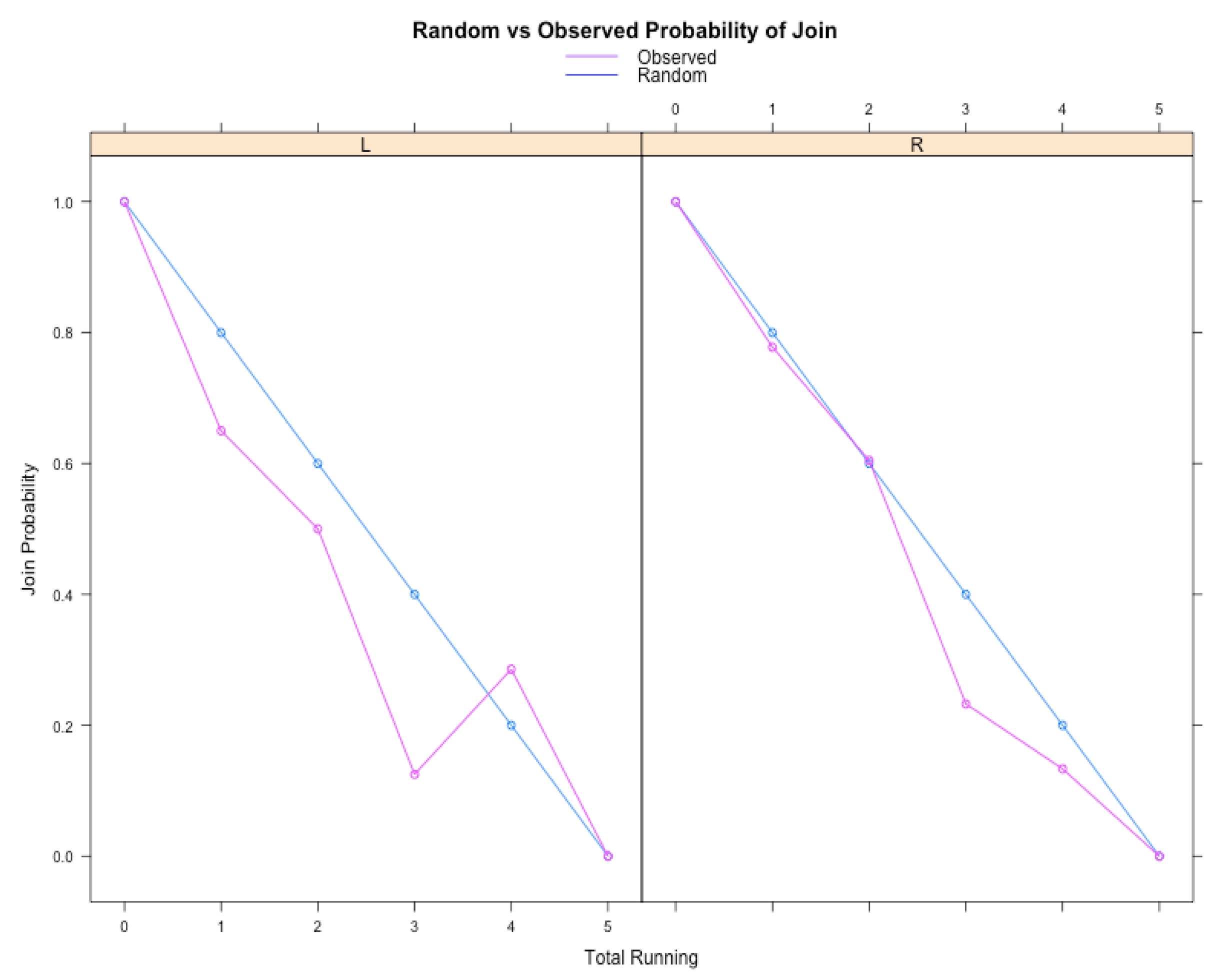


- Measures:
  - Duration captured in seconds (s).
  - Running: A mouse's hindlimbs making contact with at least 3 walls and completing 1 full rotation/lap.
  - Total Mice Running: The sum total of all mice running in a given observation.
  - Mouse Joining: Running after at least one mouse had begun running and while also having met the definition of "running."
  - Mouse Leaving: A mouse that in the previous observation met the definition of "running" and in the current observation no longer met the definiton of "running," either by no longer completing a lap or not touching at least three walls with their hindlimbs.

