MOTILITY OF DOPAMINE AND SEROTONIN-DEFICIENT *C. ELEGANS* IN FED AND STARVED CONDITIONS

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INTRODUCTION & HYPOTHESES

Dopamine and serotonin are neurotransmitters found in both vertebrates and invertebrates that play essential roles in many aspects of animal nervous system function, including motivational behavior, motor control, and learning. Abnormal signaling function in dopamine and serotonin are closely associated with a number of disorders, including addiction, bipolar disorder, attention-deficit hyperactivity disorder, schizophrenia, and Parkinson's disease. The mechanisms by which reduced dopamine and serotonin-signaling leads to many movement-related diseases in humans are poorly understood. While wild-type *C. elegans* make small adjustments to their speed to maintain their constant rates of locomotion, mutant worms with deficient dopamine and serotonin-signaling make larger adjustments to their speeds, which result in large fluctuations in their rates of locomotion. Dopamine and serotonin play a role in slowing *C. elegans* in response to food, called the "basal slowing response," which slows the movement of the worm.

MODEL ORGANISM

Caenorhabditis elegans is a transparent nematode that is about 1 mm in length. Partly due to the fact that its whole genome is sequenced, it is a widely utilized test subject and model organism. Many of the genes in the *C. elegans* genome have similar counterparts in humans, which make them useful models for human diseases. It has a rapid life cycle and exists mostly as a self-fertilizing hermaphrodite.

Wild-type *C. elegans* make adjustments to their speed to maintain their constant rates of locomotion, mutant worms with deficient dopamine and serotonin-signaling make larger adjustments to their speeds, which result in large fluctuations in their rates of locomotion. In addition, mutant worms with deficiency in serotonin exhibited extreme speeds and mutants lacking dopamine and serotonin move faster than wild-type animals on a bacterial lawn, indicating that dopamine and serotonin play a role in slowing *C. elegans* in response to food, called the "basal slowing response." *C. elegans* and humans might share certain mechanisms by which dopamine and serotonin restrict motor activity levels and coordinates movement.

METHODS & MATERIALS

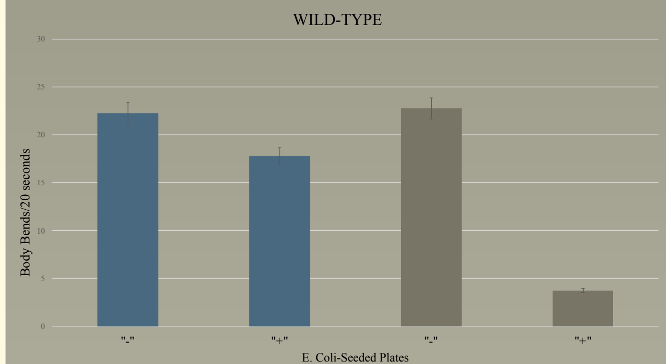
N2 wild–type (*Bristol*), CBI 112 (*cat-2*), and GRI 321 (*tph-1*) *Caenorhabditis elegans* hermaphrodites were used and kept at laboratory room temperature on NGM plates seeded with *Escherichia coli* OP50. Half of the worms in each strain of *C. elegans* were moved to unseeded plates and food-deprived for one hour, while the other half of the worms were regularly maintained within that hour and were provided with sufficient *E. coli*. After one-hour, four worms were picked to either seeded or unseeded NGM plates and were allowed 10 seconds to adjust to their surroundings and to adjust and focus the camera. We randomly chose one worm from the plate and recorded its locomotion pattern for 20 seconds to examine and count the body bends later. We counted the number of body bends every 20 seconds to measure rate. All assays were completed on the same day within eight hours of each other. We used the same batch of plates to minimize systematic errors and contamination that could be introduced by using several batches of plates. For examination and recording, the SZ-PT Olympus microscope and Olympus Pen Video Recorder was used. Any gravid or male worms were removed from all plates before the start of the experiment. All worms included in this experiment were L4, young adult, or adult. Wild-type, *cat-2*, and *tph-1* worms that were not introduced or reintroduced to unseeded or seeded plates were regularly maintained and well-fed as a control. This examination method was based off of other relevant experiments.

Body bends were used as data as they are preferable to the distance *C. elegans* travel. The distance may be influenced by the thickness of the bacterial lawn, the number of eggs the worm carries, and the number of reversals it makes. Counting body bends is a more direct measure of study and is less likely to be influenced by the factors above.