RESULTS

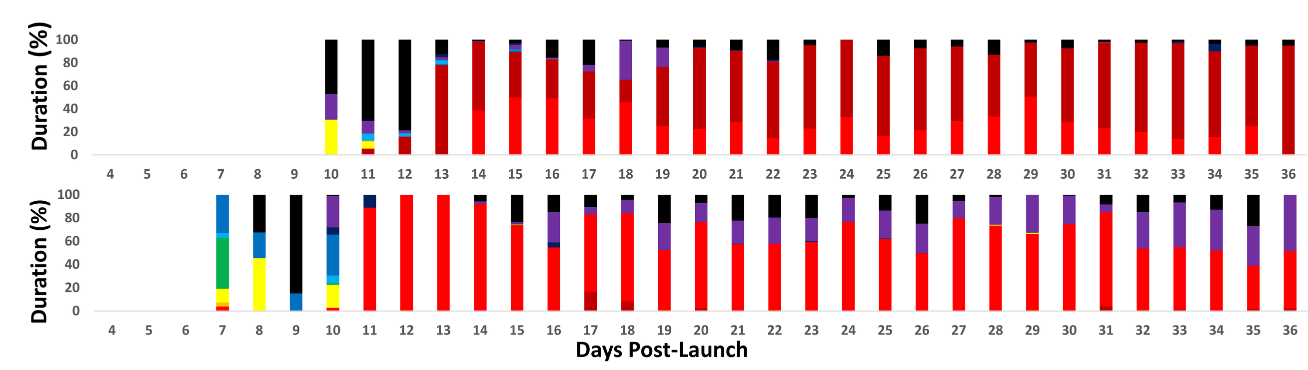




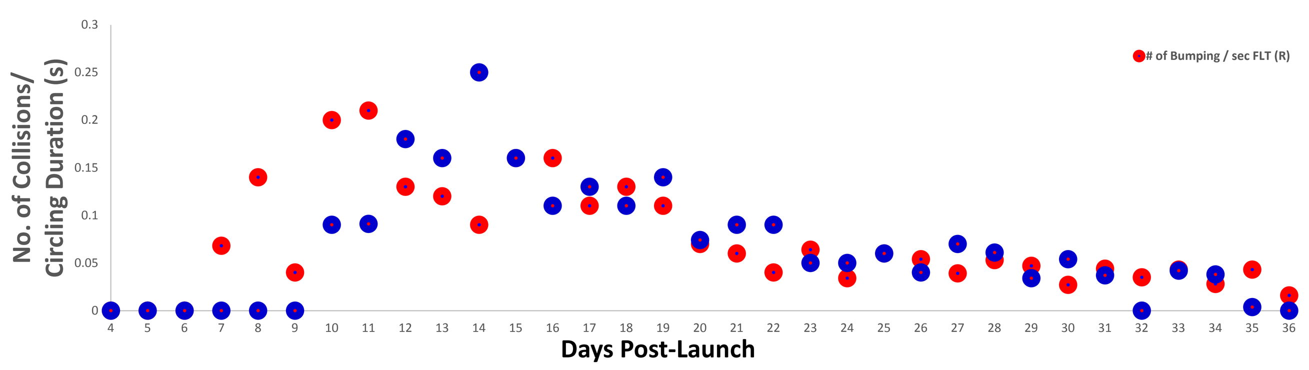


CONCLUSIONS

Directionality[2]



Collisions[2]



The results of this study are consistent with self-organized spatial patterns found in previous studies[1,3]. Cahn-Hilliard spatial self organization model, based on Cahn-Hilliard's phase separation, describes conspecific animals "whose net movement switches between aggregation and dispersion as a function of its own local density[3]" . Our findings show a density tipping point at about three mice, with a trend to aggregate in conspecific behaviors up to the density threshold. These findings are consistent with our previous findings in circling directions[2]. With circling direction, over time, mice preferred particular routs of running, however, in a given day mice would form subgroups of unique running directions[2]. These separations maybe due to a density threshold inducing the mice to disperse and formulate subgroups (separate phases) at lower density thresholds. These patterns in group organization maybe due to feedback in the mouse environment, such as the volume of the habitat and occurrences of collisions[2], vs. the drive for conspecific aggregation. This positive and negative feedback may best explain the observed novel group behavior of mice movement in the ISS better than other animal models, such as the Turning model, that are dependent on other forces driving animal behavior such predation, food acquisition and reproduction. Further analysis and modeling is needed to expand on our current findings.

REFERENCES & ACKNOWLEDGMENTS

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