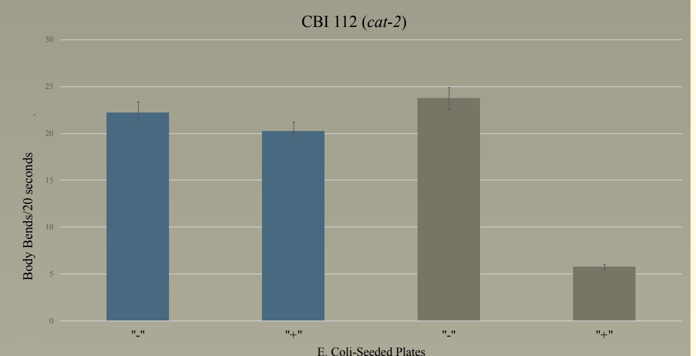
ABSTRACT

The neurotransmitters dopamine and serotonin play important roles in animal nervous system function. Abnormal dopamine and serotonin signaling results in a variety of diseases and disorders, including ADHD, addiction, and Parkinson's disease. The exact roles of dopamine and serotonin in the human brain, especially related to motor control, are not understood. Therefore, the goal of this research was to determine how defective dopamine and serotonin signalling in *Caenorhabditis elegans* affects locomotion rates. Locomotion enables *C. elegans* to seek out the bacteria they feed on to survive in the wild and in culture. In this experiment, wild-type, CBI 112 (*cat-2*) dopamine-deficient, and GRI 321 (*tph-1*) serotonin-deficient worms were chosen because these mutants have been seldom used in experiments relating to locomotion. Half of the worms in each strain were food-deprived for one hour, while the rest were fed a sufficient supply of their food, *Escherichia coli* OP50. After one hour, the worms were transferred to a plate that did or did not have *E. coli* OP50. The number of body bends of *C. elegans* were enumerated from twenty-second digital recordings. Body bends were chosen as a more accurate representation of the worms' locomotion rate, rather than speed of travel. The results suggest that food-deprived *C. elegans* that were introduced to seeded plates had fewer body bends during the observed twenty-second periods than the worms subjected to other conditions. In addition, the fed worms that were introduced to seeded plates had fewer body bends than the worms introduced to unseeded plates. This suggests that, in the presence of *E. coli*, the worms slow down in response to entering a seeded plate.

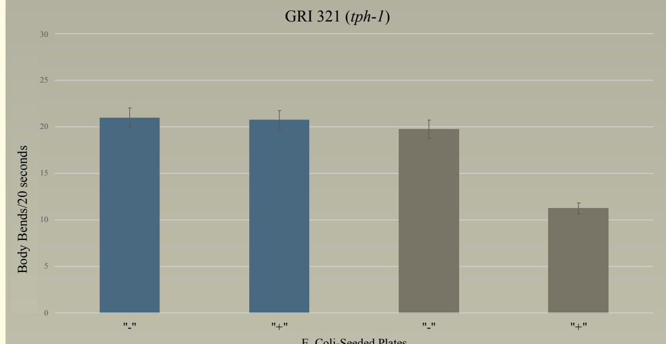
RESULTS



We examined well-fed and food-deprived wild-type *C. elegans* that were introduced to seeded and unseeded plates. (Fig. 1). Wild-type worms, who were previously well-fed, were introduced to an unseeded plate and averaged 22.5 body bends every 20 seconds. Well-fed, wild-type worms were also introduced to a seeded plate and averaged 17 body bends every 20 seconds. Wild-type worms who were previously food-deprived and were introduced to an unseeded plate averaged 23.5 body bends every 20 seconds. Wild-type, food-deprived worms were introduced to a seeded plate and averaged 4 body bends every 20 seconds.



We also examined well-fed and food-deprived *cat-2 C. elegans* that were introduced to seeded and unseeded plates (Fig. 2). The worms that were well-fed and introduced to an unseeded plate averaged 22.5 body bends every 20 seconds, while the worms that were well-fed and introduced to a seeded plate averaged 20 body bends every 20 seconds. Worms that were food-deprived and introduced to an unseeded plate averaged 24 body bends, while the worms that were food-deprived and introduced to a seeded plate averaged 6 body bends.



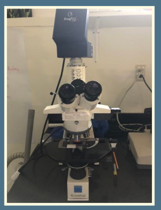
In the last chart, we examined well-fed and food-deprived *tph-1 C. elegans* that were introduced to seeded and unseeded plates (Fig. 3). The worms that were well-fed and introduced to an unseeded plate averaged 22 body bends every 20 seconds. The worms that were well-fed and introduced to a seeded plate averaged 21.5 body bends. Worms that were food-deprived and introduced to an unseeded plate averaged 19 body bends, while the worms that were food-deprived and introduced to a seeded plate averaged 12 body bends.

LEGEND:

- Well-Fed Before Transfer to Plate
- Food-Deprived Before Transfer to Plate
- − Unseeded Plate
- \+ Seeded Plate

CONCLUSION

The results show that, between all the worms tested, the food-deprived worms that were introduced to a seeded plate had significantly less body bends every 20 seconds than the rest of the worms. In addition, the well-fed worms that were introduced to a seeded plate had less body bends every 20 seconds than the worms tested under other conditions. This suggests that, in the mere presence of *E. coli*, the worms slow down. The serotonin-deficient worms had less change between the circumstances they faced than the rest of the worms.



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In the future, there are a number of experiments I would like to try to expand on my research. This would include studying the expression levels of fluorescently-tagged dopaminergic and serotoninergic receptors in worms worms using a fluorescent microscope. Studying the epigenetics of the worms would reveal whether the worms' rate of body bends is the same throughout the generations. Although I did not have time this summer, I will also be using Worm Tracker, a software used to precisely track the worms' body bends and speed, to closely examine the videos I took to identify the true rate of movement. After talking to a number of local scientists, I would also like to link the rate of body bends to the worms' pharyngeal pumping. I would also try to use bigger plates to experiment with the size of the bacterial lawn. Adding more strains of worms would be beneficial to the experiment, including olfactory-enhanced or deficient worms. Eliminating the bias in this experiment would also be essential to the advancement of the research, using a double-blind setup.

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* Non-cited photos taken by Saia Patel [Courtesy of NHAS]
** References only include the most helpful and notable sources used

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